# Quantitative Sciences

## Principles and Practice of Epidemiology


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## Definition and Uses of Epidemiology

The roots of "Epidemiology" can be traced back to somewhere around 400 BC, when Hippocrates had related the occurrence of human diseases to the environment in his treatise "On Airs, Waters and Places". (1). After a long lull for almost 2000 years John Graunt in 1662 and William Farr in the nineteenth century (2,3), revived the interest and laid the seeds of the modern epidemiological surveillance systems. These efforts were boosted by John Snow's field investigations of cholera epidemic in London in 1850s (4). However, it is only after 1940 that Epidemiology really expanded as a modern science, with the initiation of cohort studies at Framingham, the clinical trials of anti-tubercular drugs, the preventive trial of injectable polio vaccine, the community intervention trials of fluoridation of water supplies, and the advent of Case-Control studies on smoking and lung cancer, by Sir Richard Doll and Sir AB Hill (5-7).

In this regards, epidemiology seems to be a special field, for she has expanded very fast. Today almost every standard medical text book, be it Medicine, Surgery, Obstetrics & Gynaecology, or Paediatrics, would give a paragraph on "Epidemiology" of almost every disease. Epidemiology is therefore an all pervasive science and a basic tool for understanding and practice of all specialities of medicine (8). In fact, the understanding of epidemiology involves two things - firstly, the knowledge of the principles of Medicine; and, secondly, the knowledge of certain basic "principles" of epidemiology, which we shall endeavor to explain in this chapter.

For instance, if we, as medical person, or for that matter even an undergraduate medical student were asked to write a short essay on a common disease like malaria, the essay would read something like : " …….. Malaria is caused by a parasite called plasmodium. It is transmitted by the bite of female anopheles mosquito. It manifests as an acute febrile illness with chills and rigors. If untreated, many cases recover after a few febrile attacks but, in some, the disease may take a serious course and even some of those who recover may get a relapse. In our country out of every 1000 people, 2 to 3 are likely to get malaria every year. The disease is more common among the children, the poor people, among foreigner tourists, immuno-compromised persons, and among the agriculturists. It is commoner in North-Eastern states of our country, in rural areas and in urban slums but is not seen in highland areas. It is also much more common during and immediately after monsoons. Malaria can be prevented by spraying insecticides on water collections and on the walls of our dwellings. It can be diagnosed by a simple blood test and can be treated effectively by oral chloroquin and primaquin ……. ".

If we examine the above essay, we would appreciate that we have systematically covered certain facets, which are summarized in Table - 1. We would have covered up an essay in the same way for any other disease - IHD, HIV, Road Accidents or Neurosis.

The above facets according to which we consider any disease are, put together, nothing but what we call

Table - 1

| Facet | Example in our essay |
|---|---|
| What is the disease (Identification) | Malaria, which presents with fever & chills |
| How much is the disease (frequency) | 2 to 3 out of every 1000 people in our country |
| **How is the disease distributed according to** | |
| Person characteristics (who) | Children, poor people |
| Place characteristics (where) | Rural areas, slums, NOT in highlands |
| Time characteristics (when) | During & immediately after monsoons |
| **Why and How does it occur? (what are it's determinants)** | |
| What is the cause (etiology) | Plasmodium |
| What are "risk factors" | Foreigner, agriculturist |
| What is it's natural history | Many recover, some relapse |
| What is it's prognosis | Untreated cases may turn serious, some die |
| **What can be done about it? (How can it be prevented or mitigated?)** | |
| How can it be diagnosed | Blood test |
| How can it be treated | Chloroquin, Primaquin |
| How can it be prevented | Insectide spray, mosquito nets |
| | |

"EPIDEMIOLOGY". Epidemiology is that branch of medicine which answers the issues related to all human health problems and diseases, the magnitude that they pose, their distribution according to persons, place and time, and the various factors which determine the causation, risk, prognosis, management and prevention of the diseases.

## Definition

With the above background, we can define epidemiology as "The study of the frequency, distribution and determinants of diseases and health related states and events in human populations" and the application of this knowledge in prevention, control and mitigation of these problems ( 9-12 ). (Greek; Epi = upon, Demos = populations, logos = scientific study).

## How does Epidemiology differ from Clinical practice

Epidemiology uses the same tools and techniques as clinical medicine; however there are two major differences

(a) In clinical practice the focus is on an individual, the patient; however, in epidemiology, the focus is on a group of human beings (patients or healthy people) which we refer as "population" (13).

(b) In clinical practice there is no effort at "quantifying" by converting the findings into numbers, but epidemiology is essentially a "quantitative" science, in which the findings are analysed after converting them into "frequencies" which are numerical figures that "summarise" our findings.

## Uses of Epidemiology

There are a large number of uses of epidemiology (14), which can be broadly classified into 4 headings

### Uses in Health Care Management

Table 2 : Principal Uses of Epidemiology

| |
|---|
| In Health Care Management |
| In Understanding the disease process |
| In Public Health Practice |
| In Clinical and preventive practice |

(a) Making a Community Diagnosis

In clinical settings, the clinician makes a clinical diagnosis before proceeding to manage the case. In health care of large community, the health provider must make a Community Diagnosis" by epidemiological methods to obtain information on the important health problems and their associated socio-demographic characteristics, quantifying and summarizing them (15, 16 ). Only thereafter relevant health care for the community can be organized.

(b) Planning and Evaluation of Health Services

Any planning process will need accurate information about the socio-demographic profile, the diseases, the facilities, communications etc. Similarly, while evaluating a health programme, we will again need current information about various diseases and compare it with the "baseline" state that existed when we started the programme. This quantified and summarized information is available only through epidemiological steps (17).

(c) Developing Health Policies

Since Epidemiology is indispensable for making assessment of community "diagnosis" and "needs" and the fact that it provides " evidence based" decisions about the risks for the individuals and communities, due to various exposures, makes it a key discipline for developing Public Health Policies (18).

### Uses in Understanding the Disease Process

(a) Study of the Natural History of Diseases

what we know today of the natural course of HIV or pulmonary TB or any human disease has been possible due to systematic observations on hundreds and thousands of patients and describing the summarized findings from the observations on these large number of patients, which is only possible by epidemiological methods.

(b) Searching for the Causes and Risk Factors of Diseases

How do we say that smoking is a cause of IHD? Or, obesity is a risk factor for diabetes? It is by observing thousands of obese and non-obese people and following them forward to see what percentage in each group develops diabetes (cohort epidemiologic approach) or else by asking hundreds of IHD people compared to hundreds of healthy people about smoking history (case-control epidemiologic approach) (19, 20).

(c) Historic study of rise and fall of diseases

Small pox rose to its peak, killed millions and was finally eradicated; plague almost vanished after killing huge proportions of humanity and then again reappeared. Epidemiological studies of such rise and fall of diseases are essential to understand the various factors which can be effectively utilized in preventing the occurrence or re-emergence of other diseases.

(d) To Identify Syndromes

The idea of "syndrome" is that two or more different medical phenomena (constellation of signs / symptoms) occur more frequently together than can be accounted for by simply a "chance" association. It is only after obtaining data on hundreds of patients from various countries about signs & symptoms of a related nature, through epidemiological methods, that we are able to put the pieces of information together and identify "syndromes" and their etiological factors. For instance, till 1920s, peptic ulcer was thought to be a single entity. Based on collection of large scale epidemiological data (from death certificates and surgical records) and its analysis according to sex, social class, anatomical site and time-related trends the two entities, viz, duodenal and gastric ulcer were clearly distinguished (22, 23). More recently, obesity, central obesity, raised blood pressure, impaired glucose tolerance and raised triglycerides / low HDL-Cholesterol were all identified individually as CHD risk factors; however, only after studying the data from large number of subjects, in a consolidated manner, it was observed that these tend to cluster together more

frequently than can be expected simply due to chance, as "Metabolic Syndrome X" (24, 25).

**Uses in Public Health practice**

(a) Investigations of Epidemics and Other Field Investigations

While epidemiology, today, is involved in practically all aspects of medicine and health care, the fact remains that it originally started as the science dealing with investigations of epidemics (26) and even today, this remains one of the most important duties of the epidemiologists.

(b) Surveillance for Diseases

In addition to investigations of epidemics, disease surveillance was another important function for which epidemiology came into being. Today, we have huge national & international surveillance systems which all essentially involve epidemiological principles of information generation, consolidation, analysis and interpretation.

(c) Making Projections

Quite often we hear that there will be so many million cases of IHD in our country by 2025 and so on! How are these projections made? They are actually mathematical models developed by epidemiologists after collecting data from large populations for the past many years and then developing the mathematical models to calculate what is likely to occur in future.

(d) Assessing the Programmes for Mass Screening for Diseases

Based on epidemiological principles of "diagnostic test assessment", the mass screening programmes are planned and subsequently evaluated for their effectiveness in large population groups.

**Uses in Clinical and Individualized Preventive Practice**

(a) Assessing the effectiveness of treatment and preventive modalities

Any treatment modality, be it a drug, surgical intervention, or else any preventive modality (vaccine, immunoglobulin preparation, chemoprophylactic drug, lifestyle change, personal protective measure, etc.) has to be evaluated through the epidemiological approach of "Randomized Controlled Blinded Trial" (RCT or Clinical trial) before it can be taken up in clinical usage.

(b) Assessing Prognosis

Epidemiological studies on a large sample of patients, using the "cohort" approach are essential for evaluating the role of a prognostic factor in predicting the outcome of a disease.

(c) Assessing the effectiveness of diagnostic procedures

Any new diagnostic procedure, as a new laboratory test or a radiological test or even a clinical algorithm has to be evaluated for its diagnostic accuracy as well as utility, by studying it on a adequately large sample of patients who are all also subjected to the gold-standard test, based on epidemiological principles of "diagnostic test evaluation studies".

(d) Assisting in Clinical decision making

Modern epidemiological methods as "clinical decision trees" are being increasingly used in clinical practice for taking decisions regarding optimum clinical management of individual patients. Summary of definition and uses of Epidemiology is given in Table - 3.

Table-3 : Summary Box (Definition & Uses)

| Definition |
|---|
| Study of Frequency, Distribution and determinants of diseases and health problems in human populations and it's application in prevention, control and mitigation of health problems. |
| **Uses** |
| **(a) In Health care management**<br>(i) Making Community Diagnosis<br>(ii) Planning & Evaluation of Health Services<br>(iii) Developing Health Policies<br>**(b) Understanding Disease Process**<br>(i) Studying natural history of diseases<br>(ii) Searching for Causes & Risk factors<br>(iii) Historic studies of rise and fall of diseases<br>(iv) Identification of Syndromes<br>**(c) Uses in Public health practice**<br>(i) Investigations of Epidemics<br>(ii) Surveillance for Diseases<br>(iii) Making Projections for Future<br>(iv) Disease Screening Programmes<br>**(d) Assisting in Clinical Practice**<br>(i) Assessing Effectiveness of Treatment Modalities<br>(ii) Assessing Effectiveness of Preventive modalities<br>(iii) Studying Prognostic factors<br>(iv) Studying Effectiveness of diagnostic Modalities |

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## Making Measurements in Epidemiology

### Identifying the Disease and "Case Definition"

As we have seen in the previous chapter, the first step in epidemiology is "identifying" the disease or a health event or state. Hence at the very outset, the epidemiologist must clearly give a "case definition" of the disease or health related phenomena that she is going to study. It may appear too simple but is not so in reality. If our interest is to study "tobacco use", how do we define a tobacco user? - Anybody who has even once put tobacco inside the mouth in the lifetime? Or those who smoke at least one cigarette a week? Or, who smoke at least one cigarette a day for at least three days in a week? Or, how do we say that a given child is a case of Dengue fever or not?

Apparently, one has to give some definition. This, in epidemiology, is known as "case definition". Naturally, we should have a case definition which identifies each and every person who has the disease (sensitive) and at the same time, exclude every person who does not have the disease (specific). In practice, getting a definition which is 100% sensitive as well as 100% specific is never possible, for pragmatic reasons. Hence, we draw an optimum trade-off between sensitivity and specificity, and quite often, make case definitions according to two or three levels of certainty, as "suspected", "probable" and "confirmed" (27), e.g., we may define the three levels for dengue as shown in Box above.

**Case Definition : Dengue Fever**

**Suspected**

Fever of at least two days duration with myalgia, arthralgia, retro-orbital pain and severe backache, occurring between July to October in an area where at least one confirmed case of dengue had occurred during past 3 years.

**Probable**

A clinically compatible case with a single convalescent phase serum IgG titre of 1280 or above or positive IgM.

**Confirmed**

4 fold rise in dengue antibody titre in paired sera taken at least 10 days apart, or detection of dengue virus.

Now, having defined the various diseases or health related phenomena that we are interested in studying, we need to make accurate measurements. Two essential requirements come up in epidemiologic practice when we talk of making measurements. Firstly, we should be accurately measuring what we intend to measure, i.e., the measurement process should be "valid". Secondly, since in epidemiology, we study a large number of subjects, the method of measurement should give consistent results when repeated applications are made (i.e., measurement process should be reliable or repeatable) (28).

Thirdly, in the process, we would decide the various headings on which we will make measurements on our subjects. For example, in a trial of the efficacy of a new lipid lowering drug, we would note down the age, sex, blood pressure, blood glucose, total / LDL / HDL cholesterol, whether given the standard lipid lowering drug or else the new drug, final level of various lipids after, say, 6 months and so on. In epidemiology, these various "headings" are called "Variables". Thus, Age, Sex, name of the drug administered, LDL level and so on are all "variables". A variable is thus any quality, or constituent of a subject which 'varies', i.e., likely to have a different value from one subject to another. We will enter these findings initially on individual forms for each patient and later transfer the information to a chart (manual or computerized) wherein the "value" of each of these "variables" will be entered for each patient. This chart, duly completed with all details for the required sample of patients / subjects is what is known as 'DATA'. Data can thus be defined as an organised collection of information, containing the 'values' of the various variables, which would be used to derive conclusions through analysis and reasoning. As an example, a 'Data-set' of an epidemiological study on IHD and its determinants, would look something as shown in Table - 1

In Epidemiology, depending on the manner in which the values of various variables have been measured and recorded, the data that we collect can, broadly, be either of the following types (29)

(a) Quantitative Data

It is the data which is collected in terms of mathematical figures; eg, Blood Pressure, Serum lipids, Body Weight, No. of Carious teeth etc. Since such data is recorded in

Table - 1

| Sr. No. | Name | Dyspnea grade | Waist (cms) | Hip (cms) | Body Mass Index | Tobacco smoking | SBP | DBP | Physical exercise | IHD | Blood Group |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 1. | XX | 3 | 90 | 100 | 27.5 | Yes | 146 | 92 | None | Yes | A |
| 2. | AC | 1 | 84 | 96 | 23.2 | No | 132 | 78 | Regular | No | B |
| 3. | XB | 1 | 76 | 84 | 21.2 | Yes | 128 | 82 | Irregular | Yes | O |
| 5. | XY | 0 | 88 | 97 | 25.1 | Yes | 138 | 86 | Irregular | No | AB |
| 400. | AX | 2 | 92 | 96 | 26.7 | No | 148 | 94 | Regular | Yes | O |

form of numerals, one can also call it as 'Numerical data'.

(b) Qualitative Data

When information is not recorded in form of numbers but according to certain defined qualities or attributes; e.g. "Sex - Male/Female"; Outcome of treatment - Recovered/ Dead; Blood group A, B, AB or O; "Satisfied with treatment - Yes or No" etc. Both quantitative & qualitative data have 3 scales of measurement

## Quantitative

The 3 types of scales that can be used to collect such data are -

### (a) Discrete (Numerical) scale

Also called as "count" data. Information recorded on this scale has the following characteristics

(i) They correspond with a count of some sort

(ii) They are recorded as integer numbers

(iii) They can not take any decimal value

(iv) The numbers have a definite mathematical relationship.

A number of variables in epidemiology are measured on discrete scale; e.g., number of DMF teeth; no. of abortions; no. of spells of a given disease for individual subjects; no. of doses of a vaccine taken; no. of visits to the hospital and so on.

### (b) Numerical, Continuous Scale

Also known as "measured" data. Like the numerical 'discrete' scale, numerical continuous scale, also records the observations as quantities which have mathematical relationship; however the major difference is that the observations can take any value (theoretically at least) along a 'continuum' between 2 integers (and not necessarily restricted to integers as in a discrete scale). Take, for example, systolic BP. While we would generally measure systolic BP as 118, 120, 122 etc., this is only because we have calibrated the instruments accordingly. Theoretically at least, SBP can be recorded as 199, 121 etc; and can also be measured as 119.5 or 121.7, or even, for that matter, as 119.5397501 or 121.7039267 ! A large number of measurements in clinical practice are made on this scale - eg. various biochemical parameters, Body weight, height, BMI, Stroke Volume, CSF pressure and so on.

### (c) Numerical ordinal Scale

The ordinal scale uses numerical symbols for recording the data, but these numbers do not have any meaningful mathematical relationship. For example, to record the variable '"fever", we can record it as numerical values (no fever =0, Mild fever =1, Moderate = 2, High = 3). In fact epidemiologic practice is full of such examples (grades of dysponea, , grades of murmur, levels of satisfaction, grades of cancer, APGAR score, degree of relief from pain and so on). With this type of data, we would instantly think of working out the 'means of fever score'. However, it is here that the catch point lies. The numbers 0,1, 2 and 3 are not real mathematical numbers - high grade fever is not really equal to 3 times mild grade nor will a patient each of nil, mild and moderate fever added together will give a clinical state equal to high fever ! The point is important to understand because the statistical tests to be used in such situations (non-parametric) are very different from the usual parametric tests used for discrete or continuous scales.

## Qualitative Data

The peculiarity of qualitative data is that the recording of observations is not made in form of numbers as in quantitative data, but in form of words; thus it records "qualities" and not "quantities". The major 'scale' for recording the qualitative data is a "Categorical", also called a "nominal", scale in which two or more categories are made and depending on whether there are only 2 categories or else more than 2 categories, the scales are called as "nominal dichotomous" and "nominal polychotomous" respectively.

### (a) Nominal dichotomous

In nominal dichotomous there are only 2 possible alternative answers to the information being recorded; e.g. Hypertensive - Yes/No; Status - Dead /Alive; Response to treatment - Recovered/ Not recovered; Tobacco user - Yes/No; and so on. In other words, the response will be recorded as "either" - "or" of the 2 alternatives, in words, not numbers. (At this point it should be noted that the response may be recorded as '0' for No and '1' for Yes; however, in such cases, even if the response is recorded as 0 (for No) and 1 (for Yes), the scale remains dichotomous.

### (b) Nominal polychotomous

In a nominal polychotomous scale, there are more than two alternative answers or possibilities for which the information is being recorded; and the information is recorded in words, not in numbers. In addition, the categories in a nominal polychotomous scale do not have any ordered relationship, in contrast to the ordinal scale (see below) where there is a definite ordered relationship. A number of variables in medical research are recorded on a nominal polychotomous scale; eg., Blood groups (A,B, O, AB), race, religion, place of residence, hospital where treated etc.

### (c) Polychotomous ordinal scale

Sometimes, the investigator may not give numerical scores to his ordinal variables but treat them on a polychotomous (ordinal) scale. While doing so, he may not record the fever grade in numbers (0, 1, 2, 3) but in words (nil, mild, moderate, severe). The essential difference between a "polychotomous nominal" and a "polychotomous ordinal" scale is that while in the nominal scale there is no "natural" ordering of various categories, on the other hand in a polychotomous ordinal scale, the various categories have a very logical / natural ordering which cannot be overlooked. E.g., blood groups ,A, B, AB and O can be written in any sequence without any disruption in natural ordering, but grade of dyspnoea has to be written in either ascending or else, descending order. The issue is important since the statistical tests are

different for polychotomous nominal and polychotomous ordinal variables. Summary of scale of measurement is given in Table - 2.

Table - 2 : Summary (Scales of Measurement)

**Quantitative (records numbers)**
- (a) Numerical Discrete (counts)
- (b) Numerical continuous (Measures)
- (c) Numerical Ordinal (Grades)

**Qualitative (records qualities in words)**
- (a) Dichotomous (two categories)
- (b) Polychotomous (more than two categories

**Nominal (no natural ordering of categories)**

**Ordinal (natural ordering among categories)**

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## Quantitatively Summarizing the Findings

As said in the previous section, measurements in epidemiology are made in respect of 'variables' like age, sex, presence or absence of a disease (e.g. MI) and so on. For making measurements in respect of each variable, we have to specify certain 'scales' of measurement (i.e. numerical continuous, numerical discrete, ordinal, nominal dichotomous or nominal polychotomous). An organised collection of the 'values' of each and every 'variable', according to the specified scale of measurement is called 'data'. Now, this 'data-set' has a lot of scientific information but does not convey much sense. The epidemiologist should, therefore, reduce these 'values' of the 'variables' to certain 'summary' figures which convey the state of affairs and also enable him to make the desired comparisons. Depending on the type of 'Scale', the summary figures can be of the following types :

(a) For variables which are measured on a numerical-continuous or numerical-discrete scale

we would calculate the arithmetic 'mean' and make interpretations based on a single mean or on 2 or more means (see chapter on Biostatistics).

(b) For variables which are measured on ordinal scale

Here we would work out the 'median' values for making comparisons, as covered in the section on biostatistics.

(c) For variables measured on 'nominal' scale

Most of the times, we are interested in such outcomes which are dichotomous (eg, improved / not improved with a given therapy; survived / died; etc.) In such cases we work out the percentages.

Once we are dealing with dichotomous type of data, the first question that comes to us is whether we should count only the numbers or work out some frequency measure? An epidemiologist must remember that she should not go by the numbers, but proceed with some form of frequency, by relating these numbers to a denominator. See the following hypothetical example.

A study collected the total number of cases of oral cancer which occurred in a defined state in a calender year. Of the 300 such cases, all were asked about the history of tobacco chewing. The results were as shown in Table - 1

The comparison based solely on numbers would give a fallacious impression that oral cancer is two times more

Table - 1

| | Tobacco Chewers | Non Chewers | Total |
|---|---|---|---|
| Cases of Oral CA | 100 | 200 | 300 |
| Total population | 100000 | 2000000 | 2100000 |
| Rate per lakh | 100 | 10 | 14.29 |

common among those who do not use tobacco. However, when we relate the above numbers to a denominator, i.e., the total population in the same state who were tobacco users or non users, we would get the correct picture as shown in adjacent table. The correct picture that emerges is that oral CA is 10 times more common among tobacco users, since the frequency (rate) of oral Ca is 100 per lakh population among users vis-a-vis 10 among non-users.

### Second question

Which denominator to relate with? Now that we have clarified that numbers 'counted' in epidemiology must be related to a denominator for converting them into frequency, the question arises as to which denominator to use. We can have 3 types of frequency measures, depending on the denominator used (9).

**Ratio**

Where the numerator is not a part of denominator e.g. Female : Male ratio in collection of cases of Primary hypothyroidism as 8:1 is a ratio, wherein the numerator (females) are not included in the denominator (males).

**Proportion**

A proportion also has a numerator and a denominator, but in contrast to ratio, the numerator is a part of denominator. Eg, when we say that 80% of the patients of Buerger's disease are smokers, it actually means that the numerator (a) is included in the denominator (b) and hence it is a proportion. In fact, a proportion is recorded on a scale of 0 to 1. If we multiply it by 100, we get a 'percentage'.

**Rate**

The rate is a summary expression in which, in addition to

$$\frac{\text{No. of patients of Buerger's disease who are smokers (a)}}{\text{Total no. of patients of Buerger's disease (b)}} \times 100$$

the numerator being a part of denominator, there is also a relation with time. For example,

The above will be a rate in which a clear relationship to time (of one year) is also implied, i.e., "% per year"; thus,

$$\frac{\text{No. of previously healthy smokers who develop Buerger's disease in one year}}{} \times 100$$

this expression is rate.

The two most commonly used measures in epidemiological / clinical research are Incidence and Prevalence

**Prevalence**

Prevalence (often, though erroneously, called prevalence "rate") is the number of subjects having a given condition of interest out of the total subjects who were examined.

Apparently prevalence is a proportion (because the numerator is also included in the denominator) and not a

$$\text{Prevalence} = \frac{\text{No. of subjects having the condition of interest at a given time}}{\text{Total No. of subjects examined}} \times 100$$

'rate' because there is no time specification.

**Incidence rate**

The incidence rate is the no of subjects who develop a condition of interest out of a group of subjects who were initially free of the condition (but at risk of developing it), over a defined period of time. Thus,

$$\text{Incidence rate} = \frac{\text{No. of subjects who develop the condition over a defined period of time}}{\text{Total no of subjects initially free of the condition, and at risk of developing it, followed up for the required period of time}} \times 100$$

Let us give an example

In an effort to study systemic arterial hypertension at high altitude, we examined 25 young adults who were recently inducted into high altitude. 5 of them were found to be having HTN. We followed the remaining 20 who were initially normotensive for a period of 2 years posting at high altitude and found that over 2 years, 2 developed HTN.

Thus prevalence at initial exam = 5/25 X 100 = 20%

Incidence over a 2 years period =2/20 X 100 = 10% over a 2 year period (or, 5% over 1 year)

Thus, the period of time must be specified for incidence rate. An incidence of 10% over a year will have very different implication as compared to an incidence of 10% over a five year period.

The two types of incidence measures

Often, two different types of incidence measures are quoted in publications. These are

(a) Cumulative incidence (CI)

(b) Incidence Density (ID).

A brief overview is as follows

**Cumulative incidence (CI)**

This is the same as we have explained for Incidence rate above. It is also called the 'Risk Rate', or simply as 'Risk ', since it gives the risk of developing a disease.

**Incidence density (ID)**

Incidence density is thus expressed in terms of person years; it gives the "force of mortality or morbidity" of the disease of interest, reflecting the instantaneous change in the rate of disease at a given point of time. ID is the better measure in chronic diseases or survival studies where each subject is likely to contribute different follow-up periods in the study. However, in most of our routine clinical research works, where our subjects can be assumed to be a fairly "fixed population" who can all be followed up and with little inward or outward movement of the study subjects, CI is a good measure of incidence. (and also, when the time of follow up in not very long).

$$\text{CI} = \frac{\text{Total no. of subjects developing the disease over specified time of follow up}}{\text{Total subjects at the start of follow up who were at risk of developing the disease}} \times 100$$

In many diseases, the length of observation of subjects may be variable, e.g. as in table-2 when we follow up the pt for CA cervix

Table - 2

| Subject No. | Follow up details for CA cervix observed | | | | | | | | Total time |
|---|---|---|---|---|---|---|---|---|---|
| 1. | >---------- | | | | | | | * | 7 years |
| 2. | >---------- | | | | | | | * | 7 years |
| 3. | >---------- | | | | X | | | | 4 years |
| 4. | >---------- | | | | | ? | | | 5 years |
| 5. | >0 | | | | | | | | 0 years |
| 6. | - | | >---------- | | X | | | | 2 years |
| 7. | - | | | >---------- | | | | * | 4 years |
| Years | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 29 years |

>=follow up starts * = follow up ends;

0 = refused participation X = cancer detected;

? = lost to follow up

$$\text{ID} = \frac{\text{Total no. of cases}}{\text{Total person years of follow up}} \times 100$$

Thus, ID = (2 / 29) X 1000 = 70 per 1000 person years (also written as 0.07 per PY or 0.07 PY-1.

For choosing the correct incidence measure (ID or CI), it is suggested that in the usual epidemiologic health / clinical research settings, CI should be used. However, if the issue is to study the specific etiologic / risk factors or treatment modalities of chronic disease with long latency (eg, cancers, CVA etc), especially when different subjects are likely to be followed up for different periods of time (due to different points of entry into the study, migration, death, etc), then in such situation, ID should be preferred.

Table - 3 : Comparison between incidence and prevalence

| Incidence | Prevalence |
|---|---|
| Numerator consists of new cases | Numerator consists of all cases (old & new) |
| Denominator is all subjects who were at risk of developing the disease at start of follow up | Denominator is all subjects who were examined |
| Follow up is essential | No follow-up |
| All subjects examined at least twice once at start of follow up and once more at end point | All subjects examined only once |
| Is truly a "rate" | Is truly not a rate but a "proportion" |
| Gives the "risk" of developing the disease | Gives the probability of being found to be having the disease |
| Is like a "video recording" and tells how the disease occurred time | Is like a "snap shot" of what things are at a given point of time |
| Ideal for studying the natural history, risk factors and treatment | Ideal for making community diagnosis, assessing load of diseases and planning of health services |
| Expensive, time consuming | Less expensive, can be done quickly |

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## Making Comparisons between Two Summary Figures : Measurement of "Risk"

The measures of disease frequency as mean, median, incidence and prevalence, as discussed earlier, certainly do give the epidemiologist certain important answers like "serum cholesterol among patients of stroke is likely to be, on an average, 260 mg/dl", or, "the proportion of tobacco smokers among cases of acute MI is likely to be 60%, or, the incidence of acute glomerulonephritis over a 5 years period, among children who develop streptococcal sore throat is likely to be around 10%". These results give us important information for planning our preventive and curative services by way of knowing the 'load' of disease or risk factors (through prevalence), or for studying the natural history of a disease (through incidence), and for making tentative guess works regarding the role of certain risk factors or preventive/ therapeutic measures in a disease. But, most of the epidemiological questions do not stop here. The epidemiologist has to prove that the "outstanding phenomena" she has observed are really outstanding. So what if 80% of immuno-suppressed adults give history of sexual promiscuity? Even 80% of healthy adults may also give the same history ! If average serum cholesterol of stroke patients is 260 mg/dl, it may be possible that it is the same in patients of Peptic ulcer; then we cannot think in terms of hypercholesterolaemia related etiology in stroke. If 10% of persons suffering from streptococcal sore throat developed glomerulonephritis over a 5 years period, may be an equal percentage of those who never suffered from streptococcal sore throat also develope glomerulonephritis in the same period! Thus, while measures of 'frequency' strongly suggest a "causal hypothesis", they do not prove anything. The epidemiologist has to take another step - of proving that there is an "association", or "difference" , by comparing two groups, as described earlier. We show such effect by way of measures of "effect" or "difference" or "association". These measures are

### When the variables are recorded on a Numerical continuous or discrete scale

**See the following example**

To study the research question that Cancer Cervix (Ca Cx) is related to number of sexual partners, we could take 2 groups of subjects, one with Ca Cx and other of healthy ladies and take a history of total No. of sexual partners. We could work out that the average number of sexual partners among Ca Cx group was 2.1 as compared to 1.1 in the healthy group. We would now do the statistical tests for the differences between 2 means ('t' or 'Z' test) and draw conclusions. (See section on Biostatistics for details).

### When variables are recorded on an ordinal scale

For instance, we may be toying with the question "Is long term therapy of asthma with Salbutamol helpful in reducing dyspnoea as compared to the cheaper Aminophylline derivatives?" For answering this question, we would take 2 groups of comparable asthmatics, one on Salbutamol and the other on Deriphyllin. The "dyspnoea" grade of each subject would be worked out as per the grades of dyspnoea. We would finally work out the median in the two groups and compare them, eg, if median score in Salbutamol group is 1 and Deriphylline group is 2, we would do significance testing with a "non-parametric" test like Mann-Whitney U-test.

### When the variables are recorded on nominal scale

This is the setting which is most important to the epidemiologic researcher and takes the form of a "2 X 2 table". Let us illustrate with an example whether smoking is a risk factor for IHD. Now, we could address this issue by two different approaches

**First type**

We may proceed from the cause (exposure) to the disease (outcome). As an example, we took 5000 healthy adult males in whom IHD was excluded based on history and resting / exercise ECG. Then, on asking them about history of smoking we found that 1500 were smokers and 3500 non smokers. We followed up these 2 groups (1500 smokers and 3500 non-smokers) for 20 years and observed that during this period there were 150 cases of IHD among smokers and 175 cases of IHD among non smokers. This setting is a typical example of a "prospective" or "forward looking study, the details of which we shall discuss later. Our 2 X 2 table in this study would look as shown in above box.

The 2X2 table is so named because it has 2 columns and 2 rows. The two rows divide the subjects according to whether they have the exposure or not while two columns divide the subjects according to whether they developed the outcome or not. Accordingly, we get 4 cells noted at "a,b,c,d". Cell "a" denotes all those who have the exposure and also had outcome. Cell "b" denotes all those who were exposed but did not have the outcome. Cell "c" denotes all who were not exposed but developed outcome. Cell "d" denotes all those who were neither exposed nor had the outcome. One thing we would like to emphasise at this point is that you should, at the very planning stage of your epidemiologic study, clearly decide as to how you would define the exposure and non exposure as well as outcome achieved or not achieved. Secondly, never change the format of notation: cells a, b, c, d should represent what

| Exposure (E) | Outcome (O) | | |
|---|---|---|---|
| | Achieved (O+) | Not achieved (O-) | Total |
| Exposed (E+) | 150 (a) ($E^+O^+$) | 1350 (b) ($E^+O^-$) | 1500 (a+b) (all $E^+$) |
| Not exposed (E-) | 175 (c ) ($E^-O^+$) | 3325 (d) ($E^-O^-$) | 3500 (c+d) (all $E^-$) |
| Total | 325 (a+c) (all $O^+$) | 4675 (b+d) (all $O^-$) | 5000 a+b+c+d (all subjects) |

we have just explained. For instance cell "a" should always represent subjects who have both exposure and outcome; and so on. Your analysis will greatly depend on how accurately you have put the data in the 2X2 table.

Having given the notation, we would then proceed to calculate the "incidences of outcome" in the exposed ($I_E$) and non exposed ($I_{NE}$) as follows

$I_E = a/a+b = 150/(150 + 1350) = 150/1500 = 0.1$, or, 10%;

and $I_{NE} = c/c+d = 175/(175 + 3325) = 0.05$, or, 175/3500 =5%;

and the measure of effect i.e., RR (Relative Risk or Risk Ratio) is obtained by dividing the $I_E$ by $I_{NE}$. ( 30, 31). In our above example, RR = 10 / 5 = 2. We would conclude that the smokers are two times at a higher risk of developing IHD as compared to non-smokers. Against the foregoing discussion, we can now draw the following interpretations

(a) **That if RR is 1**, it means no risk, since the incidence of the outcome is the same among the exposed and non-exposed. This value of '1' for RR is also called as the "Null Value".

(b) **The higher the RR from 1**, the more is the risk. A RR of 8 would indicate a very high risk. RR is therefore a measure of the "strength of association" between the exposure and the outcome. An RR of 1.4 would mean that those having the exposure are at 1.4 times or 40% higher risk of developing the condition as compared to those not having the exposure.

(c ) **If the RR is less than 1**, it means "reversal of risk" or a "protective" effect. For example, the RR of developing IHD may be 0.6 among those who exercise regularly (exposure present) as compared to those who do not (exposure absent). In such settings, we would conclude that the risk of a physically fit person developing IHD is only 60% (or three-fifth or having a 40% reduction) as compared to one who is not physically fit. Apparently, if the RR is protective (i.e. <1) we can move on a narrow scale of '0' to '1', since RR can never be less than 0.

### The Second type of research

In a large number of epidemiological settings, the above example of 'prospective' research may be really difficult. Can we assemble thousands of subjects at the first instance and then, secondly, would it be a feasible proposition to follow up such large number of subjects for years and years - may be for a decade or two. Epidemiologists have devised an excellent, scientific short cut to overcome this dilemma. Instead of following up thousands of smokers and non-smokers for decades, seeing whether they develop IHD or not, why not undertake the easier exercise - walk down to the Cardiology centre, take 100 patients of IHD, another 100 subjects without IHD and compare them regarding smoking histories. The resulting 2 X 2 table would look like Table - 2.

Almost instantly, we would think of analysing the table to work out the RR as discussed above. However, this table is

Table - 2

| Smoking (E) | IHD (Outcome - O) | | |
|---|---|---|---|
| | O+ | O - | Total |
| E + | 80 (a) | 20 (b) | 100 (a + b) |
| E - | 20 (c) | 80 (d) | 100 (c + d) |
| Total | 100 (a + c) | 100 (b + d) | 200 |

much different. It has the following catch points.

(a) We can not calculate the 'incidence' of IHD among smokers and non-smokers because we have not started with smokers/ non-smokers and followed them up, rather, we have picked up cases / non cases which have already occurred and asked them about the history of exposure.

(b) We may try to calculate the 'prevalence' by saying that since there are 100 cases of IHD among 200 subjects, the prevalence would be 100/200, i.,e. 50%. Here again we would be wrong - these 100 cases of IHD would have come from say, 1,00,000 population and hence the prevalence would be 100/100000 i.e. 0.1%.

Thus in such a study (this is in fact the "case-control study" that we shall discuss in detail later on) we can not calculate either incidence or prevalence or RR. Then what is the use of doing such a study? The use is very much there. Epidemiologists have proved that, given certain assumptions have been met with, the odds Ratio (OR) calculated by the equation OR = (a X d) / (b X c), approximates the Relative Risk (32). Thus, in our above example, OR = (80 X 80) / (20 X 20) = 16.

This value of OR = 16 indicates that the risk of IHD due to smoking is likely to be approximately 16. There are 2 assumptions under which the OR is a valid estimator of RR Firstly, the 'controls' (i.e., the non-cases group) should be taken from the same source population that give rise to cases. Secondly, the disease should not be common, i.e., the incidence of the disease should be less than 5% (and, in fact, most of the human diseases are usually below that level , luckily for researchers). The Odds ratio as a measure of effect will have the same characteristics as RR, i.e., if it is 1, it means 'no risk'; if > 1 it indicates an increasing risk and if < 1, it indicates a protective effect. Summary of measures of risk ratio is given in Table - 3.

### Usual statistical measures of association

In addition to calculating the RR (or OR), we would do the 'Chi Square' test for finding whether the association is statistically significant or not (please refer to the section on Biostatistics). However, the epidemiologist must remember that chi square test does not tell us anything about the "magnitude" of the effect and hence can not replace the calculation of RR or OR. For example, the chi square test may give significant or highly significant result but it won't tell us whether the risk due to a particular exposure (eg. Smoking) is 1.1 times or 8 times or 0.6 times (protective). Hence we must calculate RR or OR,

Table - 3 : Summarising the Measures of Risk Ratio

- In Epidemiology, to produce the final proof of cause and effect relation, a comparison between two groups has to be made
- This comparison may be made by following forward a group of subjects with the exposure and another group without the exposure and calculating the incidence in exposed ($I_E$) and incidence in non exposed ($I_{NE}$)
- The division product between $I_E$ and $I_{NE}$ gives the 'RR' (relative risk or risk ratio). The RR is the "strength of association" between the exposure and outcome variable.
- If RR is > 1, it means increasing risk of outcome due to exposure; if < 1, decreasing risk; if = 1 NO risk (null effect)
- Farther the RR from "1", higher the strength of association
- In a retrospective (case-control or even cross-sectional) study, the incidences in exposed and non

besides doing statistical tests like chi-square.

## Measures of "Difference in Risk"

The measures of risk-ratio (RR or OR) as explained earlier are very important since they indicate to us the "strength of association" by telling us in a summary figure, as to "how many times" is the risk for those having the exposure compared to those nor having the exposure. However, that is only one facet. Besides the "ratio of risk", another important consideration is how much difference is there in risk between the exposed and non-exposed groups. Let us take the case of an advertisement which says that the cost of a new car is only two times that of a second hand car while the cost of a new music system is as much as 5 times that of a second hand one. This is apparently equivalent of the "RR". So, do we straightaway buy a new car and prefer buying a second hand music system. Well if I gave you some more data, as shown in the Table - 4, you may change your view-point.

Similarly, in epidemiology, while measures of Risk Ratio (RR and OR) are important, equally relevant are the measures of Risk Difference (RD). The most basic measure of RD is "Attributable Risk" (AR), a concept which was first

Table - 4

| | Car | Music |
|---|---|---|
| System | | |
| New | Rs. 5,00,000/- | Rs. 20,000 |
| Second hand | Rs. 2,50,000/- | Rs. 4,000/- |
| No of times : New / Old | 2 times | 5 times |

of all introduced by Levin. It is defined as the Difference in the incidences between the exposed and non exposed group. Thus, AR = $I_E - I_{NE}$. In our example on IHD, AR = 0.10 - 0.05 = 0.05. This value of 0.05 is a proportion out of 1; if we multiply by 100, we get it as 5%. To make AR more useful, two more measures of RD are derived and used

**(a) Attributable Risk (AR) % or Etiologic Fraction in the Exposed ($EF_E$)**

This is calculated as $(I_E - I_{NE}) \times 100 / I_E$. It can also be calculated as (RR - 1) X 100 / RR.

It tells us the percentage of outcome among the exposed group which is due to the exposure; conversely, if the exposed people give up their exposure habit, it would result in that much % reduction of the outcome in the exposed group.

In our example on IHD

AR% = (0.1 - 0.05) X 100 / 0.1 or else, (2 - 1) X 100 / 2 = 50%.

This means that 50% of the IHD problem among smokers is due to their smoking habit; or else, if smokers were to give up their smoking habit, it would result in a reduction of 50% in IHD among smokers.

In a case control study, since under certain assumptions, OR is a valid estimator of RR, the EFe can be calculated as :

(OR -1) X 100 / OR.

**(b) Population Attributable Risk % (PAR%) or Etiologic Fraction in total population ($EF_{TP}$)**

This is calculated as $(I_{TP} - I_{NE}) \times 100 / I_{TP}$, where $I_{TP}$ is the incidence in total population.

In our example, incidence of IHD in total population was 325 / 5000 = 0.065.

Thus, $EF_{TP}$ = (0.065 - 0.05) X 100 / 0.065 = 23%.

This means that if exposure (i.e., smoking) is removed from the total population, then it will result in a 23% reduction of the outcome (i.e., IHD) in the total population. Summary of measures of risk difference is given in Table - 5.

Table - 5 : Measures of Risk Difference (RD)

- Attributable Risk (AR) = $I_E - I_{NE}$
- AR % or, $EF_E$ = $(I_E - I_{NE}) \times 100 / I_E$ = (RR - 1) X 100 / RR
- PAR% or, $EF_{TP}$ = $(I_{TP} - I_{NE}) \times 100 / I_{TP}$

Where,

| | |
|---|---|
| $I_E$ | = Incidence of out come in exposed group |
| $I_{NE}$ = | = Incidence of outcome in non-exposed group |
| AR% | = Attributable Risk % |
| $EF_E$ | = Etiologic Fraction in Exposed |
| RR | = Relative Risk |
| PAR% | = Population Attributable risk % |
| $EF_{TP}$ | = Etiologic fraction in Total population |
| $I_{TP}$ | = Incidence in total population |

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# Epidemiological Measures (Indicators) of Health and Disease in a Community

In our previous chapter, we discussed about the "summary measures" in epidemiology i.e., incidence rate, prevalence, etc. In real health care practice, these measures are to be expressed in terms of indicators which provide a quick idea of the status of health, disease and health related conditions in the community. These measures (also called as "Indicators") can be grouped as :

(a) **Health Status Indicators** : These include Measures of Mortality and Morbidity

(b) **Indicators of health care** : (Health Infrastructure; Human Resources in health; Health Finance indicators; Indicators of accessibility & utilization).

(c) Indicators of "Quality of Life"

(d) Demographic Indicators :- measures of fertility and population distribution.

(e) Socio-economic development indicators related to health (literacy, income, accessibility to safe water supply and sanitary excreta disposal facilities, etc).

(f) Other Indirect Indicators related to health (as nutritional status, child development, environmental indicators, etc.).

## Measures Of Mortality

Measures of mortality in community health practice could be either Crude or else Specific indicators :-

### Crude Mortality Rate :

The Crude Mortality Rate, also known as Crude Death Rate (CDR), gives the deaths in a defined community in a year per 1000 population in the middle of year (i.e, on 1st July) .

$$CDR = \frac{\text{Total deaths in a defined Community / defined area in a year}}{\text{Mid-Year Population (01 July) of that community / defined area}} \times 1000$$

The CDR is useful for making "quick" comparisons regarding death rates between two population groups and for making a quick estimate of load of mortality in a given population. However comparison of CDRs between two populations may differ from each other because of confounding factors (eg, the observed differences in the CDRs of 2 populations may be because of the different age-structure of the 2 populations). Therefore, "adjustments" for such factors are made by the procedure of "standardization", to calculate "Standardized Mortality rates", by statistical methods of Direct or by Indirect Standardization. Secondly, the CDR does not tell us as to which particular "subgroups" are most affected or what are the important causes of mortality (eg, it does not tell us whether deaths are more due to TB or accidents). For this reason, "specific rates" are computed.

### Specific Morality Rates

Specific mortality rates provide more meaningful information as compared to CDR, by identifying the "risk of death" in different subgroups or risk of death due to specific diseases (35). The commonly used are

(a) Age Specific Mortality Rates (ASMR)

This is calculated as the No. of deaths in a particular age group in a defined area over a defined time period per 1000 "mid-point" population of that particular age group in that defined area

(b) Sex Specific Mortality rate

This is calculated as the No. of deaths occurring in a particular sex group in a defined area and defined period of time (usually 1 year) per 1000 Mid-point population (usually mid year population) of that particular sex in that area.

(c) Cause specific Mortality rate (CSMR) :-

The CSMR is calculated as No. of deaths occurring in a defined area due to a particular disease, in a defined period of time (usually 1 year) for every 1000 Mid point (usually mid year) population in the defined area.

(d) Cross combination of Age, Sex, cause etc.

Depending on the requirements, further combinations of age, sex, cause, occupation and so on (as relevant) may be made to further enquire and identify special risk groups. For example, we can make the cause specific (Lung CA) death rate in a specific age group (40 to 60 years) and in a specific sex (males) working in a specific occupation (Asbestos industry).

(e) Case Fatality Rate (CFR) :

The CFR is calculated as No. of persons, dying due to a particular disease, during a defined time period, in a defined area per 1000 persons in that area, having that particular disease . The CFR dose not give the risk of dying due to the given disease which a person in the defined community has or the importance of the disease as a leading cause of mortality in the community at large (that is given by cause specific mortality rate); it rather gives the "killing power" of the disease; eg, the CFR for Rabies is very high (100%); for acute MI and Japanese encephalits it is quite high (30-40%) while it is very low for common cold (almost 0%).

(f) Proportionate Mortality ratio (PMR)

This gives the proportion of total deaths that are due to a given cause, out of the total deaths. It is calculated as Total deaths due to the particular disease in a defined area over the given time divided by the total deaths (due to all causes) in that area during that time & multiplying the result by 100 to get it as a %.

While interpreting the various types of measures of mortality, the epidemiologist should be careful about certain "biases" that may occur. Such biases can occur in two ways :-

(a) Errors in the numerator

This can occur because of inaccurate or incomplete reporting of the various causes of death in large population groups; eg, in a developing country, road accident deaths may be diagnosed, recorded and reported more accurately as compared to deaths due to various neoplasms.

(b) Errors in the denominator

This may occur because of inadequate or incorrect enumeration of either the "population" or the deaths, depending on which one of the two is in the denominator.

**Special Mortality Indices Used In Maternal And Child Health Care**

(a) Infant Mortality Rate (IMR)

This is calculated as the No. of deaths among children less then 1 year age in a year for every 1000 live births in the same year in the same area. The IMR is one of the most sensitive indicators of the health and socioeconomic conditions of a community, since it is affected by diseases that directly cause infant deaths (Acute Respiratory Infections, Diarrhoeal diseases etc), by the availability and utilization of health care services & by various social factors like income, family size, customs, beliefs etc.

(b) Maternal Mortality Rate (MMR)

It is calculated as the No. of deaths due to "maternal causes" in a given community, in a year per 1000 live births in the same Year in the same area. (Maternal death is defined as death occurring to woman, while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of pregnancy, from any cause related to or aggravated by pregnancy, but not from accidental or incidental causes). Similarly, the MMR is another very sensitive indicator of the health status of women in the reproductive age group, as well as of the obstetric services. The MMR is another very sensitive indicator of the health status of women in the reproductive age group, as well as of the obstetric services.

(c) Neonatal Mortality Rate (NMR)

This is calculated as the deaths in a year, in defined area, among children < 28 days age per 1000 live births in the same year in the same area. (Note that in IMR, MMR, and NMR, the denominator is the 'total live births' and not the mid point population of that particular group).

(d) Perinatal Mortality rate (PMR)

This is defined as the No. of foetal deaths of > 28 weeks gestation plus infant deaths of < 7 days age in a defined area in one year per 1000 "live births plus foetal deaths" of > 28 weeks gestation (i.e, total live and still births) in the same area and in the same year.

The point to be noted is that as overall socioeconomic conditions and health care systems improve, the IMR may decrease quite fast but the NMR, especially PMR may not decline so fast. This is because most of the causes of "Post-Neonatal Mortality" (i.e., deaths between 1 month to 12 months age) are amenable to good health care in the from of immunization of children, early diagnosis and treatment of acute respiratory infections / diarrhoeal diseases and nutritional care. However, the causes of NMR, and especially PMR) are less amenable to improvement in health care delivery, being often related to causes like congential malformations.

It also stands to reasoning that, since MMR, IMR and other indicators are all closely related, if the health care is improving, all of them should show decline. A decline in one without a proportionate decline in the others should initiate a search for a possible "disproportionate" development of health services. For example, a decline in MMR, without a corresponding decline in IMR may be because of much improvement in obstetric care to the community without simultaneous improvement in childhood immunization or early treatment of acute infections among infants.

## Measures of Morbidity

While mortality indicators are, by and large, "incidence measures", morbidity measures can be either in the form of incidence or prevalence and are calculated as counterparts of "mortality measures', as Crude morbidity rate, Age or cause specific Morbidity, etc. For example, the

Table - 1

| | |
|---|---|
| **Incidence** = | $\frac{\text{Total new cases of HIV occurring in a year in a community, out of those initially sero-negative}}{\text{Total persons who were 'at risk' of developing HIV at the start of follow up}} \times 1000$ |
| **Prevalence** = | $\frac{\text{Total persons in a community found to be having HIV positivity at the time of the survey}}{\text{Total persons in the community}}$ |

"annual incidence", or else the "prevalence" of HIV infection in a community will be worked out as shown in Table 1

## Measures of Fertility

Epidemiologic measures of fertility are extensively used in fields of demography, family planning and health administration. The selected indices are :-

**Crude birth Rate**

It is calculated as Number of live births in an area during one year per 1000 Mid year population. The CBR has the advantage of ease of compilation. However, the denominator in CBR is total population; on the other hand, the real contribution to the births in a population groups comes from the females in the reproductive age group (15 to 44 years age). This deficit of CBR is overcome in General Fertility Rate (GFR).

**General Fertility Rate (GFR)**

It is defined as Number of live births in a given area during a year per 1000 Mid year population of females in the reproductive age groups (15 to 44 years) in that area, during that year

While GFR is definitely an improvement over CBR, comparisons between two populations based on GFR may

not be accurate because the populations structure of ladies within the category of 15 to 45 years age may be quite different between the two population. Secondly, the GFR does not allow for indentifying the "high risk" age group of females, as far as conception is concerned, so that family planning activities can be directed towards such high risk groups. This difficulty is overcome by computing the Age Specific fertility rates (ASFR).

**Age Specific fertility rates (ASFR)**

It helps in identifying the age groups of women having the highest reproductive potential, so that family planning measures can be directed towards such groups. It is calculated as Number of live births to women in a specified age group (eg, 20 to 25 years age group) in a given area and in a given year per 1000 mid year population of females in the same age group (e.g., 20 to 25 years) in that area during that year.

**Total Fertility rate (TFR)**

This gives the estimated number of children which a group of 1000 women would bear, if they were to start their reproductive life at a common point of life, and were to pass through their entire reproductive span, subject to the current age-specific fertility rates. This measure is calculated by summing up the ASFRs for the different age groups and multiplying such sum by the class interval on which the age groups have been formed; eg, if we have made the age groups as 15-19, 20-24 years and so on (thus the class interval being 5 years), the ASFRs would be summed up and multiplied by 5 to get the TFR. The TFR is quite an accurate epidemiological measure of fertility and provides valid answer to the issue "How many children would a woman have, on an average?" (or, in case the ASFR have been calculated as per 1000, it will tell us how many children 1000 women are likely to have).

**Gross Reproductive Rate (GFR)**

is a measure of the average number of female live births that would occur to a female new born, growing up and passing her entire reproductive age, if the current fertility rate were to apply. The GFR assumes that these women will not die before completing their childbearing age, which is more of a hypothetical assumption, and this drawback is overcome through compilation of Net Reproductive rate (NRR). The GRR is thus equivalent to TFR for female children only.

**Net Reproductive Rate (NRR)**

The NRR is as measure of the average number of female live births that will occur to a newborn female as she grows up and passes through her entire reproductive age group, provided she was subjected to the current rates of fertility as well as mortality. Thus, the NRR is similar to GRR, but, in addition, also caters to the fact that some women will die before completing the child bearing age, while making the calculations. The NRR is a sensitive indicator of population growth. If the NRR is 1,00, it indicates that each generation of mother is being replaced by an exactly equal number of daughters; in other words, the female population is "maintaining itself". A large number of developing countries have kept a target of achieving a NRR equal to 1,00, as a part of their family planning programmes.

**Population growth rate**

This is also known as the natural rate of population increase. It is calculated as the difference between CBR and CDR.

**Dependancy ratio**

The dependency ratio is calculated as the ratio between Population < 20 years age + population > 65 years to the population in the age groups 20 to 64 years.

## Indicators Related To "Health Services"

These are indicators which either measure the "availability" (as, Doctor Population ratio, Population served by each Health centre, Population hospital bed ratio); or, "expenditure on health care" (as, percentage of national budget earmarked for health sector, Average finances spent per person on health care); or, "health coverage" (e.g., percentage of children fully immunized, deliveries conducted by trained birth attendants, % of cases of pulmonary TB brought under ATT, etc.); or "accessibility" (e.g., Mean distance in Kms required to be traveled in a village to reach the health centre); or, "utilization" (e.g., % of women who availed of cervical cancer screening camp out of those who were eligible); or, finally, the "policy" (e.g., availability of a stated health policy and enunciated targets).

## Indicators Related To "Quality of Life"

Some of the important indicators are

**Years of potential life lost (YPLL)**

This may be defined as the years of potential life lost due to premature death. In contrast to other mortality measures, YPLL emphasizes the processes underlying premature mortality in a population. By this method, deaths occurring at younger ages accrue more years of life lost than deaths occurring at later ages. Years of potential life lost resulting from few deaths at young ages may exceed the years of potential life lost resulting from many deaths at older ages. YPLL is often calculated using age 65 as the cutoff , with grouped age of death, and is calculated as follows, where 65 is the upper age limit established, i is the midpoint of the grouped year of age at death (e.g. 59.5 for age group 55-64) and di is the number of deaths at age "i"

$$YPLL = \sum_{i=0}^{65} [(65\ i)]d\ i$$

**Disability Adjusted Life Year (DALYs)**

This is a health gap measure that extends the concept of "Potential Years of Life Lost" (PYLL) due to premature death, to also include equivalent "Years of Life Lost due to Disability" (YLD) by virtue of being in states of poor health. The DALY combines in one measure the time lived with disability and the time lost due to premature mortality. One DALY can be thought of as one lost year of 'healthy' life and the burden of disease as a measurement of the gap between current health status and an ideal situation where everyone lives into old age free of disease and disability.

$$DALY = YLL + YLD$$

**The formula for YLL for a given cause is** : YLL = N X L, where, N = number of deaths and L = standard life expectancy at

age of death in years.

**The formula for YLD is** : YLD = I X DW X L, where, I = number of incident cases; DW = disability weight, and, L = average duration of the case until remission or death (years).

The "Disability Weights" (DW) have been discussed in the WHO report on Global Burden of Diseases 2000. Additionally, 3% time discounting and non-uniform age weights which give less weight to years lived at young and older ages are used in calculating DALYs. With above mentioned non-uniform age weights and 3% discounting, a death in infancy corresponds to 33 DALYs, and deaths at ages 5 to 20 to around 36 DALYs. Thus a disease burden of 3,300 DALYs in a population would be the equivalent of 100 infant deaths or to approximately 5,500 persons aged 50 years living one year with blindness.

YLL = N X L, where, N = number of deaths and L = standard life expectancy at age of death in years. The formula for YLD is : YLD = I X DW X L, where, I = number of incident cases; DW = disability weight, and, L = average duration of the case until remission or death (years). The "Disability Weights" (DW) have been discussed in the WHO report on Global Burden of Diseases 2000. Additionally, 3% time discounting and non-uniform age weights which give less weight to years lived at young and older ages are used in calculating DALYs. With above mentioned non-uniform age weights and 3% discounting, a death in infancy corresponds to 33 DALYs, and deaths at ages 5 to 20 to around 36 DALYs. Thus a disease burden of 3,300 DALYs in a population would be the equivalent of 100 infant deaths or to approximately 5,500 persons aged 50 years living one year with blindness.

### Sullivan's Indicator

Sullivan's indicator is a health state measure of a collection of persons which is independent of its age structure. It offers a possibility to compare health states of the entire population between two dates in spite of a modification of its age composition (provided that the

Table - 2

| Indicator | Current (Figures) | Goals |
|---|---|---|
| Crude Birth Rate (CBR) | 24.1(SRS, 2004) | 21 (NPP- 2010) |
| Crude Death Rate (CDR) | 7.5 (SRS, 2004) | 9 (NPP- 2010) |
| Total Fertility Rate (TFR) | 2.7 (NFHS-3, 2006) | 2.1 (NPP- 2010) |
| Net Reproductive Rate (NRR) | 1.5 (1990) | 1 (NPP- 2010) |
| Couple Protection Rate (CPR) | 56.3 (NFHS-3, 2006) | 60 (NPP- 2010) |
| Infant Mortality Rate (IMR) | 57 (NFHS-3, 2006) | <30 (NPP- 2010) |
| Under five Mortality | 74 (Unicef, 2005) | 41 MDG (2015) |
| Neonatal Mortality Rate | 43 (WHO Report, 2005) | ---- |
| Maternal Mortality Ratio (MMR) | 3.01 (SRS, 2003) | <1 (NPP- 2010) |
| Institutional Deliveries | 40.7% (NFHS-3, 2006) | 80% (NPP- 2010) |
| Delivery by Trained personnel | 48.3% (NFHS-3, 2006) | 100% (NPP- 2010) |
| Tuberculosis Mortality (per lakh) | 30 (WHO Report, 2006) | ---- |
| Children 12-23 months fully immunized | 43.5 (NFHS-3, 2006) | 100% (NPP- 2010) |
| Children 12-23 months who have received BCG (%) | 78.2 (NFHS-3, 2006) | 100% (NPP- 2010) |
| Children 12-23 months who have received 3 doses of polio vaccine (%) | 78.2 (NFHS-3, 2006) | 100% (NPP- 2010) |
| Children 12-23 months who have received 3 doses of DPT vaccine (%) | 55.3 (NFHS-3, 2006) | 100% (NPP- 2010) |
| Children 12-23 months who have received measles vaccine (%) | 58.8 (NFHS-3, 2006) | 100% (NPP- 2010) |
| | | |

(NFHS : National Family Health Survey; NHP : National Health Policy; NPP : National Population Project; SRS : Sample Registration Scheme; MDG : Millennium Development Goals)

Table - 3 : Calculation of Important Health Indicators

## Mortality

**CDR**

Total deaths in a community in a year X 1000
Mid year population (1st July) of that community

**ASMR**

Total deaths in a given age Gp. in a year X 1000
Mid year population (1st July) of that Age Gp.

**CSMR**

Total deaths due to a disease. in a year X 1000
Mid year population (1st July)

**CFR**

Total deaths due to a particular disease X 100
Total cases of that disease

**PMR**

Total deaths due to a particular disease X 100
Total deaths in that community during same time

**IMR**

Deaths among infants (age < 1 yr) in a year X 1000
Total live births in that year in same community

**MMR**

Deaths due to maternal causes in a year X 1000
Total live births in that year in same community

**PMR**

Foetal deaths after 28 weeks pregnancy plus Perinatal deaths of children upto 7 days age, in a year X 1000
Total live births plus still births in that year in same community

**NMR**

Deaths of children upto 28 days age, in a year X 1000
Total live births in that year in same community

## Morbidity

**Disease Incidence rate**

Total new cases of a disease occurring in a given period of follow up among those who were initially at risk X 1000
Total persons who were at risk at start of follow up

**Prevalence**

Total persons found to be having the disease X 1000

## Fertility

**CBR**

Total live births in a year in a community
Mid year population of that community

**GFR**

Total live births in a year in a community
Mid year population of females in age group 15 to 45 years in that community

**ASFR**

Total live births in a particular age group of Females (e.g., 20 24 yrs) in a year
Mid year population of females in that particular age group (e.g., 20 24 yrs)

**TFR**

$\Sigma$ (ASFRs) X class interval used for age groups

## Quality of life

**YPLL** = $\sum_{i=0}^{65}$[(65 i)]d i

**DALY** = YLL + YLD

WHERE, YLL = N X L, and YLD = I X DW X L

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## Sources of Data in Epidemiology

As we said earlier, "data" means an organised collection of individual measurements for each and every subject, in respect of each and every variable of interest. Once this data has been collected, collated and "summarised" it is called "Information". Thus, information is a "factual presentation i.e, a "Summary of facts" from the data and as they exist without any added element of interpretation of facts. Now, once this information is viewed and evaluated against the backdrop of a given "socio-demographic" setting by experts in their respective fields, it becomes transformed into what is called as "Intelligence". Obtaining data, in epidemiologic practice, may take either of the two modalities. Firstly, the investigator may decide the epidemiologic or research question, select an adequately large and representative sample, and collect the data by making measurements on each subject, herself. This situation, when the data is collected by the investigator primarily for the purpose of the epidemiologic study is called "primary data" . However, often the epidemiologist cannot be so idealistic but rather has to be more realistic, in that he may have to depend on various "other" sources of information. Such situation, when the epidemiologist utilizes the data which has been collected for some other purpose is called "secondary data" analysis. In the present chapter, we would have an overview of the various common sources of obtaining such secondary data for community health care. Such sources of information can be the following (36) :-

(a) Census
(b) Vital Statistics:-
  (i) Death certificates.
  (ii) Birth certificates.
  (iii) Registration of other vital events
(c) Health Surveys.
(d) Disease notifications
(e) Disease registries.
(f) Information for special population groups
(g) Records of hospitals and other health care facilities.
(h) Disease surveillance data.
(j) Other sources of information.

### Census

Census means "to enumerate". It consists of a sequence of activities concerned with collection, collation and factual presentation of data pertaining to social, demographic and health related factors, in respect of a nation (or, large population group), undertaken periodically, and having some sort of statutory back-up for it to be undertaken. A census, in essence, gives the information, regarding the size and composition of a population, the forces that determine such size and composition, and the trends anticipated in future. The periodicity of census kept as once in ten years, and it is generally undertaken during the first quarter of the first year of the decade. The amount of data collected may vary, from as little as population size and age / sex structure on one end to a large number of social, economic, demographic and health related variables on the other end; however, a fairly developed census mechanism would usually provide information regarding total population, density according to per square kilometers of land area, decadal growth rate, literacy rate, economic conditions, occupational characteristics, and selected indicators of mortality like overall death rate and infant mortality rate. A legal authority constituted by the Federal/ Provincial government is generally made responsible for the collection, collection, collation and publication of census data. There are two general methods of collection of data in a census :-

**de-facto method**

persons are enumerated according to their location at the time of enumeration. This method is used in developing countries like India.

**de-jure method**

This method is used in developed countries like U.S.A. The persons are assigned according to their "usual" place of residence and not according to their location at the time of census, as practiced in de-facto method. This method provides a better indication of permanent population and related socio-demographic factors of an area, though it is more expensive and needs much better level of training of census-data collectors.

In India, Census 2001 was carried out in two phases-the house numbering and the house listing operations followed by population enumeration. The house listing operation was conducted in different States and Union territories during April to September 2000. In addition to collecting data on characteristics of the house, information on availability on certain amenities and assets were also collected during this phase. The population enumeration was undertaken between 9$^{th}$ and 28$^{th}$ Feb 2001 with a revisional round from 1$^{st}$ to 5$^{th}$ March. The "census moment", i.e., the referral time at which the snapshot of the population is taken was 00.00 hours of 1$^{st}$ March, 2001. For the first time during census 2001, permanent location code numbers were assigned to ensure comparability of the data at the village and other administrative levels. Special features of Census 2001 included additional collection of data on drinking water (within premises/outside premises), source of lighting, availability of toilet facility within the house & type, number of married couples living in the household having independent room for sleeping, disposal of waste water, availability of separate bathroom & kitchen, etc. For the first time during this census, the signature/thumb impression of the respondent was taken. The salient findings were as shown in Table 1

Table - 1

| | |
|---|---|
| **Population** | |
| Total population | 1,027 million |
| Total increase in population | 180.6 million |
| Annual growth rate | 2.1% (2.5% for last 30-40 yrs) |
| Children in the age group 0-6 | 15.42 %( 17.94 % in 1991) |
| **Population Density** | 324 persons per sq km (267 in 1991) Highest density : 9,294 persons per sq km (Delhi ) |
| **Sex ratio** | 933 females per 1000 males (927 in 1991) |
| **Literacy** | |
| Overall Literacy | 65.4 % (52.2 %in 1991) |
| Male literacy rate | 75.8 % (64.1 %in 1991) |

## Vital Statistics

Vital statistics means the ongoing recording of all vital events' such as births, deaths, marriages etc. Registration of Births and Deaths is a legal requirement in our country.

**Death certificate :**

It is one of the most important source of information about the distribution of a number of diseases. The death certificate as recommended by the W.H.O is depicted in

PART I
**Disease Or Condition Leading To Death**
(a) Pulmonary Embolism Due to or as consequence of
(b) Pelvic Vein Thrombosis Due to or as consequences of
(c) Septic Abortion
PART II
**Other significant conditions contributing to death but not**

the following example :-

Part I requires the cause of death to be filled up. Cause of death is defined as “morbid condition or disease process leading directly or indirectly to death". It dose not mean the mode of dying as “heart failure” “asphyxia” “Hepato renal failure” “circulatory collapse” etc. In part-I, there are usually three lines. Here, the particular cause which started the final chain of events should be entered in the bottom most line, and this is taken to be the cause of death; on the other hand, the condition in the chain of events which finally directly led to death is shown in the top most line. In the example given above, the patient had septic abortion which is entered in the bottom most line of part-I and will be taken as the cause of death during compilations. This led to pelvic vein thrombosis which finally led to pulmonary embolism directly leading to death (note that cardiorespiratory failure is not entered as the final cause since it is the “mode of dying”). In this part II, NIDDM is entered as a significant condition contributing to death but not related to the disease causing it (i.e, septic abortion). In addition to entering the cause of death correctly, the international classification of Diseases (ICD) number of the particular cause should be entered . The problem with death certificates, regarding cause of death, is the inaccurate/incomplete filling of certificates as also inadequate reporting to the relevant statistical authority. This aspect must be especially considered if comparisons regarding cause of death are being made between two countries or areas.

**Birth certificates**

Birth certificates are useful for epidemiologic research as well as health services management; they provide a denominator data for calculating various rates. Ideally, a birth certificate should contain information about date, place of birth, details of parents, domiciliary / institutional birth, sex of newborn birth attendant's details, type of delivery and complications if any, age of mother and birth order of the child.

**Other vital events**

Other vital events include registration of marriages and divorces; reporting of still births; and reporting of foetal deaths.

## Health Surveys

Health surveys are an important source of reliable health information. Such surveys may be directed towards a particular disease (eg sample survey for TB); or, general health surveys directed towards specific population groups like a cluster of villages/ a tribal area/school children; or surveys concerned with planning and evaluation of health services in the form of survey committees appointed by the Government or private agencies to evaluate health programmes or assess general health situations and needs; or, surveys directed towards determinants of health, like dietary surveys or air/water pollution surveys. Surveys provide valuable information for planning/evaluation of health services / programmes; for identifying needs; for providing information about available health manpower and other resources; for suggesting “hypothesis” regarding individual or community risk factors; and for providing statistics for public health / educational programmes. A paradigm situation can be quoted regarding the “National Health survey” of USA.

In India, the National Family Health Survey (NFHS) is an important step for generating epidemiologic information. The NFHS-3 has provided information on population, health & nutrition in India and each of its 29 states. The main objectives are to collect data at the national and state level on demographic rates pertaining to fertility, IMR, PMR, reproductive health pattern; to measure prevalence of contraceptive practice; to collect and analyze data on HIV/ AIDS related behavior and health of slum populations. The survey is based on a sample of households which is representative at the national and

state levels. Total of 10.9 million households including 19.8 million men and women were interviewed using the method of multistage sampling, the sample being selected in two stages. Three types of questionnaire were administered in NFHS: - the village questionnaire to collect information about basic health care and education facility; the household questionnaire to collect general data about household and women's questionnaire for eligible women from household sample. The findings of HFHS 3 revealed that knowledge of HIV/ AIDS among men and women was found to be 80% and 57% respectively. In general, knowledge was found to be much better in urban setup rather than rural areas. Some findings regarding key indicators were as given in Table 2.

Table - 2

| INDICATORS | FIGURES |
|---|---|
| Total Fertility Rate | 2.7 |
| Institutional Deliveries (%) last 3 yrs | 41 |
| Contraceptive Use (%) (Currently married woman (15-49 yrs) | 56 |
| Children Immunization & Vitamin A supplementation (12-23 months fully immunized children) | 43.5 |
| Children under 3 yr who are underweight (%) | 45.9 |

## Disease Notification And Registration

At the international level, cholera, plague and yellow fever are notifiable to the WHO under International Health Regulations. In addition, Malaria, Rabies, Salmonellosis, Influenza, Polio, Epidemic (louse borne) Typhus and Relapsing Fever are subject to international surveillance. Similarly, under the national Integrated disease surveillance programme (IDSP), a number of diseases have been made notifiable. Similarly, the Indian Armed forces have a very well established programme of diseases (groups 'A', 'B', and 'C') which are notified as per format of AFMS Form 73. The general problems with notifications and registrations of diseases is the inadequacy in respect of complete coverage and the delay in initiating the notification report. However, it may be mentioned that even though under-reporting is common, still one can always monitor the trends and take action to prevent/control impending epidemics, using such information.

## Disease Registries

A disease registry keeps a record of salient features of the cases suffering form a particular disease in a defined population or geographical area. It also helps in monitoring trends of a disease . Population based as well as hospital based cancer registries have been established quite methodically in many countries over the world, including India (37).

## Information form Special Populations

Some groups have well maintained and extensive health data (eg, uniformed services, factories, mines, occupational groups, Insurance policy holders, persons covered by various health insurance programmes etc). However, one must remember that these groups have special characteristics and it may be difficult to apply the findings regarding health status and it's determinants on the general population.

## Records of Hospitals and Health Services

In developing countries with inadequate notifications of morbidity and mortality, hospital records are important tool for the epidemiologist as well as the health administrator. In addition to hospitals, records form other health services (national health programme offices, Community/Primary Health centers ) also provide valuable data. An advantage of these records is that the diagnosis is likely to be quite accurate. The disadvantage is that they tend to produce a 'biased' view of the disease picture since there may be many factors as to why patients come to a particular hospital for treatment ( eg, the patients may be having complications; or the hospital may be close by to their residence; or, may be they have the capacity to pay for the services). Secondly, hospital statistics tends to represent only a very small picture (generally the severe forms of the disease) of the actual disease in the community and hence it may be difficult to work out the 'rates' of disease occurrence from hospital or such records-based-data. The advantages and disadvantages of hospital based data have been reviewed in detail by Masi (38).

## Epidemiological Surveillance Data

Ongoing surveillance systems are generally built up in the various national health programmes. Such data can be used for calculating the incidence of the particular disease by relating it to population size being served by the surveillance system. Similarly, 'sentinel surveillance' data from selected hospitals can be utilised for various epidemiological purposes.

## Other Sources of Information

Depending on the information needs, the epidemiologist may need data from the meteorological / environmental

**Box - 1 : Important sources of epidemiological data in indian armed forces**

- Annual Health report of the Armed Forces issued by the DGAFMS
- Annual Health reports of Army, Navy & Air Force issued by respective DGsMS
- Notification of notifiable diseases (groups 'A', 'B' & 'C') raised by admitting hospitals on AFMSF 73
- AFMSF 40 & 42 showing monthly details of admissions & discharges, with diagnosis, raised by individual hospitals
- Monthly reports on HIV / AIDS & HAPO issued by Armed Forces Central Epidemiological Surveillance Centre (AFCESC) and AIDS Control Organisation (ACO) functioning at Dept of Community Medicine, AFMC, Pune.

Box - 1 (Contd.)

- Notifications of HIV infection (ACO Forms 1 & 2) and HAPO (HAPO Forms 1 to 4) raised by individual hospitals and sent to AFCESC / ACO
- Monthly Health Report initiated by Station Health Organizations (SHOs) and Preventive Medicine Staff Officers of various formation HQs
- Daily Hospital Admission & Discharge Registers of military hospitals
- Laboratory investigations registers of military hospitals.
- Strength returns forwarded by individual military units to the SHOs and feeding returns forwarded to Army Supply Corps (ASC) units (for denominator data)
- Reports of epidemic investigations forwarded by individual SHOs to AFCESC
- Reports of various health surveys undertaken by Preventive Medicine and Clinical Specialists
- Documents maintained by Regimental medical Offrs (RMOs) : barrack treatment register, sanitary diaries and register of low medical category persons
- Individual Health Record Cards maintained for All ranks both by the military units and individuals

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# The Epidemiologic Method (Designs) : (a) Descriptive Studies

The various aspects covered till now deal with the basic, fundamental principles, a knowledge of which is essential for any type of Epidemiologic practice. However, once the correct epidemiological question has been asked and due consideration has been given to the various basic principles dealt with earlier, the worker has to select out the particular type of epidemiological "design", most suitable for the question ((39). As described earlier, any epidemiologist would be, very broadly, undertaking one of the following 2 types of exercises :-

- We may be simply 'describing' a phenomena of interest, expressing it in terms of a measure of health or disease (as mean, median or incidence or prevalence). In such instances, we do not have a 'preformed hypothesis' regarding cause and effect relationship (ie., this particular 'exposure' leads to that possible 'outcome'). It is only after a 'descriptive study' has been completed that the researcher, based on the results of the study, develops one or more hypothesis regarding causal association. Such studies are called the "Descriptive Studies".
- The second general situation is that investigator may be proceeding with a "preformed hypothesis" regarding a cause-effect relationship (ie., this 'particular exposure' leads to that particular 'outcome'). In other words, the investigator proceeds to invstigate his hypothesis of cause-effect relationship between a possible exposure and postulated outcome. These studies are called 'Analytical Studies".

## Descriptive Studies

As stated earlier, on a number of occasions the epidemiologist does not have any preformed hypothesis regarding a cause - effect relationship. His object is, rather, to describe certain clinical or health related phenomena and, at the end of study, to develop some sort of hypothesis regarding a possible cause-effect relationship, which can be further subjected to evaluation by analytical studies. In medical research, the various settings in which the investigator may undertake descriptive studies are :-

- Describing certain health related variables and their "distribution" (eg, mean serum cholesterol among patients of IHD or among healthy people, and the distribution of serum cholesterol according to age, sex, time of day etc).
- Describing the "Natural history of disease" (eg, progress of untreated HIV +ve/AIDS patients) or "Natural history of health related phenomena" (eg, growth and development among children).
- To describe the load of a disease (eg, prevalence of TB in community) or a health related factor (eg, prevalence of smokers) or to describe the available health services, usually with a view to plan the health services.
- To describe the occurrence of a disease (eg, 'incidence' of poliomyelitis among children) or a health related phenomena (incidence of death among patients who suffer from CACx).
- To describe the occurrence of an interesting clinical or health related "episode(s)" (e.g. description of a case of a given disease, presenting with atypical symptoms).

A descriptive study gives a strong suggestion that a causal association may be present but doesn't prove it. Eg, the incidence of acute glomerutonephritis among children developing sore throat may be described as 10%. This gives a strong indication that sore throat may be causally related to glomerulonephritis; however for proving such an association, one has to do an analytic study by comparing the incidence of acute glomerulonephritis in two groups - a group which had suffered from sore throat and another that did not. Thus, a descriptive study does generate hypotheses; however to prove them, analytical studies are required.

As is evident from the nomenclature, a descriptive study "describes" our findings of the epidemiologic study. Such descriptions are given according to three types of epidemiological variables, namely, distribution of the disease according to time (when does the disease occur), place (where all) and persons (who all are affected). It is desirable to compile and analyse the data as per these three variables for certain reasons. Firstly, we become intimately familiar with the data and the extent of public health problem due to the disease. Secondly, it provides a detailed description of the health of a population which can be easily communicated Thirdly, such analysis identifies the subgroups that are at high risk of getting the disease and these clues can be used to plan the health services as well as converted into testable hypotheses.

### Time

Disease rates change over time. By knowing that malaria will increase during monsoons, health administrators can time their insecticidal spray rounds. Some other diseases make unpredictable changes over time. By examining events that precede an increase or decrease in disease rates, we may also identify possible causes and appropriate actions to control further occurrence of a disease.

We usually show time data as a graph. We put the numbers (or, preferably, "rate") of the disease along the vertical ('Y') axis and the time periods along the horizontal ('X') axis. Such a graph provides a simple visual depiction of the relative size of a problem, its past trend and future course, as well as how other events may have affected the problem. Depending on what event we are describing, we may be interested in periods of decades, or annual or monthly or weekly or daily periods along the 'X' axis. In general, for infectious diseases, the unit of time along the 'X' axis should be a quarter of the median incubation period of the disease. Thus, for clostridium perfringens food poisoning it could be 3-hourly period, for cholera, daily, for hepatitis A , weekly and monthly for hepatitis B. Depending on the length of period used along the 'X' axis,

we can have secular type of graphs, cyclical and seasonal graphs or short term variations, as follows :-

Secular Trends

Plotting the annual cases or rate of a disease by bi-annual, 5-yearly or decadal period for one or many decades shows long term changes or "secular trends" in the occurrence of a disease. These can be used to

(a) Predict the future course of the disease.

(b) Evaluate programs or policy decisions ( as a slight decline in incidence of IHD in USA, after 1980, seen in decadal secular trends from 1940 to 1990, could be related to extensive anti smoking campaigns during 1960s and 70s)

(c) Hypothesize as to what could have caused the changes in incidence (as a decline in tuberculosis in developed countries during initial period of 20th century, even though vaccine or chemotherapy was not still available, led to the hypothesis that improved housing and economic status could be preventive.

Seasonal pattern are studied by plotting the disease incidence according to 3-monthly (preferably monthly) periods for at least 2 to 3 years. Increase in incidence during particular seasons (malaria during monsoons, measles and scabies during winters, etc.) could also help us in generating possible hypotheses about the factors that facilitate the transmission of these diseases, besides planning the preventive measures well in advance.

Cyclical patterns

Some diseases show a spike in incidence after every 2 to 3 years or such regular periods. This is called as "cyclical pattern" and is seen in diseases like malaria, measles, etc. We may hypothesis that this may be due to collection of "susceptible, immunologically naive" people during the intervening period.

Short Term Fluctuations

Herein we plot the occurrence of diseases over short periods as monthly, weekly, or daily (or even hourly in a disease like food poisoning). Regular plotting of disease according to such small time interval helps us in undertaking 'surveillance" of these diseases and getting an early warning of an impending epidemic. If the time period of interest while plotting such short term fluctuation is one when an epidemic is actually occurring, the line diagram or the histogram depicting it is more specifically called the "epidemic curve". As said earlier, the optimum time interval along the 'X' axis would be a period which is about one-fourth of the median incubation period for that disease. The epidemic curve can give a lot of insight about the possible factors which led to the transmission and the possible point at which the infectious agent was introduced into the vehicle. The following are certain types of epidemic curves

(a) Point source

Classically seen in food poisoning outbreaks and shows

(i) A tight clustering of cases in time (nearly all cases occur within 1.5 times incubation period, if the disease agent is known).

(ii) It has a sharp upslope, a well defined peak and a trailing down slope.

(iii) The peak generally coincides with the median incubation period.

(iv) The approximate time of exposure may be pinpointed by counting back the median incubation period from the peak, the minimum incubation period from the initial cases and the maximum incubation from the last case. These three points of time would generally bracket the time of exposure.

(v) Sometimes, a point source outbreak of communicable disease produces a substantial number of infected individuals who, themselves, may serve as sources of agent to infect others. In such instances, secondary cases may appear as a prominent wave separated by the point source peak by about one incubation period. If the incubation period of the disease is short, this secondary wave may appear only as a more prolonged downslope. Such a graph is called as "point source with secondary transmission" (41)

(b) Common, Continuous Source Epidemic Curve

In contrast to point source, outbreaks may also arise from common sources that continue over time, known as "Common, Continuous Source"(42), as may happen when a water pipe line gets cross-connected with sewage pipe and the contamination continues till such time this is repaired. In such situations, the epidemic curve will have following characteristics :

(i) Rise sharply but the peak will be a gradual pleatau rather than a sharp peak.

(ii) The downslope may be sudden and sharp if the common source is removed (as repair of cross connection in above example) or else will be a gradual downslope if the common source gradually exhausts itself.

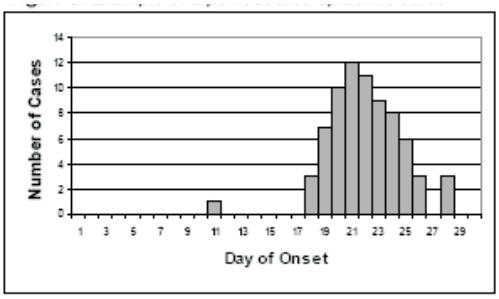
(c) Propogated curve

This is seen in cases of disease agents that are communicable between persons either directly or through an intermediate vehicle. The curve encompasses several incubation periods, begins with a small number of cases and rises with a gradually increasing upslope; often a periodicity which is equivalent to the generation period of the agent may be seen during the initial stages of the outbreak. After the peak occurs, the exhaustion of susceptibles usually results in a rapid downslope. Propogated curves are classically seen in airborne / droplet infections as mumps, measles; in STDs; and in insect vector borne disease outbreaks (43).

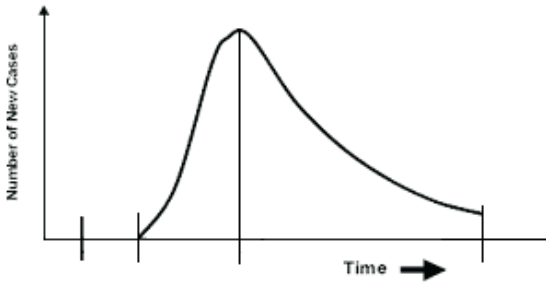
Fig - 1 : Graphical representation of epidemic curves

**Common Vehicle, Point Source epidemic curve**

**As Histogram**

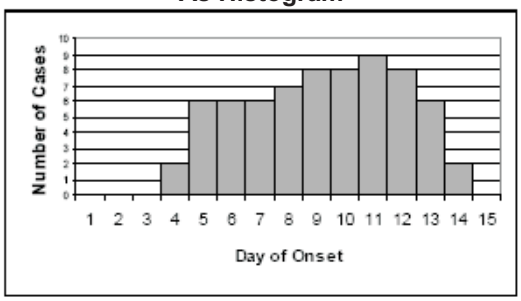



**As Epidemic Curve**

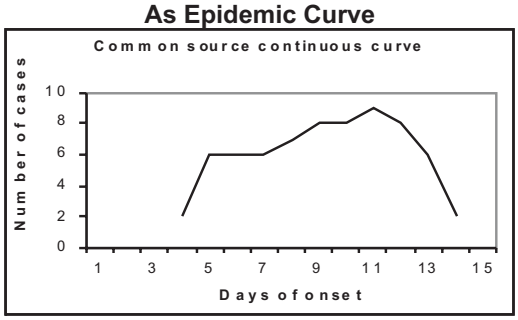



**Common source continuous curve**

**As Histogram**

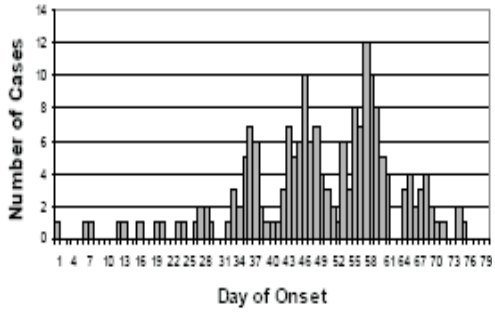



**As Epidemic Curve**

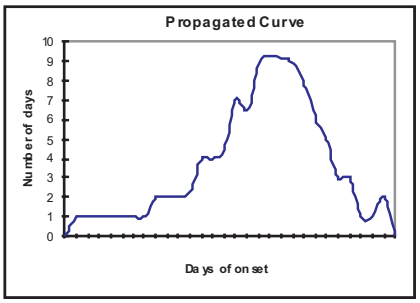



**Propagated epidemic curve**

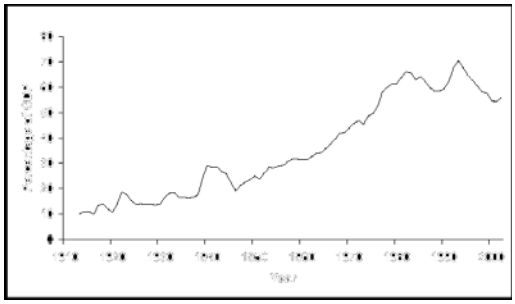
**As Histogram**




**As Epidemic Curve**




**Secular Trends of Incidence of Lung Cancer in a Developed Country**



### Environmental Epidemic Curves

As a special case of propogated outbreaks, we have the "environmental" epidemic curves, which reflect complex interactions between agent, host and environmental factors which lead to the exposure of human beings. Such curves last for quite long, over many incubation periods. They differ from propogated curves in that they do not show the periodicity equal to the generation time in the initial stages and the downslope may not be as rapid as in propogated epidemics. In such cases we should attempt to represent the suspected environmental factor along with the curve, to give a clear idea of the possible association; for example while plotting an epidemic of leptospirosis, we may also present the weekly rainfall curve along with the epidemic curve to support the hypothesis of the importance of rainfall and water logging in transmission of leptospirosis.

**Place**

We describe a health condition by place to gain insight into the geographical extent of the problem. For such depiction, we may use a number of place related variables, as place of nativity, place of usual residence, place of work, school, district, hospital unit, etc., depending on which, as we suspect, may be related to the health event being studied. Often, rural versus urban or national vs. foreign differences, or larger place denominations as countries or continents may be plotted.

Although we can show the data in a table, it is often better to show it pictorially in a map, where we can use different shadings or colours to depict different numbers or rates of disease occurrence in different areas. Such depiction, especially when done for a localized area during an epidemic investigations is called as "spot map".

Looking at the differences in disease numbers or rates according to different places, we can generate worthwhile hypotheses about the factors that may be concerned with the transmission of the disease. For instance during the initial investigations of "American" (murine) typhus, Maxcy developed a spot map and found that the disease was clustered in the commercial areas which had a large number of granaries and not in residential areas which was expected for "european" (louse) typhus. This led to the hypothesis that in USA, typhus may be associated with rats (and not with louse as was the case with epidemic (European) typhus). Finally a different typhus (rat flea borne) was identified (44).

**Person**

There are a very large number of "person" related variables which could be available to us for describing the diseases. These may be classified into

(a) Firstly, the inherent characteristics of a person (age, sex, genetic background, blood group, ethnicity, serum cholesterol, and so on);

(b) Secondly, their acquired characteristics (immune status, marital status, etc);

(c) Thirdly, their activities and lifestyle variables (occupation, use of medications / tobacco / alcohol, leisure time activities, physical exercise, diet, etc)

(d) Fourthly, the conditions under which they live (housing, water supply, economic status, availability of health care, etc).

These various categories determine to a large extent who is at higher risk of acquiring the disease or health outcome that is of interest. We may show person related data either as "frequency tables" or a graphical representations (see chapter on biostatistics for details).

While analyzing data according to person characteristics, we must try to assess a number of different type of person variables, before we find which are the most meaningful and enlightening. Age and sex are most crucial; we almost always analyze data according to these. Besides these, depending on the disease and what may be relevant, we may study the data according to socioeconomic status, educational status, race, family history, marital status, blood group, blood sugar levels, height, weight, and so on. Sometimes we may analyse data into more than one category simultaneously. For example, we may look at age and sex simultaneously to see whether sexes differs in how they develop a condition that increases with age as it happens for heart disease.

### Developing the Hypotheses in a descriptive Study

After having studied the distribution of various time, place and person related variables, we make certain tentative guess-works, which we call "hypotheses". These guess-works are made by observing as to which person variables are very common among the disease. For example if we find that among cases of IHD which we studied, 70% are males, 80% are aged more than 45 years, 65% have waist circumference of > 94cms, 50% give history of IHD among first degree relatives, 15% have blood group 'A', 5% have brown coloured iris and so on, then we start hypothesisng that middle age, male sex, central obesity and family history may determine the occurrence of IHD while blood group 'A' and brown iris may not. But, do note that we only develop "hypotheses" based on descriptions of person, place and time variables. The final proof has still not come, as we shall explain in the next chapter.

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# The Epidemiologic Method (Designs) : (b) Analytical Studies

In contrast to descriptive studies, in analytical studies, the investigator proceeds with a 'preformed hypothesis' regarding a "causal exposure". A large number of epidemiological and health research questions are answered by undertaking analytical studies. The various settings in which the epidemiologist proceeds to establish a relationship between exposure and an outcome may address issues related to treatment, preventive or diagnostic modalities, or regarding the role of a risk factor

Table - 1 : Issues in which "comparative" (analytic) studies are required

**Risk factor** : e.g., "Is tobacco smoking a risk factor for IHD (as compared to when people do not smoke)?"

**Prognostic marker** : e.g., Is appearance of malena in viral hepatitis associated with increased mortality"? (as compared to when malena does'nt appear)

**Treatment modality** : e.g., can "Dopexitine be effective in treating premature ejaculation"? (as compared to when only placebo is given)

**Preventive modality** : e.g., " Can use of condom be effective in preventing STDs among promiscuous persons"? (as compared to when condom is not used)

**Diagnostic modality** : "Can a combination of cold intolerance and unexplained weight gain diagnose hypothyroidism"? (as compared to the gold standard of T3, T4 and TSH).

or prognostic marker (Table - 1).

The key word in analytical studies is "COMPARISON". The basic protype of such comparative research is the 2 X 2 table which we have already explained at length, earlier in chapter 4 of this section and which gives us the notations E+, E-, O+ and O-. Now, "Comparison" of the two groups in any analytical study can be made in either of the two methods :-

Either we take a group with the exposure ( E+) and another without it (E-); follow them up for a reasonable period of time and observe how many in each group have developed the outcome (D+); eg, we can collect two groups of subjects, all free of colonic CA, one group eating low fibre diet and another eating high fibre diet; follow up both these groups for 15-20 years and see how many in each group develop colonic CA. The comparison would then be made between "those who develop the outcome out of total exposed" (i.e., a / (a+b) and "those who develop the outcome out of the total not exposed", (ie., c / (c+d). This can be demonstrated as

$$\text{Criteria for comparison} = \frac{a/(a+b)}{c/(c+d)} = I_E / I_{NE} = RR$$

In case this resulting figure from this comparison is "much more than normally expected" (the "normally expected" being defined by statistical tests) we would conclude that the exposure is definitely associated with (or, carries a high risk of) the outcome.

The second way of doing the comparative analysis could be to collect a group of subjects who have already developed the outcome (D+) and another group of subjects who do not have the outcome, and then interrogate all the subjects regarding history of exposure (E+ or E-) eg, we may take a group of patients already suffering from colonic CA (D+) and another not suffering (D-) and take the history of low dietary fibre intake during last 15-20 years from all of them. In this contingency the comparison would be made between "those with the outcome having the exposure" (ie., a / (a+c) and those without the outcome but having the exposure b / (b+d). The comparison thus would be

$$\frac{(E+D+)/(a+c)}{(E+D-)/(b+d)}$$

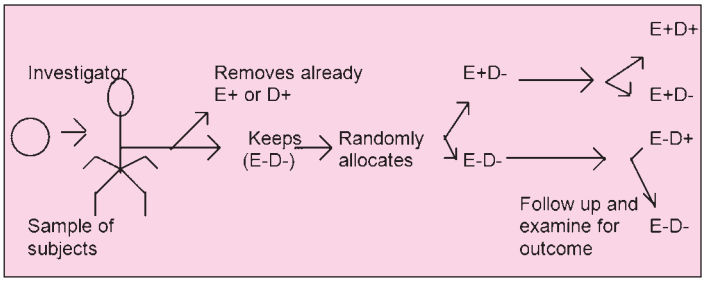
If the result is much more than 'normally expected' we would conclude that the association exists; i.e., the exposure carries a risk of the outcome.

## Individual types of Analytical Designs

### The ideal setting

The most scientifically reasonable setting would be, apparently, when the researcher collects a group of subjects in which neither the exposure not the outcome have occurred; ie., all subjects are initially "E-D-". Now the researcher "randomly allocates" these subjects into two groups, so that both these groups are exactly similar to each other in all respects. Now, one of the groups is deliberately given the exposure (ie., made to become E+D- from E-D-) and the other group is not given the exposure (ie., continues to be E-D-). The investigator now follows up both these groups over a reasonable period of time to see how many in each group become D+ and makes the comparison as

$$\frac{(E+D+)/(a+b)}{(E-D+)/(c+d)}$$




This type of research design is called the **'Experimental"** or **"Intervention"** design. This is scientifically the most suitable because :

Since it is the investigator who decides (on a random basis) and allocates the exposure, the possibility that "subjects might have taken up the exposure due to natural selection factors which may also be related to the outcome" is ruled out. For example, if we compare a group of children who have been already given measles vaccine and follow them up to see the occurrence of measles in each group, the possibility exists that children who have already been given measles vaccine are also possibly the ones who belonged to better socio-economic status, better housing, better nutrition, less overcrowding etc, and hence the lowered occurrence of measles in this group may not be due to vaccine per se but possibly because of the other factors. However in an Experimental (Intervention) design, the investigator will firstly take in only those children who have still neither been given measles vaccine nor developed measles (E-D-), (excluding those who have already been given the vaccine (E+) or who have already suffered from measles (D+). Secondly he would "randomly allocate" this E-D- subjects into 2 groups, one getting the vaccine (E+D-) and another not getting it (D-D-); since the division is by "randomisation", both the groups will be exactly equal to each other in respect of all other factors (like socio-economic status, nutritional status, housing etc). Hence no objection of the type as mentioned in the foregoing example on measles can be made against this design. (see chapter on Sampling Methods in section on Biostatistics and chapter on clinical trials in section on research Methodology for further details on randomization).

(a) Since the outcome has been excluded from both the groups to start with, (the investigator takes only E-D- to start the study) and then both the groups are followed up over a period of time for the development of outcome (D+ or D-), one is definite that exposure preceded the outcome; ie., the absolute requirement of "temporality" for a "cause-effect" relationship is fulfilled.

(b) Since the exposure status (E+ or E-) has been recorded by the investigator himself at the start of the study, there is no possibility of recall 'bias' which could happen if the investigator was asking the history of "exposure" from the subjects who have already developed the outcome (D+ or D).

This type of research, while the most scientifically sound, suffers from the outstanding problem that while studying "risk factors", "markers" and "prognostic factors" it is impossible for the investigator to randomise the subjects into two groups - one getting the exposure and the other not. Eg, in a study of the association between cigarette smoking (exposure) and Lung CA (outcome) it is impossible for the investigator to "randomly allocate" the subjects into 2 groups, one group being told to smoke and other being told not to do so". However, for any study directed to answer the questions about "treatment (therapy)" or "preventive procedure", the experimental design must be used since the subjects can be randomised into 2 groups, provided it is ethically correct do so.

Experimental (intervention) designs can be of further three types, as follows

**(a) Randomized Controlled Trial (RCT) (Clinical trial)**

Details are given in the chapter on clinical trials in Research Methodology section.

**(b) Preventive Trial**

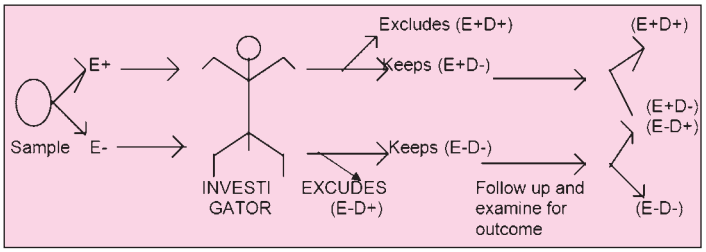
This addresses issues of prevention (as, vaccine, chemoprophylaxis, personal protective methods, etc.) as compared to therapeutic issues addressed by RCT.

**(c) Community Intervention Trial**

In a RCT or preventive trial the random allocation is done at the level of individual subjects; e.g, each individual subject will be randomly allocated by lottery into Gp.'A' which will get the vaccine and Gp. 'B' which will get the placebo. However, in situations like assessing whether fluoridated water is effective for prevention of dental caries, it will be impossible to randomly divide the individual subjects. In such cases, it is groups or "clusters" of human beings; e.g., we will randomly allocate villages into a Gp of villages to receive fluoridated water and another Gp of villages to receive non-fluoridated water. Such trials, wherein the unit of study are "individual human beings" but the unit of random allocation are "communities" are called "Community Intervention Trials".

**The next situation : "Cohort Study" :-**

In case it is not possible to "randomly allocate" the subjects into two groups, what we can do is that we can select out two groups at the start of the study, one having the exposure (E+) and other not having the exposure (E-). Now, those subjects, in both the groups, who already have the outcome (D+) at this point of starting the study are excluded, so that we have two groups, one having the exposure but no disease (E+D-) and the other neither having the exposure nor the disease (E-D-). The groups are followed up for the required period of time and comparisons made between (E+D+) / (a+b) and (E-D+) /




(c+d) as for an experimental study.

The advantages of this design, called 'Cohort Design" are the last two mentioned for experimental design, ie., temporal association is ensured and recall bias is minimised. The main scientific drawback of this study is that lacks the effect of "equal distribution due to random allocation" and hence the problem of "natural selection factors" related to both exposure and outcome may be forwarded. Hence, as far as effects of therapeutic regimes or preventive measures are to be seen, the experimental design is to be taken up since random allocation can be undertaken. However, for study of "risk factors", "markers" and "prognostic factors" the cohort study

remains the choice.

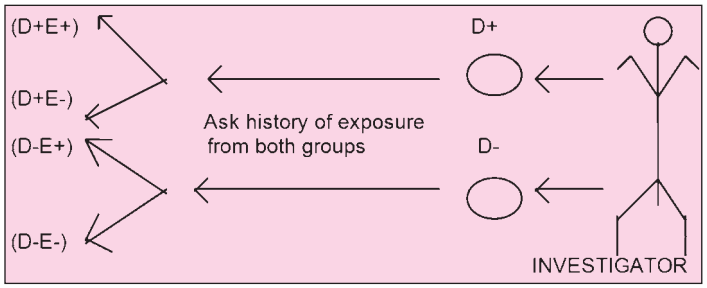
This design has disadvantages too. Firstly, if the period of follow up is very long, the medical fraternity has to wait for many years before the final conclusions can be drawn. Secondly, if the outcome is rare, the investigator needs to follow up a very large number of subjects to get a reasonably adequate number of subjects who develop the outcome. Thirdly, a large number of subjects may be lost to follow up/die/ drop out during the period of follow up leading to "loss to follow up bias". Fourthly, such study needs quite a bit of men, material and money.

**The third situation : Case control study :-**

The problem of "cohort study" can be sorted out by using the method we mentioned in making the second type of comparison between the two groups. What we can do is that we can start by selecting a group of subjects who have already developed the outcome (D+) and another who have not developed the outcome (D-) and ask the history of exposure (E+ or E-) from all the subjects.

The comparison is made as

$$\frac{(D+E+) / (D+)}{(D-E+) / (D-)}$$




The above situation is what we call a very special type of study, the "case-control" design. Intuitively, this study design appears very appealing. However, it suffers from a large number of outstanding problems :-

(a) The very direction of the arrows are 'reversed'; in other words, this study involves a reversal of "scientific reasoning" which should normally proceed from "exposure to outcome" as in an experimental or cohort design.

(b) The fact that the investigator has not recorded the exposure (E+ or E-) himself but is dependent on the history given by the subjects leads to a high possibility of "recall bias".

(c) Since the investigator has not started from the exposure and followed up subjects till the outcome (as happens in an experimental or cohort study), one is not sure whether exposure really preceded the outcome ie., "temporality" is not guaranteed. Eg, an association between poverty (postulated exposure) and mental illness (suspected outcome), if concluded by such a design, may not necessarily be because poverty led to metal illness but may be because after suffering from mental illness, persons may become poor.

(d) What the investigator starts with in such a design are the subjects who are present with a given outcome, ie., living with the outcome of interest but not those who have already died of, or have been cured of, the outcome. The possibility of "survivorship bias" is, therefore, high. (see example on suvivorship bias, in chapter -1 in section on Research methodology).

(e) The problem of "natural selection" also remains high as in cohort study. However, it may be mentioned that if all the potential confounding factors (PCF) are identified and data recorded, this problem can be overcome to a large extent (though not completely eliminated) in a case control or a cohort study.

The case control design has its own advantages, however. It is very good for a rare disease (in contrast to a cohort design) because cases of a rare disease can be picked up from a general / specialised hospital. It does not need any (prolonged) follow up effort. It is cheap and logistically simple. It becomes the method of choice when we are doing an initial evaluation of a hypothesis (fishing expedition) for "risk factors" and "markers". It becomes a particularly good method if the exposure is not likely to change over time and can be objectively ascertained (eg, blood group, race, religion, sex, seropositivity for certain infections etc).

**The fourth setting : Cross-sectional analytic design**

In a case control design, the researcher starts by collecting a group of subjects who have the outcome (D+). This he does in a hospital, or to a limited extent, at large OPDs. But if a disease is mild, or has a marked 'gradient' of mild, moderate and severe cases, a large number of cases will not be admitted in the hospital and hence will not appear in the case control study. In fact the mild (not admitted) cases may be systematically different from the serious hospitalised cases as regards the exposure itself.

In such settings therefore, instead of doing a case control design, the researcher takes a "sample" of subjects from the 'total population'. At this point he is not aware whether the subjects are having the disease or not. Now, the investigator examines each and every subject for the presence / absence of outcome (D+ or D-) and exposure (E+ or E-) at the same point of time and hence gets the four groups, E+D+, E+D-, E-D+ and E-D- at a given point of time. This is what we call the "Cross-Sectional Analytic Design". In addition to those diseases that have a wide spectrum of symptoms, the design is also quite useful when the investigator wants to see for correlations between variables which need to be studied among healthy people and not necessarily hospitalized patients; eg, if we want to see whether waist circumference correlates well with blood pressure we will have to do such a study and not a case control one. The problem of proving temporal relationship is a major drawback of cross sectional analytical studies as it is for a case-control study.

**The last setting : The Diagnostic test study**

The analytical approach for the evaluation of a diagnostic test (which may be a Pathological / Radiological / Microbiological procedure or even a "set of signs / symptoms") in diagnosing a given outcome (or, disease) is slightly different. Firstly, in such a study the investigator must enunciate a "gold standard", against which his diagnostic tool which is to be evaluated, will be validated. Secondly, each and every subject must be subjected to both the procedures (the gold standard as well as the test under study), thereby getting 4 category of subjects. Let us say, we are evaluating the efficacy of pap smear in diagnosing CA Cx, the gold standard being biopsy. We will then have the following setting as shown in Table 2.

a = Subjects who are having the disease (+ve by gold standard) and also identified +ve by the test under consideration (True positive or TP);

Table - 2

| Result of Pap Smear | Biopsy (Gold standard ) results | | |
|---|---|---|---|
| | CA Cx present | CA Cx absent | Total |
| Positive | a | b | a + b |
| Negative | c | d | c + d |
| Total | a+c | b+d | a+b+c+d |

b = do not have the disease but called +ve by the test (False positive or FP); c = have the disease but called -ve by the test (False negative or FN)

d = do not have the disease and -ve by the test (True negative or TN) ; (a + b) =Total number found +ve by test (ie., TP + FP);

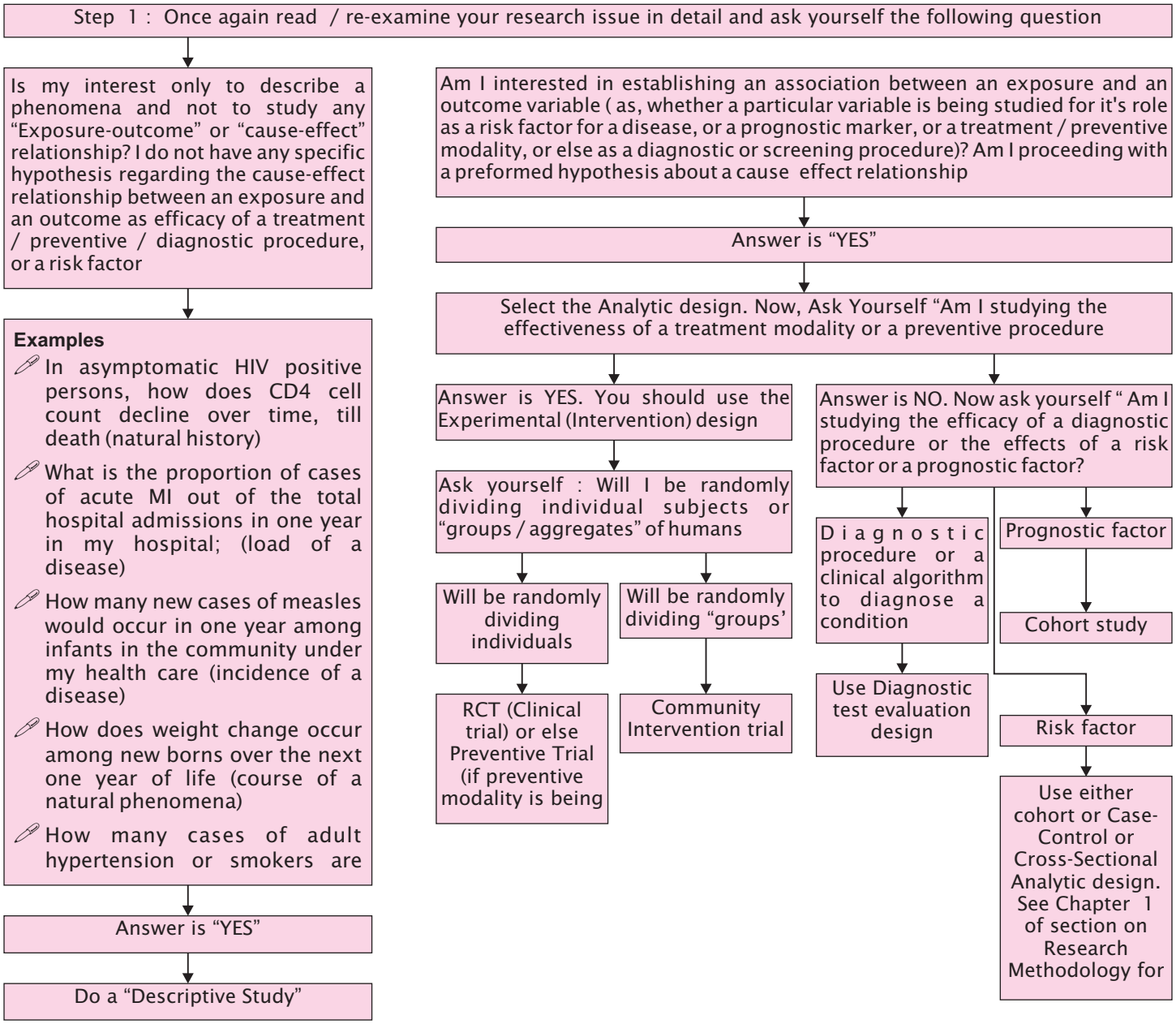
(c + d) =Total number found -ve by test (ie., FN + TN); (a + c) =Total number actually having the disease, by gold standard (ie., TP + FN);

(b + d) =Total number not having the disease by gold standard (ie., FP + TN)

The investigator now does **not** work out the statistical tests for associations ( as Chi-square) and risk (as RR or OR), but something different - he works out the validity (or accuracy) of the test under consideration by calculating the sensitivity, specificity, positive and negative predictive values and likelihood ratios, the details of which we shall discuss in the chapter on screening for disease and chapter on diagnostic test evaluation studies.

**How do we decide as to which Epidemiological design we should use ?**

It is of importance that the correct "Research Design" be selected by the researcher. The following guidelines are given in the succeeding flow chart to assist you in selecting the design most appropriate to your research question.


Step 1 : Once again read / re-examine your research issue in detail and ask yourself the following question
Is my interest only to describe a phenomena and not to study any "Exposure-outcome" or "cause-effect" relationship? I do not have any specific hypothesis regarding the cause-effect relationship between an exposure and an outcome as efficacy of a treatment / preventive / diagnostic procedure, or a risk factor
Examples
In asymptomatic HIV positive persons, how does CD4 cell count decline over time, till death (natural history)
What is the proportion of cases of acute MI out of the total hospital admissions in one year in my hospital; (load of a disease)
How many new cases of measles would occur in one year among infants in the community under my health care (incidence of a disease)
How does weight change occur among new borns over the next one year of life (course of a natural phenomena)
How many cases of adult hypertension or smokers are
Answer is "YES"
Do a "Descriptive Study"
Am I interested in establishing an association between an exposure and an outcome variable ( as, whether a particular variable is being studied for it's role as a risk factor for a disease, or a prognostic marker, or a treatment / preventive modality, or else as a diagnostic or screening procedure)? Am I proceeding with a preformed hypothesis about a cause effect relationship
Answer is "YES"
Select the Analytic design. Now, Ask Yourself "Am I studying the effectiveness of a treatment modality or a preventive procedure
Answer is YES. You should use the Experimental (Intervention) design
Ask yourself : Will I be randomly dividing individual subjects or "groups / aggregates" of humans
Will be randomly dividing individuals
RCT (Clinical trial) or else Preventive Trial (if preventive modality is being
Will be randomly dividing "groups'
Community Intervention trial
Answer is NO. Now ask yourself " Am I studying the efficacy of a diagnostic procedure or the effects of a risk factor or a prognostic factor?
Diagnostic procedure or a clinical algorithm to diagnose a condition
Use Diagnostic test evaluation design
Prognostic factor
Cohort study
Risk factor
Use either cohort or Case-Control or Cross-Sectional Analytic design. See Chapter 1 of section on Research Methodology for

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## Cause and Effect Relationship

Except in the limited situations of describing a phenomena of interest, most of the times epidemiologic research is directed towards finding out the "causal" association; eg., "Is smoking a cause of IHD ?" This is called as study of "cause-effect" relationship; it is also equivalently called as "exposure-outcome" relationship. A "cause and effect" (or exposure and outcome) relationship can be defined as "an association between two variables in which an alteration in the frequency or quality of one variable is followed by a corresponding change in the other" (45-49); eg, if smoking is a cause of Buerger's disease, increase or decrease in smoking should lead to a corresponding change in the disease occurrence.

The process of establishing a "cause and effect relationship : Establishing a cause and effect relationship, i.e., this particular 'exposure' is the cause of that particular 'outcome' needs epidemiologic research on the lines of 'hypothesis testing'. i.e., an analytic study, as described in previous chapter. Once the investigator proceeds with a "cause and effect" hypothesis and conducts a study, the final evaluation whether an "exposure-A" (eg., smoking) is a cause of the "outcome B" (eg., Buerger's disease) consists of a sequence of steps as follows :-

### Step 1

Has the study been done using correct methods ? Has the investigator 'measured' what he or she really wanted to 'measure' ? Has the validity and reliability been preserved in the study and there is no bias ? In other words, we analyze whether the results of the study are accurate and not "spurious"?.

### Step 2a

Do the statistical results indicate that the 'exposure' and 'outcome' are significantly "associated" ? In this step, the investigator ensures, through statistical tests of significance and 95% CI that the differences/associations observed in his sample are not simply due to matter of "chance" or, in other words, variations that could occur when different samples from the same whole population are drawn ("chance" or random variations or sampling variations). This entire aspect is dealt with in the section on biostatistics in this book.

### Step 2b

If the statistical results show that the statistical relationship is not significant, we must still give consideration to the possibility that a real association might have been missed out due to low power of the study i.e., a high Beta (type II) error consequent to a small sample size. Hence, before finally denouncing the association as "not statistically related", we must back-calculate the "power" of the study; in case it is found that the power was inadequate (say less then 80% for the usual research settings), the investigator should suggest additional studies using larger sample, (or else, a meta-analysis 'type of study). Further details of procedures are given in the section on Biostatistics.

### Step 3

If the tests of step 2 show that the relationship is "statistically significant" the investigator should now evaluate as to whether this relationship is due to 'indirect relationship' with a third variable; in other words, the investigator should undertake analytic procedures for control of confounding as described in the section on Research Methodology.

### Step 4

Once it has been demonstrated in step 3 that the exposure-outcome relationship is not due to confounding (i.e., holds good even after adjusting for confounding variables), the investigator should now test this postulated "casual" relationship on the following criteria of "casual association" as enunciated by Sir AB Hill (50):-

#### (a) Temporality

The absolute requirement for any postulated cause and effect relationship to hold good is to demonstrate that the suspected cause (exposure) preceded the effect (outcome). Eg., for smoking to be a cause of IHD, smoking should start before the occurrence of IHD.

#### (b) Strength of association

The "strength of causal association is shown by relative risk (RR) or, odds ratio (OR); higher the RR or OR, (i.e., farther the RR or OR from the value of "1"), more is our confidence regarding the casual association.

#### (c) Consistency

Whether a number of different studies conducted by different investigators at various times in different geographical areas on different populations have indicated similar "cause and effect" association as regards our exposure and outcome variables. Eg., smoking lung CA association has been consistently demonstrated in various countries, religions and sex etc.

#### (d) Biological gradient

Usually, increasing dose of exposure should be associated with increasing occurrence of outcome; eg., with increasing consumption of tobacco, the occurrence of IHD rises. This is also called "dose-response relationship". However, the investigator should remember that not all casual associations would demonstrate this phenomena; eg., the association between DES consumption by mothers and vaginal CA in daughters many years latter does not exhibit this 'gradient' phenomena, possibly due to a phenomena called "sufficient dose for maximum effect".

#### (e) Biological plausibility

Does the cause-effect association "stand to reasoning" i.e., commensurate with the already known and accepted facts. However, here too the researcher must note that biological plausibility is a relative phenomena based on present day knowledge of the state of affairs; what we

think nonsensical today may be accepted as correct tomorrow, eg., in the mid 19th century when Semmelwis recommended hand washing by medical students and teachers before attending obstetric units, his recommendations were dismissed by medical fraternity as "doesn't stand to reasoning" ! The rest is history (51, 52).

**(f) Experimental evidence**

An evidence, in the laboratory or in human subjects, based on deliberate introduction of the cause (exposure), thereby demonstrating that the outcome (effect) occurs in the group which has been subjected to the exposure and not in the other group. Here again it should be noted that such experimentation on human subjects may be often impossible; (eg., we cannot deliberately tell a group of human beings to smoke and the other group not to smoke and watch them for the development of lung CA). However, basic laboratory proof (eg., microscopic demonstration of histological changes in the respiratory tract of animals subjected to tobacco smoke or in tobacco using humans) may further strengthen our belief in a "causal" association.

**(g) Other criteria**

Like, 'analogy'. (eg., if one drug can cause congenital malformations, others can also do so); 'specificity' (i.e., one cause, one effect) and 'coherence' (findings should not conflict with the known natural history of the disease) have also been forwarded to finally test a casual association. However, in general, criteria mentioned in step (a) to (c) are most important; (d) to (f) may lend additional support to the causal reasoning while those mentioned in (g) may also be considered. Sequence of establishing a cause and effect relationship is shown in Table-1

Table-1 : Sequence of establishing a "cause and effect relationship" from a epidemiological study

- Is the Internal validity maintained? Any measurement errors? Any Bias?
- Are the results statistically significant? Or, is it that they may be due to chance?
- Any indirect association (confounding)?
- Test for Hill's criteria of causal relationship :- Strength of Association (magnitude of RR); temporal relationship; consistency; plausibility; dose-response

## Epidemiological Theories of Disease Causation

Epidemiologists have developed various models to explain the causation of human disease

**Germ theory**

This was the central philosophy of the famous Koch's postulates, formulated by Robert Koch (now also known as Henle-Koch postulates) (53, 54), which enunciated that firstly, the disease agent occurs in every case of the disease and under circumstances can account for the pathological changes and clinical course of disease; secondly, It occurs in no other disease as a non-pathogenic parasite; thirdly, after being fully isolated from the body and repeatedly grown in pure culture, it can induce the disease anew, from where again it can be isolated, grown in pure culture and should be able to cause a new case of disease if transmitted to another healthy human. However as the 20$^{th}$ century started rolling, it was realized that the germ theory could not fully explain the causation of human diseases. The occurrence of tuberculosis in western world fell down dramatically in the beginning of 20$^{th}$ century, even before the availability of a specific vaccine (to specifically prevent infection) or a specific treatment (to specifically kill the tuberculosis "germ"). Simple facts like disease does not necessarily occur in everybody who has the tuberculosis germ in the body (i.e., infection does not necessarily lead to disease in Tuberculosis) started putting a question mark on the ability of the germ theory to completely explain causation of human diseases.

**The epidemiological triad theory**

Though not refuting the importance of germ theory, thinking processes were started to explain the role of other factors in accentuating or attenuating the effect of the "germ" or "agent" of disease. This finally culminated into an extremely well known theory of human disease - the "Epidemiological triad". The epidemiological triad theory hypothesizes that there are 3 important determinants of the state of health or disease in a human being, namely, firstly, the agent factors, related to the various characteristics of the "agent" which causes the disease; secondly, the host factors which relate to various characteristics of the human being himself, and thirdly, the environmental factors which relate to the various characteristics of the environment in which the human being is living.

As per the theory, as long as a state of fine balance or equilibrium is maintained between the various agent, host and environmental factors, the person stays in a state of health. On the other hand, the moment this fine balance is disturbed due to change in any one or more of the agent, host and environment related factors, a departure from the state of health occurs (though, outwardly, evidence of disease may still not occur because manifest evidence of disease may take sometime to develop. The various agent, host and environmental factors fall into the following categories :-

(a) Agent factors

These include Physical agents (as heat, cold, vibrations, electricity, mechanical forces, etc); Chemical agents (as acids, alkalies, heavy metals, allergens, etc); and, Biological agents (as viruses, bacteria, parasites).

(b) Host factors

These include Sociodemographic factors as age, sex, occupation, education, marital status); Psycho-social factors (as attitudes, practices, behavioural patterns, life style, etc); and, Intrinsic characteristics (eg., genetic factors, HLA types, biochemical and physiological

characteristics, etc).

(c) Environmental factors

These include Physical environment (as seasons, climate, altitude, rainfall, etc); Biological environment (eg., arthropod vectors of diseases like mosquitoes, animal reservoirs like canines for rabies, etc); and, Social environment (eg., community attitudes, beliefs, practices and cultural factors affecting disease; level of socio-economic development; availability of health services, etc).

**The theory of "web of causation"**

The "epidemiological triad theory" was very effectively used by Leavel and Clark in explaining the natural history of disease, and levels of prevention. However, difficulties come up when an attempt is made to explain the causation of non communicable diseases like IHD or road accidents on the basis of epidemiological triad. For example, no single agent can be ascribed for IHD; a wide variety of interacting factors like Hypercholesterolaema, hypertension, tobacco, obesity, physical inactivity, genetic background, age, sex, just to name a few, interact in various ways to finally lead to IHD. For explaining the causation of such non communicable disease in particular, MacMahon and colleagues forwarded the theory of "web of disease causation" (45), which hypothesizes that various factors (eg., hypercholesterolaemia, smoking, hypertension and so on) are like an interacting web of a spider. Each factor has its own relative importance in causing the final departure from the state of health, as well as interacts with other, modifying the effect of each other. The web theory also postulates that for preventing a disease, it is not necessary to take action against all the factors if we could identify a few "weakest links" in the inter-lacing webs, actions directed to break these chains at their weakest links may be of considerable value in prevention.

**Epidemiological wheel theory**

As medical knowledge has advanced, the additional aspect which has been exciting interest is the comparative role of "genetic" and the "environmental" factors (i.e., extrinsic factors outside the host) in causation of disease. The "triad" as well as the "web" theory do not adequately cover up this differentiation. To explain such relative contribution of genetic and environmental factors, the "wheel" theory has been postulated. The theory visualizes human disease in the form of a wheel, which has a "central hub" representing the genetic components and the peripheral portion representing the environmental component. The peripheral portion is further subdivided into 3 sub components, representing the social, biological and physical components of the environment. For every disease, the genetic, social, biological and physical environmental components take different sizes, according to their relative importance in causing the disease.

**The theory of "necessary" and "sufficient" cause**

It is being realized that the "cause" of a particular human disease is like the constellation of various factors, and when all of them come into play in optimum combination, the pathological process which finally produces the disease, gets initiated (49). This led to the concepts of "necessary" cause and "sufficient" cause. "Necessary cause" is one whose presence is essential for disease causation, but which alone, by itself may or may not be able to finally cause the disease. Thus, while disease cannot occur in its absence, it may or may not occur if it is present. For example, Tubercular disease cannot occur if TB bacillus is not present in the body; however, if it is present, still tubercular disease may occur or may not occur. On the other hand when the required combination has been achieved, say, presence of TB bacillus,

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## Principles of Infectious Diseases Epidemiology

One way of broadly classifying human diseases is according to whether they are "infectious (communicable)" or else, "non-communicable". Out of these two, infectious diseases account for lion's share of death, disease, ill-health and suffering. This is especially true of the developing countries. For this reason an epidemiologist must have a sound understanding of the epidemiologic principles that underlie infectious disease practice.

### General Terms And Definitions (55)

**Infection & Infectious Disease**

This refers to the entry and development or multiplication of an infectious agent in the human (or, animal) body, with an implied response (eg, immunological response) on the part of the human or animal. It must be remembered that "infection" by itself does not mean "infectious disease". An infectious disease is that part of the spectrum of "infection" which is clinically apparent. In fact, this is the basic difference between epidemiologic practice and clinical practice as regards infectious disease the clinician is mainly interested in "infectious disease" while the epidemiologist is interested in "infection" and its dynamics including the subclinical cases, the carriers, the reservoirs of the infectious agent and its modes of transmission.

**Colonisation**

Colonisation indicates presence of infectious agent in the human body but without any evidence of specific host immune responses to the agent. In short, colonization means "infection less specific immune response".

**Endogenous infection**

Infection due to a colonizing agent; eg, *E Coli* normally colonises the human GIT; however, under certain circumstances, it may enter the blood stream and cause endogenous infection.

**Contamination**

Refers to a infectious agent being present in inanimate articles like food, water, linen, patient care items or routine usage items like cutlery, toys etc. often, the term is also used to denote presence of infectious agent on skin surface, particularly on hands.

**Pollution**

Refers to presence of either infectious agent or such other disease causing noxious agents (as industrial effluents) or mechanical agents (as sound), usually in the general environment, air or water (eg, sound pollution, water pollution, air pollution).

**Infestation**

Infestation may refer to human beings, animals or personal usage items, wherein it implies either the presence and development of insect vectors on the body or linen (eg, louse infestation, infestation with acaius) or else on the mucus membranes (eg, roundworm infestation). Infestation is also sometimes used for describing a state wherein an accommodation or such articles as containers have the presence of arthopods or vectors (eg, cockroach or rat infestation in the houses).

**Communicable disease**

A communicable disease is one that is caused by an infectious agent (or its toxic products, eg, preformed toxins of *B cereus* or *C botulinum*) which can be transmitted to a human being either directly, or indirectly (through food, water, insect vectors, soil), or else a disease which can be transmitted between humans and animals. All infectious diseases are not necessarily communicable; eg, osteomyelitis or brain abscess are infectious diseases but not communicable. Similarly, an infectious disease may be communicable in one form (eg pneumonic plague) but not in the other form (eg, bubonic plague).

**Dead-end infection**

A state when an infectious disease, which is usually "communicable", cannot be transmitted any further between human beings or from humans to animals or vice versa, for various agent, host and environmental reasons. Examples are Japanese Encephalitis, Rabies, Tetanus, Bubonic plague, scrub typhus in humans.

**Subclinical infection (inapparent infection)**

It is a state when there is a host immune response following entry of the infectious agent; the agent may also multiply in the host body, but there are no clinical manifestations of the disease. Thus, the presence of infection cannot be recognized clinically though the infectious agent is constantly passed out of the human body and hence a person with subclinical infection is a greater health hazard for community then those having apparent disease (since the latter can be identified, treated and isolated if required). Diseases like viral hepatitis A have large number of subclinical infections; on the other hand, diseases like measles hardly have any subclinical infections. Thus, infections which have a large proportion of subclinical infections in their spectrum are less amenable to prevention; on the other hand, diseases which have very few or no subclinical infections are more amenable to prevention by surveillance methods.

**Latent infection**

This refers to a state when the infectious agent lies "dormant" within the host body, without any clinical manifestations but does not come out of the human body (thus it is different form subclinical infection). After a period of time, under certain circumstances, the agent which had been lying dormant, reactivates and produces a different type of disease (eg, Herpes Zoster; Brill-Zinser disease) or else the same type of disease (eg, reactivation Tuberculosis).

**Zoonoses**

Zoonoses are infections which are normally transmitted between vertebrate animals, either directly, or indirectly through a vehicle or insect vector. Those which are of

health importance are the ones that are transmitted to man from vertebrate animals, either directly, or indirectly through vehicle or vectors. These are called "anthropozoonoses" and include a long list of infections like Rabies, plague, bovine TB, salmonellosis, Japanese Encephalitis, scrub and murine typhus, echinococosis, Anthrax, Brucellosis, and so on. The second group are infections which primarily infect man but can be transmitted to animals; these are called as zooanthroponoses. The third group is amphixenosis which includes infections that may be transmitted from man to animals and vice versa.

**Opportunistic infections**

The term refers to disease, caused by infectious agents, which are normally not pathogenic, due to a decline in the general or specific immune status of the host. The term has assumed greater importance following identification of HIV infection whose clinical manifestations comprise of a wide variety of such opportunistic infections like P carini, T gondi, CMV etc.

**Nosocomial infection**

This is an infection contracted while in hospital, as a result of health care or related procedure. Such infections would include those whose clinical presentation may start after discharge from the hospital but NOT those which were "incubating" in the patient's body at the time of admission. The field of "Nosocomial Epidemiology" is fast becoming a specialized one. Hospital epidemiologists should ensure prevention and control of such hospital infections.

**Eradication**

The term refers to a complete cessation of transmission of the infectious agent. Usually this would imply that the infectious agent as well as the disease has also been completely reduced to zero. Small pox is the only example wherein eradication has been achieved.

**Control**

This refers to reducing the transmission of a disease to a level when it no longer remains a "public health problem". Control is more pragmatic then eradication but needs ongoing preventive measures, and consequently continuing expenditure, alongwith an efficient surveillance system to give an early warning of increase in the level of transmission.

**Elimination**

Elimination implies either a 'regional eradication" (say from a country or continent), or else reduction of disease to zero without total removal of infectious agent.

## Epdiemiologic "Chain" Of Infection

There are 4 inter- related factors, which together are referred to as the "epidemiologic chain of infection'

(a) the infectious agent and its characteristics.

(b) the human host who is suspectible to the infectious agent, and various factors which determine such suspectibilty.

(c) characteristics of the infectious process which are determined by the interactions between agent and the host.

(d) inter-connecting the agent and host are the "channels (or, modes) of transmission of the agent to the host. Let us discuss the details of each of these components of the chain of infection.

**Agent**

There are three broad groups of characteristics that are important in respect of infectious disease agent, viz., the reservoir and immediate sources of the agent; the characteristics of an agent that are connected with its survival in environment; and, the characteristics of agent which determine the production of infection and, consequent to infection, the production of disease.

**Reservoir And Immediate Source Of Agent**

Any infectious agent has a primary habitat, called the "reservoir of infectious agent" which can be defined as "a person, animal, or inanimate environment (like soil), where an infectious agent lives, depending primarily for its survival, and where it propogates itself so that it can be transmitted to a human host". On the other hand, a source of infection is the person, animal, or their excretions or inanimate environment from where the infective form of the agent is immediately available to the susceptible human host. Let us take the example of hookworm. The adult forms live in human gut, depending primarily on the human being for their survival; they multiply there and propagate themselves, the eggs being passed out for further transmission to another human so as to further propagate the species. The worms do not depend primarily for survival and multiplication on any other animal, soil, plants, etc. Thus, the "reservoir of infection" is "human being, infected with Hookworm", (human reservoir). On the other hand, infection of another human being occurs due to skin contact with soil contaminated with infective stage larvae. Thus, the "source" is "soil contaminated with infective stage larvae".

Types of "Reservoir of infection"

The most important "reservoir" for large majority of human infectious agents is the human being himself. The "human reservoir" of infectious agents can occur in two forms, viz., Cases and Carriers :-

**(a) Cases**

Those who have clinically apparent disease .

**(b) Carriers**

A carrier is a human being who harbours an infectious agent and sheds it, thus becoming a potential source of infection for other human beings, but does not exhibit any manifestation of the disease. The fact that they cannot be detected despite being a potential source of infection for other makes carriers extremely important from epidemiological point of view. Depending on the stage of disease in its natural progression, a person may be a carrier either during the incubation period (incubatory carriers) as occurs in measles, mumps, Hepatitis A, etc. The importance of the incubatory carrier state lies in the fact that after the incubation period is over and the disease manifestations come up, we may isolate and treat the person, but the damage has already been done by him, by transmitting the infection during incubation period. Secondly, he may be having subclinical or clinically inapparent disease (contact or healthy carrier), eg.,

Hepatitis A, Cholera, Poliomyelitis, diphtheria, etc. A subclinical carrier should be differentiated from a subclinical case, which refers to a person who has the infection beyond the incubation period but do not show clinical manifestations and do not shed the organisms so that the infection cannot be transmitted to other human hosts; eg., subclinical case of Japanese Encephalititis in which the infectious agent is present in the body, but the low titer viraemia is inadequate to infect the mosquito vector. Thirdly, the person may continue to shed the infectious agent even after apparent recovery, during the convalescent stage, and hence known as convalescent carrier as occurs in cholera, typhoid and bacillary dysentery. Such "convalescent carriers" may be short term or temporary carriers (lasting upto 4 weeks or so) or chronic carriers (lasting beyond 4 weeks; may be upto years as in chronic typhoid infection of gall bladder) (56).

Animals and other forms of reservoir

Besies human beings, animals form another reservoir wherein the infectious agent lives primarily, thrives, multiplies and is available for being transmitted to the human host. Such diseases fit in the scope of "zoonoses" as has been already described. Finally some infectious agents like fungi may primarily thrive and multiply in the contaminated soil.

**Characteristics of Agent concerned with Survival in Nature**

The capability of an agent to thrive outside the reservoir and withstand adverse environmental effects like drying, heat, acidity, etc is known as "survival capacity in nature". Some agents can hardly survival outside the human body (eg., measles, chicken pox). Others may survive for limited time provided conditions are favorable (eg., cholera vibrio, polio virus, Hepatitis A, etc can survive in water, ice, sewage, milk, etc; HIV can survive in blood and blood products; however all of them are quite vulnerable to drying, heat and disinfectants). Finally some organisms or their intermediate forms are quite sturdy and can withstand adverse environment very well (eg., clostridal spores, cycts of intestinal protozoans, ova of helminths, etc). Usually, agents which have very poor survival in nature tend to adopt the direct modes of transmission like droplet infection or direct mucous contact. Survival in nature becomes all the more crucial for the agent, if human being is the only reservoir.

**Characteristics of Agent Involved in Production of Infection and Disease**

The various characteristics of an infectious agent which determine the production of infection, as well as the causation of disease are (57) :-

Infectiousness

This is the relative ease with which the agent is transmitted to the host. Infectiousness is more of function of environmental factors; eg infectiousness of measles would be higher in overcrowded conditions but lesser in affluent communities.

Infectivity

This is the ability of the agent to cause infection, i.e, to enter, survive and multiply in the host. A useful epidemiologic measure of infectivity is Secondary Attack Rate (SAR). It is defined as the number of susceptible persons who, within the duration of one incubation period, following exposure, develop the disease out of the total susceptibles who were exposed. SAR is usually measured by conducting studies in closed communities or families wherein the first case which brings in the infection is called the index case. Thus,

$$SAR = \frac{\text{No. of susceptables exposed to index Case, who develop the disease, within the duration of maximum incubation period of the disease X 100}}{\text{Total number of susceptables exposed to the Index case.}}$$

Pathogenecity

It is the ability of the agent to produce manifest disease out of those who have been infected. Generally, agents which have high pathogenecity have features which protect them from non-specific host defenses, and elaborate toxins or similar products (eg, Diptheria, Tetanus) or else, may cause such host immune response that leads to disease (eg, Rheumatic fever, Glomerulonephritis).

Virulence

Higher in order, from infectivity and pathogenecity, is virulence. It is the ability of the agent to produce severe disease. If "serious' infection is being measured in terms of death, then Case Fatality Ratio (CFR) becomes a reasonably good measure of virulence.

Infective dose

Infective dose is important for certain infectious disease agents like V cholera and S typhi in which, if the inoculum is not adequate, then infection may not settle, or at least, manifest disease may not occur. On the other hand, in infections like plague, even a very small dose may be enough to cause infection.

**Host Factors**

Like the agent is on one end of the epidemiological chain of infection, the "HOST" is at the other end of the chain. The host factors which determine the dynamics of infection fall into two broad categories:-

Host Attributes Which Affect The Probability Of Being Exoposed To The Infectious Agent

These include age (eg, young children, because of hygienic innocence and habit of "orally exploring" the items, are more susceptible to exposure to soil transmitted helminthic infections); Sex (eg, females, by virtue of leading a mainly indoor life may be less exposed to sylvatic zoonoses like Kyasanur Forest Disease), Economic status (poverty, squalor and infection form an almost invincible trinity and this needs no further highlighting), Occupation (eg, agricultural workers and veterinarians are much more likely to be exposed to certain zoonoses), Education (by way of improving the knowledge regarding causation and prevention of infection, may help in reducing the chances of exposure), Living conditions (Poor housing, overcrowding, lack of sanitary eating and drinking facilities will all increase the

chances of exposure), Life style and behavioral factors (eg., permissive attitude toward sex will increase the probability of exposure to reservoir of STDs), and use of Personal protective measures (eg, use of mosquito nets and repellents decrease the chances of exposure to mosquito borne diseases).

Host Factors that Influence Occurrence of Infection and Disease

Once the host been "exposed" to the infectious agent, certain factors will determine whether disease will actually occur and the severity of the same. These include "status of host immunity", whether actively or passively (or naturally or artificially) acquired; Age (In general, extremes of age viz., the very young, i.e, < 2 years and the old, > 65 years are more susceptible); Genetic make up (known to occur in respect of diseases like tuberculosis and malaria); and, Availability and utilization of health services (by providing chemoprophylaxis, immunization and health education at the primary preventive level and early diagnosis and prompt treatment)

**Herd Immunity**

Herd immunity refers to the level of immunity that is present in a population against an infectious agent. It is, thus, concerned with the protection of a "population" from infection, the protection being brought about by the presence of immune individuals. It may be defined as "the resistance of a group to attack by a disease to which a large proportion of the members are immune, thus decreasing the probability that a person having the infectious agent will transmit it to another susceptible person in the same population". In general, while dealing with childhood infectious diseases amenable to prevention by immunization, vaccination coverage of about 85% is likely to provide adequate herd immunity, which will effectively block the disease transmission, even if remaining 15% children are not immunized (though there may be many exceptions to this generally held belief).

## Factors affecting the Process of Infection as a result of Interaction between Agent and Host

There are certain features which are peculiar to each infectious disease as follows

**Incubation period**

Incubation period is the time period between the entry of infectious agent (or its toxin) into the human body to the point when the earliest clinical manifestations of the disease are apparent. During this period, the host does not exhibit any outwardly clinical manifestations, though immunological and histopathological changes within the body would definitely occur. If, during this period, the organism is also shed form the body of the host, the host qualifies to be an "incubatory carrier". Incubation period is usually measured in terms of "median incubation period", i.e, the time in which half of the infected subjects will develop clinical manifestations, following entry of the organism into the body. Alongwith the median incubation period, a "range" is also given which indicates the minimum and maximum incubation periods. Incubation period of a diseases is found out by studying the time taken for onset of secondary cases following exposure to the index case, in family groups or in closed communities, or else during investigation of "common-vehicle, point source epidemics. Different diseases have different values of median incubation period and range, and a specialist in Public health should remember them well.

**Latent period**

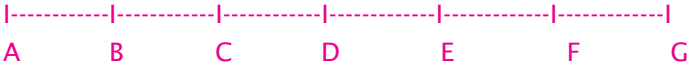
In infectious disease epidemiology, latent period refers to the time that elapses between the entry of the agent in the human body to the point when the shedding of organism.

**Period of communicability (Infectious period)**

This is the duration for which the host sheds the agent, i.e, remains infectious. This may be very long in case of diseases like leprosy and HIV infection.

**Generation time**

The generation time is the duration between the entry of infectious agent into the body to the peak infectivity of the host. As a crude calculation, generation time (G) is equal to (latent period + period of maximum communicability). The relationship between the various landmarks of a typical infectious disease is depicted as follows :-




**Landmarks**

A = Entry of agent into host

B = Shedding of agent starts

C = Clinical manifestations start

D = Maximum infectivity of host

E = Clinical disease ends

F =Shedding of agent ends

G = Convalescence ends

A to B = Latent period

A to C = Incubation period

A to D = Generation time

C to E = Clinical phase

E to G = Convalescence phase

B to F = Period of communicability

B to C = Incubatory carrier phase

E to F = Convalescent carrier

E to G = convalescent phase

C to F = Subclinical (healthy) carrier phase (if clinical disease did not occur).

**Biological Gradient (Gradient of infection)**

Biological gradient of a disease refers to the range of manifestations that may occur in the host as a result of infection. Thus, it is like a "spectrum", ranging from inapparent infection at one end, and passing through mild illness, clinical disease, serious forms of disease, to death at the other extreme of the spectrum. Diseases like viral Hepatitis-A, poliomyelitis and cholera have a classically wide biological gradient with all varieties of severity as outlined above being present. On the other hand, measles and chicken pox tend to have only the middle part of the

spectrum with either subclinical cases or deaths being uncommon. Diseases like rabies occupy only the other extreme of the spectrum, having a very serious biological gradient, with certain death being the only outcome.

**Frequency of disease**

As has been repeatedly stressed in this chapter, the epidemiologist should not go simply by observed number of cases of a disease but convert it into some form of frequency measure (like incidence or prevalence) by relating the number of cases to a denominator (the population at risk). Depending on the "frequency" of the disease, the occurrence may be

(a) "Epidemic"

This is the occurrence of disease frequency, in a defined population or area, which is clearly in excess of the normal expectation.

(b) "Endemic"

Endemic frequency refers to continued transmission of a disease, in a defined population or area, at a relatively low level (without any importation from an outside area or population). It would also be appreciated that the difference between an epidemic and an endemic situation is dependent on two factors firstly, the high frequency and the "abrupt increase" which occurs in epidemic situation, compared to "continued transmission" in endemic settings. Depending on the "frequency" with which this continued transmission is going on an endemic scenario, the endemicity could be described as "hypoendemic" or "low endemic", (incidence being low), mesoendemic, hyperendemic, and holoendemic. In both hyperendemic as well as holoendemic situations, the transmission continues at a very high frequency; however in the latter situation, exposure to infection generally occurs during early childhood so that by the time adulthood is achieved, the population becomes immune and a high level of herd immunity occurs. For this reason, epidemic outbreaks of the disease are not likely in holoendemic situations (the classical example being "stable malaria" situations). The epidemiologist should note that half-hearted or unscientific measures (eg., sudden introduction of insecticidal spray programs without full coverage and without concurrent coverage with surveillance for prompt diagnosis and treatment for a disease like Malaria) would tend to convert a "stable", holoendemic situation into an "unstable" meso-endemic one, thus increasing the propensity to epdemic outbreaks.

(c) "Sporadic"

Sporadic frequency which refers to few, scattered cases of infection, which do not have any relation to each other temporally or spatially (i.e, according to time or place). The difference between a "low endemic" disease and sporadic disease is based on this fine dividing line-that in a low endemic disease, the frequency of disease is low but the cases would show a reasonable relation to each other according time or place which will not be the case in sporadic situations.

**Channels Of Transmission**

The two end points in the epidemiological chain of infection are the infectious agent and the (susceptible) host. Now, to the complete this link, the infectious agent must be transmitted to the susceptible host. Such establishment of the link between agent and host is brought about of two types, viz "direct" and "indirect" modes of transmission.

(a) Direct Modes Of Transmission

A direct mode of transmission is one in which the infectious agent has to be in a state of actual physical or physiological proximity with the susceptible host, or even if not in such proximity, should be within a very close distance so as to be able to directly come in contact with the host.

There are five methods of such direct transmission

(i) Contact of host skin or mucous membranes with the infectious agent contained in a living tissue; eg., sexually transmitted diseases.

(ii) Contact of skin or mucous membranes with the infectious form of the agent contained in inanimate environment. The examples include transmission of hookworm (infective form in soil) and leptospirosis (infective form in water or soil contaminated with urine ).

(iii) Inoculation of the agent, directly from the reservoir into the skin or mucous as in Rabies.

(iv) "Vertical transmission" from mother to child, through the placenta, eg., HIV, syphilis, "TORCHES" agents etc.

(v) Direct transmission due to the agent being within a reasonably close distance of the host, as occurs in "droplet infection". Droplets are actually very finely dispersed aerosol containing the infectious agent, which are formed when a person harbouring the agent in his respiratory tract undertakes such activities like coughing, sneezing, talking etc. if another susceptible host is within a 'reasonably close' distance (usually taken to be 1 meter at the most), such infective droplets can be directly deposited on to the mucous membrane of oral cavity or respiratory passage (i.e, the relevant portal of the respiratory tract infections.) TB, common cold, influenza, measles, mumps, pertusis, diphtheria, meningococcal infection, leprosy etc are transmitted by such mode.

(b) Indirect Modes Of Transmission

An indirect mode of transmission can defined as one in which its infectious agent requires an "intermediary agency" to convey it from the source of infection to the susceptible host. Like for direct modes, there can be five types of indirect modes of transmission

(i) **Vehicle borne :** The various types of "vehicles" which can convey the infectious agent, from the source of infection to the susceptible host include anything which is eaten (eg, food, sweets, milk products, confectioneries and so on, or anything which is drunk (eg, milk, ice, water, beverages etc). Infections of the gastrointestinal tract are classically transmitted by this mode and include

such common examples as cholera, typhoid, hepatitis-A, ascarisis, amoedeasis and so on. A vehicle also would include anything which can be "injected" (eg, blood and blood products, drugs, vaccines, diluents; examples are HIV, Hepatitis B, Malaria etc).

(ii) **"Fomites"** which are defined as inanimate objects of general use by the infected person (eg, untensils, linen, fountain pens, tooth brushes ) The infectious agent may remain on the surface of such fomites and may be transmitted to the susceptible host usually when such objects are put into the mouth or come in contact with conjunctiva.

(iii) **Fingers** : Fingers form a very important mode of indirect transmission. If Contaminated, they can transport a number of gastrointestinal infection (especially, shigella, salmonella typhi, vibrio and Entamoeba).

(iv) **Air** : Often droplets containing the infectious agent may dry up, or may settle down on the dust. Now, if the agent can survive environmental adversaries like drying or heat, it can be carried for long distances by air currents, alongwith the dust or droplet nuclei; and if deposited on the portal of entry of a susceptible host, can initiate infection. Important examples are legionnaires disease, 'Q' fever, tuberculosis, nosocomial infections. Air borne infected nuclei and dust should be differentiated from "droplet infection". As explained, the latter is a 'direct" method of transmission in which the agent is directly deposited from the immediate source of infection onto the portal of entry of a susceptible host, the intervening distance being very short (maximum 1 meter). On the other hand, in an air borne transmission the agent is not directly deposited from the source of infection on to the portal of entry of susceptible host but transported indirectly by air over long distances.

(v) **Vector borne indirect transmission** : A vector is a living invertebrate which transfers the infectious agent from the source of infection to another susceptible host. Usually the term encompasses arthropods, and to a smaller extent, molluscs like snails. Such transmission by a vector could be either "mechanical", in which the vector simply acts as a "fomite", transferring the infectious agent from the host on to another vehicle like food, by carrying the agent on its body surface or in the gut (finally excreting them in the faeces). The common example is of the housefly, which mechanically transmits a number of oro-faecal disease agents from the faeces to the food. Secondly, it could be a "biological" transmission, wherein the infectious agent is transmitted, not simply in a mechanical form, but undergoes, within the body of the vector, one or more of the biological changes pertaining to the stages in its life cycle. Such biological changes may occur in one of the following three ways :-

- Take the example of plague bacillus. After being taken up by the rat flea following a blood meal on the rodent, the bacilli so taken up with the blood, multiply enormously, increasing in number, in the mouth parts of the rat flea. However, there is no developmental change as regards stages of life cycle of the bacillus. Such a method of biological transmission in which the agent "multiplies" but does not "develop" in the body of the vector before being finally transmitted to the susceptible host, is known as "propagative" mode.
- As another example, once a female culex mosquito takes in a microfilaria along with the blood meal, the microfilaria so taken up will undergo developmental changes of life cycle in the body of the mosquito (the three larval stages, finally becoming the infective stage larva). However, there is no multiplication and for each one microfilaria taken up with blood meal, there will be, finally, only one infective form larva. Thus, if the agent undergoes developmental changes in the body of the vector but no multiplication, the same is known as "developmental" or "cyclo developmental" method.
- Finally, let us consider the sequence of events that occur following ingestion of malarial male and female gametocytes along with blood meal by a mosquito. The gametocytes transform into gametes, form a zygote, followed by oocyst and sporozoites. Thus, there are developmental changes pertaining to the life cycle of the agent. In addition, for one each of male and female gametocyte taken in by the mosquito, there will be formed, not one but thousands of sporozoites; thus, if in addition to developmental changes, there is multiplication, it is know as "cyclo-propogative".

Col RajVir Bhalwar

## Investigation of an Epidemic

Investigations of epidemics is one of the most important duties of not only the epidemiologists but for all medical officers concerned with health care of the community. Investigating an epidemic involves a series of steps, as narrated in the succeeding paragraphs. These steps are not necessary to be undertaken in the same sequence. In fact, often, at any given point of time during the course of an investigation, it is quite possible that a number of steps may be addressed simultaneously(58 - 60). In this chapter, we will explain the various steps in detail, alongwith an example of an epidemic which occurred in a large military cantonment.

**Example : Real Life Situation**

Maj. 'X', a classified specialist in Preventive Medicine was posted as Officer Commanding of Station Health Organization (SHO) in a large cantonment. In the evening of 10th May, the Regimental medical officer (RMO) of a large Army camp rang up to inform that 2 cases of diarrhea and vomiting with mild dehydration had occurred and he was referring them for admission to the dependent large military hospital. The Army camp was meant to provide accommodation and messing to almost one thousand army personnel, mainly clerks and office runners, working in various large Army offices located at various places in the city. There were four "messes" with dining halls (named 'A', 'B', 'C', and 'D' mess) to provide for meals, besides a canteen run by a contractor to provide snacks. These army personnel used to leave early morning in buses for their respective offices, after breakfast and used to carry packed lunch. They used to come back in late evening from their respective offices and have their dinner in the camp, before going to bed. Another about 300 personnel were staying with families in family quarters located in close vicinity of the camp and shared the same general piped water supply and sewerage system (from military engineering sources). These family members also used to go to the same offices with the single staying personnel. There was a small cantonment market nearby with all daily requirements available. (Dates, locations and number of personnel have been slightly

### Step 1 : Verification of the diagnosis

The earliest report regarding an outbreak is often obtained from a non medical or paramedical person. Often the initial report is not in the form of particular diagnosis but rather in the from of a "syndromic" constellation of symptoms and signs (eg, outbreak of diarrhoea and vomiting , or fever and skin rash). It is therefore essential to verify the diagnosis of the condition that one is dealing with in epidemic form. This also helps in developing the epidemiological case sheet and planning the laboratory, environmental and entomological procedures for investigations. At this point, talk in detail with the patients (cases), about their signs / symptoms, about their movements, about the possible exposures and what they think could have caused their present illness, and whether they know of similar cases in their neighbourhood, workplace or among friends. Recording as much details at this point of time may be of great value later when hypotheses are being developed. Verification of the diagnosis is usually made on clinical, laboratory and epidemiological parameters. Most important are the clinical parameters. In real life situations, it may not be necessary to confirm 100% cases by lab parameters; a 20% to 30% random sample, if confirmed by lab tests to be having similar disease should be adequate. At this point it is also very wise to describe the distribution of various signs / symptoms according to frequency distributions, which greatly helps in suggesting the diagnosis and also in developing the case definitions.

**Continuing with the example of the real life situation,** To start with, a "syndromic" diagnosis of "gastroenteritis, without fever & with moderate dehydration" was made. The possibilities which were kept within this tentative diagnosis were food poisoning (due to either of *S aureus*, non-typhoid salmonella, *C perfringens, B cereus*); cholera; ET EC gastroenteritis; and algid malaria. The patients were contacted by the SHO at the hospital in the night itself and a quick clinical history and examination was done, and cases were discussed with the Medical splt and Pathologist. Both the patients were young soldiers working in the same office and dining in the same ('B') mess. They had 1-2 bouts of vomiting in the afternoon, followed by 4-6 watery loose motions and felt "weak". There was no fever or tenesmus or blood / mucous in the stools. Except for moderate dehydration, physical examination was non-contributory. GBP, PBS for MP, and stool examination for microscopy, hanging drop and culture for enteropathogenic organisms was requested.

### Step 2 : Confirm the existence of an epidemic

An epidemic is defined as "occurrence of a disease in a frequency which is clearly in excess of the normal expectations". Thus, having verified the diagnosis, one must work out the incidence rate, by dividing the total cases by the population at risk. This rate is compared with the rate occurring in the same population, during the corresponding period of the past three years. Often, the decision as to whether the present rate is clearly in excess of the normal expectations (based on past three years' rates) is taken on the basis of informed and experienced judgement, through various statistical procedures for calculation of "control limits" are available to further assist in such decision (see Chapter on "surveillance" in this section for details). Quite often, in such situations, rates may not be able to be calculated in such an emergency and so, numbers may be compared. Usually, comparison is done of the present rates (or number of cases) with those

## General guidelines for "syndromic approach" to "common epidemic prone" diseases

Quite often, reporting of epidemic is often in the form of a "syndrome". Moreover, laboratory diagnostic results may take time to be available and till then the epidemiologist has to proceed with some tentative diagnosis, to give some direction to his investigations. The following list is intended to provide a general reference for the epidemiologist in the field, till definitive results are available.

### Syndrome of fever without rash

**Usual manifestations** : Sudden or insidious onset with fever of continuous, biphasic or recurrent type; frequently headache, myalgias, arthralgias; sometimes GIT manifestations, polyadenopathy or hepato-splenomegaly;

NO specific localizing sign.

**Common Diseases** : Vivax Malaria; Enteric fever; Leptospirosis; Uncomplicated Dengue fever (without haemorrhages or shock; Chikungunya (without

### Syndrome of haemorrhagic fever

**Usual Manifestations** : Onset with fever and systemic symptoms; often a second phase of fever after 3 to 5 days with cutaneous haemorrhages (petechiae, ecchymosis or puncture oozing); sometimes internal bleeding (haemetemesis, malena, haematuria, vaginal bleeding); sometimes jaundice with or without terminal shock syndrome.

**Common Diseases** : Dengue Haemorrhagic Fever or DSS; Kyasanur Forest Disease; Lassa Fever; Chikungunya (very few patients would have

### Fever & respiratory manifestations

**Usual manifestations** : Onset with fever and often fatiguability; sometimes systemic manifestations; cough; dyspnoea; chest pain; persistent or blood stained sputum.

**Common Diseases :**

URTI :Pertusis; Influenza; Acute bacterial or viral pharyngitis.

LRTI :Streptococcal pneumonia; Pneumonic plague; Influnza, SARS, Avian influenza; Pulmonary anthrax (keep possibility of bio-terrorism).

### Syndrome of fever & lymphadenopathy

**Usual Manifestations** : Onset with fever and systemic symptoms; Lymphadenopathy (generalized or localized; supputrative or non-suppurative)

**Common Diseases** : Bubonic plague; kala azar; hyperendemic filariasis.

### Syndrome of fever with jaundice

**Usual manifestations** : Initial phase with only fever and systemic symptoms; sometimes there may be no such initial phase; jaundice; sometimes haemorrhages.

**Common diseases** : Viral Hepatitis 'A', and 'E'; Viral hepatitis 'B' (due to common parenteral experience); sometimes Leptospirosis

### Syndrome of fever with rash

**Usual manifestations** : Onset with fever and systemic symptoms; macular, papular, vescicular or pustular eruptions, either generalized or localized to certain parts of skin or mucous membranes; eruptions are NOT haemorrhagic.

**Common Diseases** : Chickenpox; Measles; Rubella; Typhus group of fevers (scrub, louse borne, murine and tick borne typhus); Meningococcal bacteraemia.

### Syndrome of fever & neurological manifestations

**Usual manifestations** : Onset with fever and systemic manifestations; signs of meningitis or encephalitis or paralysis of central or peripheral type.

**Common Diseases :**

Mainly paralysis : Paralytic poliomyelitis.

Mainly meningitis : Meningococcal meningitis

Mainly encephalitis : Japanese encephalitis

### Fever with GIT Manifestations

**Usual manifestations** : Fever; nausea / vomiting; diarrhea with or without blood or mucous; abdominal cramps; systemic manifestations usually mild or absent; sometimes neurological manifestations or rash may follow.

**Common Diseases** : Non-typhoid salmonella food poisoning; Shigella dysentry; Enteroinvasive / Enteropathogenic *E coli* diarrhea; rotaviral enteritis especially in children; Giardiasis; Amoebiasis; Yersinia or Campylobacter food poisoning.

### Syndrome of "Afebrile" illness

**Afebrile neurological disease** : Convulsions, shock or GB syndrome (search for common vaccination history); botulinum food poisoning; Organophosphate Insecticide poisoning (food borne or after spray); mushroom poisoning.

**Afebrile GIT illness** : Cholera (epidemic 'O' Gp); Food poisoning due to *S aureus*, *C perfringens, B cereus, giardiasis, V parahaemolyticus;* (common-vehicle-food-borne)

**Afebrile Conjunctivitis** : Bacterial or adenoviral.

**Afebrile rash** : Swimming pool associated dermatitis.

**Afebrile genito-urinary syndrome** : Gonorrhoea, Chanroid, HSV

Table - 1

| Sr No | Name | Age | Sex | Residential address | Work-place address | Date / time of onset of symptoms | Main symptoms/ signs | Name / address of medical facility |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | 1 2 3 | |

of corresponding time period of preceding three years. For finding out as to what is the "normal" expectation during the period being compared with, we use the existing data based on records of hosp admission and discharge data and if these are not available, find out from various physicians in the community whether they have been observing more number of cases with the given set of symptoms recently; or, lastly, undertake a survey of the community to get an idea of the baseline (historical) data. Ultimately pragmatic considerations are also important as to whether to investigate or not. There could also be situations when a single case of a disease may be enough

**In Our Example :** With 2 cases out of 1000 personnel staying in the camp, the rough incidence was worked out as 2 per 1000. Daily epidemiological surveillance system available with the SHO indicated that maximum of one case of gastro-enteritis with dehydration could be expected in a day in that military station, during that part of the year. Moreover, since "cholera" was also one of the possibilities, it was decided to tentatively consider the situation as one of "epidemic". The Sr Exec Med Offr (SEMO) of the cantonment (Commandant of the military hospital) and Dy Dir Med Services (DDMS) of the Area HQ were intimated for their permission to investigate and their administrative & technical help was sought.

to call for investigations, eg, a suspected case of plague, or in many of the military situations, even a single case of cholera.

### Step 3 : Develop an Initial (Rough) "Line-listing" of cases

A line list is like a nominal roll of the cases which have already been reported to the various health care establishments (like MI Room, OPD, or admitted to the hospitals) till now. Line listing of the cases is a major help in initial definition of the disease / syndrome that has occurred in epidemic form, in delineating the population at risk & in preliminary definition of the transmission dynamics of the epidemic according to place and time. A line list is a serial, chronological listing of all the known cases till now, as per the following headings in Table 1

### Step 4 : Define the population at risk

By knowing the general population from where the cases have been coming, as evident from the initial line listing and subsequently from the details of cases as recorded on the epidemiological case sheet (see below), one can define, in a demarcating manner, the source population. For example, the population at risk may be defined as "19 Satpura Battalion", or " Units and family lines under GE (South)" or "Male cadets of AFMC", etc. The more clearly

**In Our Example** : Urgent telephonic calls were made to the various RMOs in the city whether similar cases of gastroenteritis were seen by them on that day. The duty Medical Officer of the hospital was asked whether any other case (other than the two in question) with similar symptoms were also admitted to the hospital that day from some other military units. Since there were no other case, these two were taken as the initial cases and their details were noted on a line list as per format already discussed above. Since both these cases were from a single unit, "people living in that particular military camp" were defined as the "population at risk".

such source population is defined, better the results of investigation would be.

### Step 5 : Develop valid case definition

Often the search for additional cases would involve a number of medical officers / paramedical personnel. It is therefore important that the investigator develops case definitions which are adequately sensitive (i.e. include all those who are having the target disease, though this may entail including many who do not really have the disease) as well as adequately specific (exclude all those who do not have the target disease, though many mild or equivocal cases of the disease may also be missed out). Apparently, the case definitions should be developed in a way that there is adequate trade-off between both sensitivity and specificity. Development of proper, standardised case definitions is important to ensure uniformity during the investigations. For practical purposes, it is better to have cases in three categories, viz., definite, probable and suspect. Initially during the

**In Our Example** : The case definitions were developed as :- Suspect case (for use by the paramedical nursing / health assistants) : any person with at least one vomiting and 2 episodes of watery loose motions in a day; Probable case (for use by RMOs and Duty Med Offrs) : suspect case criteria plus no fever , no tenesmus, and no blood in stools; Confirmed case (for use by SHO for investigating the epidemic) : probable case criteria plus laboratory demonstration of ETEC / V cholerae / salmonella sp / Shigella sp / Giardia / Entamoeba from

investigations, while formulating the hypotheses, it may be desirable to have more sensitive definitions, and later, as the hypotheses are being refined / tested, the definitions may be made more specific by removing the "suspect" category.

### Step-6 : Develop the epidemiological case sheet

The epidemiological case sheet is an extension of the clinical case sheet on which, for each and every subject, the personal and clinical details are filled up. In addition , the details of all factors which are relevant to the mode of transmission for a period which is equal to the range of incubation period of the disease, going back from the date / time of onset of symptoms, are also recorded. For example, in an outbreak of cholera, the epidemiological case sheet would include the personal particulars, clinical features, laboratory investigation results, and details of all meals, casual meals, snacks, sources of water supply, drinks, soft-drink etc, consumed by the person between 1 day to 5 days prior to the onset of symptoms. Thus, if the patient had onset of first symptoms of cholera on 10 Aug, we will record all these relevant factors for the period of 06 to 09 Aug. In addition, it will also include details of his movements in time and place during I day to five days prior to the onset of symptoms (i.e., the range of incubation period of cholera).

**In Our Example** : Maj 'X', as the SHO, had been undertaking regular visits to the various units in health cover, to assess various aspects of hygiene & sanitation, during the past one year, since she had joined. She could identify that the disease being investigated would have come from either of drinking water being provided through water coolers placed in each of the mess and each barrack; or from food which was prepared in the various messes; or from some snacks / Lassi consumed at the unit run canteen; or from water consumed from coolers at workplace; or from one of the two sugar-cane-juice stalls or a sweet-meat shop in the cantonment market; or a "bara-khana" (unit level community feasting) which was held in the unit on 8th May. These various possible factors which could have led to the transmission were specifically kept in the epidemiological case sheet. By now, the hospital laboratory had intimated that organisms with darting motility were seen on hanging drop exam from the two patients; hence the diagnosis was finalized as "cholera" and it was decided to record the history of these various transmission factors for a period of 1 to 5 days, retrospectively from the date of onset of symptoms.

### Step-7 : Organise the laboratory (including Entomological and public health lab) work

A very important step in epidemic investigations is laboratory work. This would include collection, storage and dispatch of body samples (blood, CSF, stool, throat swabs, rectal swabs etc), environmental samples (water, food items), entomological samples, and animal samples. It would be extremely desirable to consider what all items would be required for such laboratory procedures keeping in view the possible disease which is being investigated.

**In Our Example** : Maj 'X' had kept her SHO laboratory in a state of constant readiness to deal with any such public health emergency. However, she once again had detailed discussions with the hospital pathologist as regards various samples to be taken and their method of dispatch to the lab. She quickly organised a portable container having gloves, rectal swabs, rectal catheters, sterile Winchester bottles, specimen vials having Cary-Blair transport medium, sterile vials, centrifuge, and personal protective equipment. She decided to collect and dispatch stool samples / rectal swabs, food samples, water samples and serum for immunology.

Close liaison with the local hospital laboratory and with the pathologist / microbiologist needs no emphasis.

### Step 8 : Contact administrative and engineering authorities and establish rapport

In a service set up, it is extremely important to explain the objectives and requirements to the unit/stn cdr and est close rapport with them. This way a lot of information can be obtained without any resistance. Similarly, it is also desirable to establish close rapport with the engineering auth since a substantial part of investigations is likely to be directed towards public health engineering systems like water supply, excreta disposal etc. The layout maps of water supply and sewerage system should be obtained from the eng/adm authorities.

**In Our Example** : Maj 'X' had kept "spot maps" showing hygiene and sanitation of various military units under her health cover, and constantly updated them after her regular visits to units. She had also liaised with MES authorities and kept updated maps of water supply and sewage disposal systems. However, she once again contacted the MES authorities and asked for their assistance in conducting the investigations. She also sought the sanction of DDMS and SEMO to undertake the investigations. Thereafter she contacted the Commanding Officer of the affected military unit, took him into confidence and discussed the details as to how the investigations would be undertaken. Finally, she had discussions with lower level MES functionaries, with the junior functionaries of the affected unit (JCOs / OR) and with the paramedical members of her investigative

### Step 9 : Collection of Information

Having undertaken the preliminary steps, the investigator proceeds to collect the information, recording the details on the epidemiological case sheet for each subject. Information is collected in respect of all possible modes of transmission which are relevant to the disease being investigated, and going back for a period which is equal to the "range" (difference between maximum and minimum) incubation period of the disease, going back from the time of onset of first symptom. For example, in an epidemic of hepatitis A, we would ask for details of sources of regular meals, casual meals, water, milk, sweets, snacks, and so

on, from the date of onset of symptoms and going back for a period of two to 6 weeks. The information is collected from the following sources :-

**(a) From the cases**

The persons who have already reported to the health care facility (MI Room/OPD or admitted to the hospital) now (as indicated in the line list) or who report subsequent to the initiation of investigations are the straightway available source of information.

**(b) Search for additional cases and make the final "line-list"**

The cases who have reported to the health care facility may not represent the entirety of epidemic. Many cases may be lying hidden in the community, being mild cases, or those who may have reported to some other agency for treatment. It is therefore mandatory to search for additional cases so that the complete picture of the epidemic may be obtained. Using the standardised case definition, an extensive search is made using door to door survey in the entire population defined to be at risk. In case of very large populations, a random sample (usually a systematic sample) can be taken. The population must be informed well in advance about the search, through mass-media, announcement systems, fixing hand-bills describing the symptoms and requesting the people to report the disease, Part -I Orders, evening roll calls, etc. Apparently, assistance of adm authorities would go a long way in this process. In addition, other health sources like other hospitals and general practitioners in the area may also be contacted to find out additional cases. In addition to clinical and epidemiological information, laboratory specimen, as applicable, should also be obtained in the field, from suspected cases. Fill up the epidemiological case sheet for cases detected during the search.

Now, a final line list is made. It would include a list of all cases, including those detected on search for additional cases, in a chronological order as they occurred, showing their personal particulars, date of onset, place of stay, place of work and all exposure histories that are relevant to the disease (eg, sources of meals and water in case of an epidemic of oro- faecal disease). A review of the line listing of cases will give important clues as regards the various possible sources of exposure - these would be those exposures which are commonly shared by the cases, as seen in the line listing.

**(c) Environmental information**. Besides clinico-epidemiological information from cases, a detailed environmental assessment is made of the area, depending on the disease one is investigating. Thus, while investigating an epidemic of cholera , one would make a detailed assessment of water supply system, nightsoil disposal system, cook houses and other eating/drinking establishments in the area where the defined population is staying. Similarly, in a suspected epidemic of dengue, one would make a detailed environmental assessment of vector breeding areas. In addition, various environmental samples (eg, water, food, etc) and entomological samples (eg, larval and adult mosquitoes) would also be collected as relevant.

**(d) Information for those who did not suffer from the disease**. This is a very important step which is often overlooked. While search for additional cases is going on, one must record the information regarding possible exposures (eg, movements, sources of meals, casual meals, snacks, water, drinks etc.) not only from those who suffered from the disease symptoms, but also from those who were a part of the population at risk but did not suffer (i.e., the controls). This information from controls is of vital importance in the later part of investigations, when hypothesis regarding various suspected exposures are to be analysed by comparing cases and controls.

**In Our Example** : By now a total of 7 cases had been admitted with same presentation. All were from the same unit and all showed growth of V cholerae Biotype O-1, serotype Ogawa from stool samples. The line list was accordingly revised. All cases were interviewed personally by Maj 'X' and detailed information about various transmission factors was recorded on the epidemiological case sheet for the retrospective period of 1 to 5 days from date of onset. Cases were also asked in detail about any other factor which could have led to the transmission and which might not have been included in the epidemiological case sheet. In this regards, 5 of the cases said that they had also been often going to a kiosk selling "fruit chaat" (mainly water melons) which had come up in the cantonment market recently; accordingly, this was also included in the epidemiological case sheet.

All the units in the cantonment were asked to announce the "suspect case definition" during evening roll calls and Part-1 orders and direct any person or family member having such symptoms to their respective RMO. The RMOs were asked to refer any person or family fitting into "probable case definition" to the hospital for admission and also inform the SHO. The Health Assistants & Lab of SHO went "door to door" in the affected unit including their family quarters and asked if any person had suffered with symptoms fitting into "probable" case definition; if yes, their stool samples

**In our Example** : A team of the SHO and MES staff conducted a detailed physical, on ground check of water distribution and chlorination system and sewage pipe lines. Water and food samples were taken from all messes, water coolers, eating joints in the market and water taps in work-places. These samples were dispatched to hospital lab. Water supply pumps in the affected unit were run for continuos 3 hours by MES, while the ground was being observed. At one place, there was apparent moistness on the ground overlying a major water pipeline. The affected ground was dug open and it was noticed that there was a break in the water pipe line at that spot; this water pipe line was running approx. 5 feet above a sewage pipe which was also slightly damaged. These were immediately repaired. However, this particular water pipe was a main trunk, which was supplying water to the entire affected unit as

well as the adjoining family quarters and not to any single mess.

No other case could be confirmed despite extensive search for cases. Hence information was recorded on the epidemiological case sheet from the seven cases. In addition, 50 healthy people (who did not even fit in the definition of even suspect or probable case), from the same affected military unit were selected from the list of personnel supplied by the unit authorities, by systematic random sampling and all information about various transmission factors as recorded from cases was also recorded from these "controls".

## Step 10 : Describe the epidemic

Once the information has been obtained, an epidemiological description of the epidemic is prepared. This description is vital for developing hypotheses regarding various possible sources of exposures that could have caused this outbreak. The description of epidemic would include:-

**(a) Developing the overall attack rates,**

Developing the overall attack rates using the cases (reported to health care facility plus found during additional search) as the numerator and the population defined to be at the risk at the denominator.

**(b) Describing the clinico epidemiological profile.**

This would include a percentage wise distribution of clinical presentation among the cases a description of the mild/moderato/severe forms, and fatalities.

**(c) Describe the cases according to distribution of person related variables.**

This step involves development of proportional distribution of cases according to relevant, person related variables like age, sex occupation, source of water supply , etc . The detailed line list described in the preceding paragraph is used to describe the cases according to all possible exposures. For example, in an epidemic of cholera, description of cases according to person related variables will include their distribution according to age groups, sex, occupation, place of regular meals, sources of drinking water, sources of casual meals / snacks, etc.

**(d) Describe the epidemic according to time.**

An epidemic is described according to time by plotting an epidemic curve. This curve is developed by plotting the attack rate along the vertical (Y) axis and unit of time along the horizontal (X) axis. The unit of time would depend on the disease; in food poisoning epidemic it would be in hours, in days for cholera and in weeks for Hepatitis A or E outbreaks. Often, it may not be possible to compute the attack rates according to time; in such instances, the epidemic curve may be prepared by plotting the actual number of cases along the vertical axis, instead of attack rates. The shape of the epidemic curve give us important leads as regards the cause. For details of the shapes of various epidemic curves and their interpretation, refer to the chapter on descriptive epidemiology.

**(e) Describe the epidemic according to place.**

Description of the epidemic according to place is given by making the spot map of the area on which the frequency of the disease is plotted as coloured dots. Often, instead of plotting the frequency, only the actual number of cases are plotted and this may be simple and effective method too. Sometimes, different spot maps may have to be developed, eg, separate spot maps for place of residence , place of work etc, depending on the possible places where exposure to disease could have occurred. For example, in a suspected epidemic of scrub typhus, we may have to prepare separate spot maps for cases, according to places of residence, place of work, places visited on patrolling all for a period equal to the range of incubation period of the disease, going back from the day of onset of signs / symptoms. Spot map also gives important insight in to the possible causes of the diseases. One would be inclined to develop possible hypothesis regarding the cause of the outbreak, considering those places where the local concentration of cases is high.

**(f) Describe the environmental conditions just before and**

Table - 2 : In our example, the following was the description of the 7 cases, according to history of major transmission factors as were recorded in epidemiological case sheet as shown

| | | | | | |
|---|---|---|---|---|---|
| Living in barracks | 7 (100%) | Age < 35 yrs | 6 (85%) | Took sugar cane juice from kiosk No. 1 | 5 (72%) |
| Living with family | 0 (0%) | Age > 35 years | 1 (15%) | Took fruit chaat from market | 6 (85%) |
| Eating in 'A' mess | 0 (0%) | Took water from workplace No. 1 | 4 (58%) | Ate during barakhana on 8th May | 6 (85%) |
| Eating in 'B' mess | 6 (85%) | Took water from work place No. 2 | 2 (28%) | Had snacks / Lassi from unit canteen | 5 (72%) |
| Eating in 'C' mess | 0 | Took water from workplace No. 3 | 1 (14%) | Ate sweet-meat from cantonment shop | 2 (28%) |
| Eating in 'D' mess | 1 (15%) | Male sex | 7 (100%) | Ate snacks at workplace | 2 (28%) |

In our example :- 2 cases had onset on 10th may, 3 on 11th and 1 each on 12 and 13th may. There was no case thereafter. The 7 cases were plotted according to the date of onset of their symptoms. The resultant curve showed a sharp rise, a sharp peak and an abrupt fall, indicating a "common vehicle, single exposure (point source)" transmission. It indicated that all these cases had probably got infected at a common source which existed only for a brief period of time, as can occur when a particular meal or drink gets contaminated, or a water storage cistern gets contaminated for a small time till the water is used, or when a infected food handler who is "incubatory carrier" contaminates a food or drink for a brief period of time, before himself coming down with symptoms.

3 different spot maps were made according to workplace, place of staying and place of routine eating and drinking, and cases were plotted as coloured dots on these maps. A clear-cut "clustering" was seen in all the three maps in mess No. 'B', at workplace No 1. and in Living barrack No. 4 and 5. Further assessment indicated that large majority of these cases were staying in barrack No. 4 and 5, as well as eating in Mess 'B' and

**during the outbreak.**

A clear description of the findings of environmental and entomological assessment is given. For example, details of damaged water supply lines, cross-connections with sewer lines , unhygienic conditions in cook house, vector breeding and densities are described and efforts made to correlate these finding with description of epidemic according to line listing and distribution according to person, place and time, thus developing various hypotheses regarding possible causes of the outbreak. It is often worth while to superimpose these environmental findings on the spot map for a quick visual evaluation.

### Step 11 : Developing various alternative hypotheses regarding the cause of outbreak.

Once the epidemic has been described according to its clinico-epidemiological profile, line-list, and distribution according to person, place and time, various hypotheses are developed regarding possible cause(s) of the outbreak. The basis of developing these hypothesis is to start with the descriptions of cases according to various person, place and time related variables and see as to what are the possible exposures which are very common among cases. If the investigations have been done rightly till now, a large number of hypotheses will be developed.

### Step 12 ; Testing the hypotheses : Comparisons using analytical epidemiology .

**In our example** : The factors which were very commonly found in a large proportion of cases were male sex, staying without family, age < 35 years, eating meals in mess 'B' or drinking water from its water cooler, drinking water from water cooler of work-place No.1, staying in barrack No. 4 or 5, having lassi or snacks from unit canteen, eating barakhana on 8th may, consumption of sugarcane juice from kiosk No. 1, and eating fruit-chaat from the market. These were kept as possibilities which could have transmitted the organism (hypotheses). On the other hand, eating snacks at work-place, eating sweetmeats from cantonment shop, eating / drinking in messes Nos. 'A', 'C', or 'D' or drinking water from workplaces No. 2 and 3, were very uncommon among cases and hence not kept as "hypotheses" requiring further exploration.

This step is the backbone of epidemic investigations. A comparison is made between the cases, and those who did not suffer, though being a part of same source population (controls), in respect of each and every possible hypotheses developed in the previous step. The Odds Ratios for each of these exposures are calculated and their statistical significance is seen by 95% confidence interval of odds ratios, or more simply, by a chi square test. Thus, out of the various hypothesized exposures, one would find out one particular exposure in which the cases and controls differ significantly and this is, then, the likely source of the outbreak (See Table - 3)

Further exhaustive search is now made, based on the indications given by the preceding step, to explore in detail as to what could have been the reason for transmission of the organism.

**Final Laboratory proof of cause and effect relationship** . This is a difficult proposition, but if done, can give the final

**In our example** : Once the results of hypothesis testing step focused the suspicion on 'B' mess, the conditions in 'B' mess that existed at the time of the outbreak were further evaluated. Extensive study of hygiene and sanitation of cook house and dining halls, drinking water storage and handling, health state of food handlers and cooking / food serving practices were evaluated. It was noticed that the tap of the water cooler was not functioning and hence drinking water was drawn manually by civilian mess waiters, by immersing a "jug" into the cooler. Water samples were dispatched fro bacteriological exam. There were total of 9 civilian food handlers, including 2 cooks, 2 cleaners and 5 waiters in the 'B' mess. 1 of the waiters (named herewith as waiter No. 'Q') had not reported for duty because of "upset stomach" from 10th may to 13th May. Clinical exam of all these food handlers was undertaken and rectal swabs of all 9 were dispatched to the laboratory

proof of the cause and effect relationship. For example, if the same organism that is isolated from the food handler, who has also been incriminated by analytical epidemiology (case control step above), is also isolated from the cases, then the link is finally proved. However, it is not necessary that this step must always be completed, though best efforts should be made. In most of the real life situations, description of epidemic and test of hypotheses

Table - 3

| In our example, comparison of the 7 cases and 50 controls as regards the 6 different hypothesized factors indicated | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Hypothesized factor** | **Cases** | **Controls** | **Statistical results** | **Hypothesized factor** | **Cases** | **Controls** | **Statistical Results** |
| Eating in 'B' mess | 6 (85%) | 11 (22%) | $p < 0.001$ | Fruit Chaat | 6 (85%) | 39 (78%) | $p > 0.05$ |
| Water from workplace no. 1 | 4 (58%) | 32 (64%) | $p > 0.05$ | Barakhana | 6 (85%) | 44 (88%) | $p > 0.05$ |
| Sugar cane juice | 5 (72%) | 38 (76%) | $p > 0.05$ | Lassi / snacks from canteen | 5 (72%) | 35 (70%) | $p > 0.05$ |

based on analytical epidemiological are enough proof of the cause.

## Control and Prevention

**In our example** : Water samples from water cooler showed very high coliform count of 180 per 100 ml but no *E coli*. Rectal swab of the food handler 'Q' grew *V cholerae* O-1 Ogawa, i.e., the same biotype and serotype as was isolated from the 7 cases.

Steps for immediate control measures and long term prevention should not wait for the final proof of the cause of epidemic but should start immediately and continue concurrently as the investigations proceed. The following broad categories of steps are to be undertaken:-

**(a) Measures directed towards the source of infection**

These would include detection and treatment of cases and carriers, isolation if required, notification, and control of zoonotic reservoir if applicable.

**(b) Actions directed towards channels of transmission**

These would include measures like protection of water supply and food hygiene, vector control, proper disposal of night soil and solid waste, various disinfection procedures, etc, depending on the disease.

**(c) Protection of susceptible population**

This includes steps like immunization, immunoprophylaxis, chemoprophylaxis, personal protective measures etc.

**(d) Developing a long term early warning system**

A proper epidemiological and public health surveillance system should be developed and launched, so as to give ongoing data regarding the frequency of disease and changes in various environmental risk factors, with a view to give early warning of impending outbreaks. Details of surveillance are discussed later.

## The Armed Forces Central Epidemiological Surveillance Centre (AFCESC)

AFCESC has been established at Dept of Community Medicine (PSM), AFMC. This est is headed by Prof & HOD of the dept of PSM, and consists of a team of classified splts in Epidemiology, Medicine, Microbiology and Entomology, who are all faculty members. The functions of this est include :-

(a) Keeping "Mobile Epidemic Investigations Team" consisting of the epidemiologist, physician, microbiologist, and entomologist ready for moving to any location, if so directed, to assist in investigations and control of epidemics. Move of the specialized team is on the directives of the DGAFMS / Commandant, AFMC, Pune.

(b) Developing a surveillance and early warning system for all the important, epidemic prone diseases, in the armed forces.

(c) Establishing a Central registry for various important diseases in the armed forces.

(d) Assisting Medical officers and Specialists in the periphery to undertake investigations, as and when requested and to develop protocols for investigations of common epidemic prone diseases.

Further information on the above mentioned organisation and its objectives may be obtained from :- Officer i/c, AFCESC & CDR, Dept of Community Medicine (PSM), AFMC, Pune 411040; e-mail : psmafmc@rediffmail.com; Tele : 020 (2630) 6029, 6031, 6032, 6339

## Investigating an outbreak of food poisoning

**In our example** : Super-chlorination of water supplies to bring the level of free residual chlorine at consumer end point at 1 ppm was ensured from the very first day the epidemic was reported and was periodically checked by SHO staff. As investigations proceeded, the damaged water pipe lines and sewage lines were promptly repaired. The cantonment market and civilian canteen were ordered to be placed "out of bounds" for all ranks and families on 12 may, till further orders. The food handler 'Q' was removed from duty for 5 days and treated with oral tetracyclines at the cantonment general hospital; all other food handlers, though not found infective were given a presumptive dose of oral doxycycline, on orders issued by DDMS. The damaged tap of the water cooler in 'B' mess was repaired and the top lid was closed and locked. Unit RMO was provide guidance to launch a daily surveillance system for diarrhoeal diseases and their reporting to SHO. Cook house in-charge NCOs were trained to undertake regular, daily medical surveillance of all food handlers.

**Some Tips for Specialists in Preventive Medicine and Medical Officers of Armed Forces for Readiness For Investigating Epidemics**

Officers Commanding Station / Field Health organizations (SHO / FHO) and Medical Officers in charge of health of troops and families should develop readiness for investigating and controlling epidemics and public health emergencies. Some tips to ensure such readiness are:-

- Know your area and the clientele very well. Move out regularly of your offices and scan the area on foot. Where all are the personnel and families staying? Where all do they eat and drink, not only regular meals and water supply but also casual meals, snacks and drinks? What are the defects in water supply and sewage disposal systems? Where are the potential vector breeding areas? Where all do the troops and recruits from training centres go for their patrolling? For their camp training? It is a thorough awareness of all these factors in respect of your clientele that will come greatly handy while developing hypotheses regarding various exposures. There is no short-cut to these painstaking steps. It has been rightly said that a public health specialist need not be necessarily a good epidemiologist but a good epidemiologist has to be a good public health specialist.
- Identify the common epidemic prone diseases in your area. You would be able to do that on the basis of previous records of disease occurrence and your own assessments of the health conditions as said above.
- Maintain a good liaison with engineering authorities. Get the maps of layout of water supply and sewage disposal systems and check them on ground. Keep "spot maps" showing various aspects of geographical layout and areas with adverse hygienic conditions, ready and continuously updated.
- On the basis of the common epidemic prone diseases in your area of health cover as well as the various observations regarding the health related habits of your clientele, as explained above, keep draft "epidemiological case sheets" ready. For example, in case there is an outbreak of viral hepatitis A, I may ask about the history of source of routine water supply, about snacking at a particular wet canteen, about drinking sugar-cane juice from a particular vendor, about consumption of sweets from a particular shop in the training camp area and so on.
- Again, on the basis of the commonly expected epidemic prone diseases in your area, keep your laboratory and entomological procedures ready the equipment and expendables required to collect, store and dispatch the samples. Ascertain well in advance from the pathologist as to what all tests she can undertake at the local hospital? If some test is necessary but is not available at the local hospital, where would the samples be sent and how they will be dispatched?
- Keep your ongoing surveillance for common diseases in place and well established (details are given in next chapter). This will greatly help you in detecting any potential outbreak at a very early stage.
- And, finally, in the event of an outbreak, BE THERE at the site. Your presence may make the difference for

Investigations of an outbreak of food poisoning, takes the same general approach as any other epidemic, as has been outlined earlier. However, there are certain differences in approach, vis a vis the details often described in other textbooks. In a civilian setting, where generally all people live and eat separately, the "common" meal (as a banquet, religious get-together, picnic etc.) can be easily identified and the details of food histories of that meal can be obtained. On the other hand, in armed forces settings, the fact that personnel live and eat all meals together, every meal is a common meal, and hence identification of the common meal which caused the episode of food poisoning may not be as simple a common-sense conclusion. For instance, if 25 soldiers from an infantry company, eating from a common cook house are admitted with symptoms of gastro-enteritis between 9 a.m. and 3 p.m. on 10 May, which meal do we investigate whether breakfast of 10 may, or dinner of 9th may or lunch of 9th May? Secondly, the idea of investigations is not simply to incriminate a given food stuff. The goal is to trace back the entire history of that food item to find out why contamination occurred so that the episode does not repeat. We shall deliberate on the steps to be undertaken for investigating an outbreak of food poisoning, illustrating it with a real-life example. (The location and general settings have been slightly modified in the example, for reasons of confidentiality).

**Step 1: Confirm whether it is an outbreak?**

An outbreak of food poisoning has three characteristics firstly, the symptomatology should be usually referable to GIT (and sometimes systemic in case of mushroom or organophosphate etiology or neurological in botulinum etiology). Secondly, a large number of cases should occur in a small period of time. Thirdly, the cases should have some history of sharing at least one common meal. If these three criteria are fulfilled, we would say that it is an outbreak of food poisoning.

**Step 2 : Verifying The Diagnosis & Deciding Which Meal To Investigate?**

In a food poisoning episode one has to decide as to which meal is to be investigated and this is done by making a "tentative" verification of diagnosis mainly on clinical grounds. While microbiological diagnosis is always desirable, for all practical purposes it is extremely difficult to establish lab diagnosis quickly because the procedures are highly specialized, available only at specialized centres and take time; more important, the food samples are themselves usually not be available due to ignorance or deliberation on the part of food handlers. For example, lab confirmation of C perfringens food poisoning requires

Table - 1

| Etiologic agent | Median incubation (range) | Nausea / Vomitting | Loose motions | Abdominal Cramps | Fever | Blood / Mucous in stools | Neuro-muscular symptoms |
|---|---|---|---|---|---|---|---|
| Staph aureus & B cereus - 1 | | 2 hr (1-6) | +++ | + | + | - | -- |
| C perfringens & B cereus 2 | | 13 ( 10-18) | + | +++ | +++ | - | -- |
| Salmonella spp | 18 (16-24) | ++ | +++ | ++ | +++ | - | - |
| Shigella spp | 24(12-96) | +++ | +++ | +++ | +++ | +++ | - |
| Insecticides / mushroom | Few Mts. | ++ | + | - | - | - | +++ |
| C botulinum | 24(18-36) | + | - | - | - | - | +++ |

**( Legend :- +++ = occurs in 90 to 100% patients; ++ = 40 to 60%; + = 20 to 30%; - = 0 to 5% patients show this manifestation)**

demonstration of $10^7$ spores per gram of faeces from patients or food handlers and S aureus or mushroom poisoning requires toxin assays available only at few centres in our country.

The mainstay is therefore to see the "clinico-epidemiological" profile of the outbreak by quickly analyzing the frequency of symptoms in the present outbreak and comparing this profile with what is expected during outbreaks caused by common etiological causes of food poisoning, as shown in the Table 1

So, the first thing is to work out the % of various signs / symptoms in the present outbreak (besides taking all available samples as food samples, water samples, stool samples of cases and food handlers). Now, see with which etiologic symptomatology (as shown in above table) does the present outbreak match and make a tentative diagnosis of the cause of the present outbreak.

Now, draw an epidemic curve, plotting the number of cases along the vertical axis and the time according to hourly period (i.e., 9 a.m, 10 a.m. etc.). See where the peak of epidemic curve comes, as also the first case and the last case. Go back in time by the known median incubation period of the suspected etiologic agent (as shown in table above) as also the the minimum and maximum incubation periods from the first and last case respectively. The meal which was consumed where all these three time periods converge gives the meal which was most probably contaminated and needs to be further investigated. (See example in Box - 1)

**Step 3 : Getting the Food Histories About the Suspected Meal**

Once the meal which was most probably associated with the epidemic has been identified, a list of each and every dish (including even chapattis, rice and water / drinks) which was served during that meal is made. Now, each and every person who attended that meal is interviewed and asked about the history of consumption of each and every food item that was served during that meal. The information is recorded as per the following work-sheet, which, in fact, is nothing but the line-list as shown in Table 2 and example in Box - 2.

Box - 1

**Example** : On 8th March, Maj 'X', the Dy Asstt Director of Health (DADH) got the information that yesterday, i.e., 7th March, an episode of gastroenteritis had occurred in an Infantry company located independently at a company post. Out of 87 personnel, 36 developed symptoms and have been admitted at the nearby Advanced Dressing Station (ADS). Since the incident was concerning, the ADMS of the Division directed the DADH to move to the affected site and investigate. Maj 'X' left immediately and reached the location at 2 p.m. on 8th Mar. Preliminary investigations revealed that out of the 36 patients, 31 were admitted to the ADS while another 5 were detained for treatment by the RMO. All the cases (100%) had 6 to 8 watery loose motions, 100% had abdominal cramps, 3% had nausea / vomiting, none had fever or blood / mucous in stools. No case had dehydration or any complications. The first 3 cases had onset of symptoms at 7 a.m. on 7th March, 7 between 7 and 8 am, and similarly, 9, 5, 4,3,2,2 and 1 had onset between 8 and 9 am and similar hourly periods; the last case had onset at 3 pm. The peak of the epidemic was reached at 9 a.m. by which time, 19 cases had onset. No food sample of any meal had been kept since the infantry company was in a field area with no electricity or refrigeration facilities.

The epidemic curve plotted with the above data showed a classical "common vehicle point exposure" curve typical of food poisoning. As evident from clinical profile, the entire epidemic was clearly due to either C perfringens or B cereus type 2. Going by the median and range of incubation periods of these organisms, the

Box - 2

In Our Example :- Maj 'X' made a list of each and every item which was served during the dinner on 6th march. These items were Mutton Curry, Matar-Paneer, Moong Daal, Chapati and Rice. She then interviewed each and every of the 81 persons of the Infantry company who had attended that dinner in their company dining hall and asked them whether they developed any symptom. If they had developed symptoms, details of each symptoms were enquired. Details were also taken each and every of these 5 food items whether eaten or not eaten, irrespective of whether the person developed sickness or not.

Table - 2

| Serial No. | Name & Personal particulars | Whether developed illness (Yes or No) | If ill, Presence of symptoms (Yes / No) | | | | History of eating various food items served during the suspected meal | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Nausea / Vomitting | Watery Diarrhoea | Abdominal Cramps | Fever | Matar Paneer | Mutton Curry | Kheer | Item No. 4 | Item No. 5 |
| 1 | ABCD | No | - | - | - | - | Yes | No | Yes | Yes | Yes |
| 81 | XYZ | Yes | No | Yes | Yes | No | No | Yes | No | Yes | No |

**Step 4 : Consolidating the food histories and sickness histories**

The details recorded on the above line list are now consolidated into a summary table as follows

| Food Item | Those who ate the item | | | | Those who did not eat the item | | | | Relative Risk | Attributable Risk |
|---|---|---|---|---|---|---|---|---|---|---|
| | Became Sick | Did not Become sick | Total | Incidence among those who ate the item | Became Sick | Did not Become sick | Total | Incidence among those who did not eat the item (INE) | | |
| (a) | (b) | (c) | (d) | (e) (b ÷ d) | (f) | (g) | (h) | (i) (f ÷ g) | (j) (e ÷ i) | (k) (e - i) |
| Item 1 | 31 | 9 | 40 | 78% | 5 | 42 | 47 | 22% | 3.6 | 66% |
| Item 2 | | | | | | | | | | |
| Item 3 | | | | | | | | | | |

In our example : Maj 'X' now consolidated the line list that she had made into a summary table as follows

| Food Item | Those who ate the item | | | | Those who did not eat the item | | | | Relative Risk | Attributable Risk |
|---|---|---|---|---|---|---|---|---|---|---|
| | Became Sick | Did not Become sick | Total | Incidence among those who ate the item | Became Sick | Did not Become sick | Total | Incidence among those who did not eat the item (INE) | | |
| (a) | (b) | (c) | (d) | (e) (b ÷ d) | (f) | (g) | (h) | (i) (f ÷ g) | (j) (e ÷ i) | (k) (e - i) |
| Mutton Curry | 31 | 9 | 40 | 78% | 5 | 42 | 47 | 22% | 3.6 | 66% |
| Matar Paneer | 30 | 31 | 61 | 49% | 6 | 20 | 26 | 23% | 1.9 | 7% |
| Dal Moong | 27 | 24 | 51 | 53% | 9 | 27 | 36 | 25% | 2.1 | 28% |
| Chapati | 32 | 43 | 75 | 42.7% | 4 | 8 | 12 | 33.3% | 1.27 | 14.4% |
| Rice | 34 | 46 | 80 | 42.5% | 2 | 5 | 7 | 28.6% | 1.5 | 13.1% |
| Water | 36 | 50 | 86 | 42% | 0 | 1 | 1 | 0% | Infinite | 42% |

Now, the food item which shows the maximum Attributable Risk is the food item which most probably was involved in the transmission of the epidemic.

Sometimes all persons who ate the suspected meal may not be available for interrogation. In such instances, the "cases" and a "random sample" of those who ate the meal but did not become ill (controls) are interrogated about the food histories. This is the case-control approach, wherein we would calculate the Odds ratio (OR) and not the Attributable risk. The food item showing highest OR would be taken as the suspect item.

**Step 5 : Undertake an extensive assessment of the sanitary history and food hygiene of each constituent of the suspected food item :**

The objective of investigations is, naturally, to find out why a particular food item got contaminated so that recurrences are prevented in future. Therefore, once a particular dish has been identified as per details given in previous step, it's each and every constituent (including condiments and water) should be noted and detailed history of every constituent should be taken

(a) From where they were procured;

(b) What were the hygienic conditions at the point of procurement;

(c) How they were stored in the cook house;

(d) Sanitary conditions at the time of cooking;

(e) What temperature did the initial cooking achieve;

(f) Whether the cooked food was eaten hot and freshly cooked or else stored;

(g) If stored, at what temperature and under what hygienic conditions was it stored; and, if stored, was it adequately re-heated before consumption. ( Box -3)

Box - 3

**In our Example** : Once mutton curry was identified as the possibly contaminated dish, the suspicion became strong regarding C perfringens etiology, since B cereus is more likely to be conveyed through rice dish while C perfringens is more likely through a meat dish. Maj 'X' quickly made out a detailed list of all items used in making the mutton curry, including condiments, vegetables and water. She thereafter took a detailed sanitary history of each and every item, starting from the point of procurement till the final cooking and subsequent storage / serving of the cooked dish. She also verified the details by personally observing the hygienic conditions on ground.

Maj 'X' noticed some peculiar and interesting findings. The affected infantry company was located in a cut-off field area, hence supply of meat and other fresh items was through a local contractor. The cook house and dining hall were in tentage accommodation, under improvised field conditions. The contarctor used to get mutton from a local civilian butchery. On visiting the civilian butchery it was found that the conditions were grossly unhygienic. The floor was cracked and there was no arrangement for washing the floor, nor there were arrangements of hygienic disposal of excreta of slaughtered animals. There was no system of starving the animals prior to slaughtering. Animal excreta (which is a rich source of C perfringens spores) was seen lying all over the floor of the butchery and the raw meat was apparently getting mixed up with the excreta.

On 6th March, the contractor could finally reach the company location, with mutton and other fresh items by aroung 1 p.m. since there was a breakdown in his vehicle. By that time, lunch had been cooked and was being eaten. It was therefore decided to cook the mutton for dinner. Cooking of mutton curry started at about 3 p.m. and was completed by about 4 p.m. Thereafter, this cooked mutton curry was stored in the large utensil, which was kept on a table, since there was no arrangements of a fridge. This dish was therefore kept at an environmental temperature of about 30°C for almost 4 hours, till 8 pm, giving optimum time and temperature for the heat-shocked C perfringens spores in the mutton to germinate and produce large amount of toxin. At 8 pm, the mutton dish was "warmed" (to about 40°C) (and not reheated thoroughly which could have inactivated the preformed perfringens toxin) and served for dinner starting at about 8.15 pm till 10 pm.

**Step 6 : Make focused recommendations based on the findings of investigations**

Make specific and "do-able" recommendations, based on the actual findings and develop a system of keeping a check that these recommendations are being adhered to.

Box - 4

**In our Example** : Based on her findings, Maj 'X' made the following do-able recommendations :

- Meat should not be taken from the particular civilian butchery, since it was difficult to have adequate sanitary control on it.
- Meat on Hooves be provided to the affected unit and slaughtering be undertaken at unit level.
- Slaughtering be undertaken early morning.
- Meat should be lunch dish and not dinner dish.
- Meat dish should be the last one to be cooked for lunch.
- All meals should be served freshly cooked and hot.
- No cooked food item should be stored, unless operationally essential.
- If cooked item is to be stored, the storage should be on ice, in ice box and not more than 4 hours
- Cooked food item, if stored (even on ice) should be thoroughly reheated to > 60°c before serving
- Company Nursing Assistant to check implementation.

Col RajVir Bhalwar

# Epidemiological Basis of Public Health Surveillance for Disease

Epidemiological Surveillance is a major function of Public Health. The genesis of modern surveillance can be traced back to 1662, when John Gaunt was the first to quantitatively study the patterns of human disease and its possible causes. However, it was only after almost 200 years, when William Farr, in 1838, while working in the office of Registrar General, UK, created a modern surveillance system; he is aptly called the founder of "Epidemiological Surveillance" (61). Twentieth century saw a rapid growth in the scientific concepts and data collection / analytic procedures. By now, public health surveillance activities have widely proliferated, encompassing a large gamut of communicable as well as non-communicable diseases. In fact, surveillance played a major role in the conquest over small pox.

## Definition

(By Langmuir and adopted by WHO in 1968) : "Surveillance, when applied to a disease, means the continued watchfulness over the distribution, and trends of the incidence, through the systematic collection, consolidation and evaluation of morbidity, mortality and other health relevant data, as well as regular dissemination of interpretations to all who have contributed and to all those who are in a position to take action". In a nutshell, surveillance means "information for action". In addition, surveillance is distinguished by methods having practicability, uniformity and rapidity, rather that by complete accuracy" (62 66).Summary of definition and uses of surveillance is given in Table -1

Table - 1 : Surveillance : Definitions & uses

**Definition** :- continued watchfulness over the distribution and trends of the incidence, by systematic collection, consolidation and evaluation of health data, as well as regular dissemination of interpretations to all concerned. In a nutshell, "information for action". It is distinguished by methods having practicability, uniformity and rapidity, rather than complete accuracy".

**Uses** :-

- To study the trends of disease
- Early warning of epidemics
- To provide quantitative estimates of magnitude of health problem
- To study the natural history of disease
- Demonstrating the spread of a disease in time and place
- To develop epidemiologic research questions
- To test epidemiologic hypothesis
- Evaluation of control and preventive measures
- Monitoring of changes in infectious agent

## Surveillance Vs Monitoring

The term 'surveillance' and 'Monitoring' are often used interchangeably but they are, in fact, distinct. Monitoring refers to ongoing measurements of health services or a health programme with a view to 'evaluate' the particular programme / service or intervention, with constant adjustment of performance in relation to the results. In addition, surveillance concerns general populations while monitoring applies to specific target groups (eg, vaccinated infants).

## The objectives of Public Health Surveillance

The specific objectives of surveillance systems are one or more of the following (67)

### To study the trends of disease

Changes in the frequency over short term or long term periods help in identifying as to whether significant rising of falling trends are present and to predict the future course of the disease.

### To provide quantitative estimates of magnitude of health problem

By providing data on incidence and prevalence and further descriptions of incidence/ prevalence according to various socio-demographic characteristics, surveillance helps in identifying the priority (i.e, high risk) groups.,

### To study the natural history of disease

Surveillance of AIDS during the last decade has added significantly to our knowledge regarding the natural history of HIV infection and AIDS.

### Early warning of epidemics

Constant analysis of surveillance data of a disease would identify any upward trend, at a very early stage.

### Demonstrating the spread of a disease in time & place

Description of surveillance data using time and space combinations can demonstrate the spread of a disease and identify the possible vehicles and routes of spread.

### To develop epidemiologic research questions

Sensible interpretations of surveillance data can open up interesting research questions; eg, increase in the request for pentamidine noted by CDC Atlanta, in 1981, led to generation of research questions and finally "AIDS" was recognised.

### To test epidemiologic hypothesis

Sometimes surveillance data can be used to test hypothesis; eg, in 1973, a particular insecticide was suspected of being related to birth defects. However surveillance data for 1970 73 showed decrease in total birth defects even though there was five fold increase in insecticide sales during the same period, thus acquitting the particular insecticide.

### Evaluation of control and preventive measures

Surveillance data on poliomyelitis during 1950's in USA showed a dramatic decline in disease incidence, thereby confirming the efficacy of polio vaccination campaign.

Monitoring of change in infectious agent :- Development

of antibiotic resistant gonococci have been identified with the help of surveillance data.

Detecting changes in health practices

Surveillance of delivery practices has shown that caesarian deliveries increased from 5% to 25% in USA.

## Criteria for identifying high priority areas for establishing surveillance activities

Surveillance activities are costly and hence should not be launched inadvertently. Careful consideration should be made beforehand as to whether the particular disease is a high priority area from public health point of view. This includes review of the data on Frequency of the disease (in terms of incidence of mortality, and incidence/prevalence of morbidity, due to the disease); Severity (in terms of case fatality ratio, proportionate mortality ratio, hospitalization rates due to the disease and disability rates); Economic impact (in terms of direct costs that accrue due to medical treatment for the disease and indirect costs due to reduction in productivity); Preventability; and, Public interest (community attitudes towards the disease and political will).

## Organization and structure of a surveillance system :

The essentials of a surveillance system are

(a) An overall organization : Consisting of personnel, finances, logistic and administrative back up.

(b) The originators of data : This would include the sources of data, data collectors and data collecting mechanisms.

(c) The transmission of data to the surveillance center, with specification of the mode of transmission and frequency of such transmission.

(d) Data management and analysis : This includes manual /computerized data files, and statistical analysis procedures.

(e) The sensible interpretation or results : Including their consolidation and preparation of reports.

(f) A system of feed back of results : To the originators of data and to those who are in a position to enforce preventive steps.

(g) A system to periodically evaluate the surveillance system itself.

## Steps In Establishing A Surveillance System

**Step - 1**

**Is It Justifiable To Establish A Surveillance System ?** As said above, at the outset we must analyse whether it is really required to initiate a surveillance system by asking whether the disease is of public health importance (see criteria above) and whether prevention / control measures are available.

**Step - 2**

**Spell out the objectives of surveillance system** :- The following issues should be addressed :-

(a) Clearly specify the disease (s) proposed to be brought under surveillance.

(b) Specify : Who needs what information, for what purpose? (eg, whether a rapid case count for epidemic warning is required by the DDMS Corps or detailed information to identify temporal trends is required by the DGAFMS?)

(c) The target population : eg, whether it is "mothers and children" or "blood donors" or "all troops inducted into high altitude".

(d) The health problem : eg, whether only MI or entire spectrum of IHD is to be put to surveillance ?

(e) Nature of control programmes : eg, if it is a rare disease/disease moving towards eradication, a fine surveillance will be needed; on the other hand if it is a common disease, a crude surveillance would suffice.

**Step - 3**

**Specify the organization and structure of the surveillance**

At the very planning stage, clear specifications should be made as to "who will do what, how, and will be responsible to whom" .

**Step - 4**

**Clearly define the disease(s) being considered for surveillance**

Case definitions should be meticulously worked out after detailed consultation with experts. They should be adequately inclusive. (ie., sensitive) as well as adequately exclusive (i.e, specific). All those involved in the collection of data should be well trained in the use of these case definitions/ diagnostic methods. Case definitions/ diagnostic procedures should be simple enough so as to be understood and used by all those on which the system depends for reporting. It would be desirable to report the cases under three different diagnostic categories, viz., confirmed / probable / suspect, with clear definitions for each category stipulated.

**Step - 5**

**Specify the Details of Collection of Information**

Collection of data is the most costly and difficult component of a surveillance system. The quality of a surveillance system is as good as the quality of the data collected. The Epidemiologist will therefore have to make the following specifications :-

(a) Select the proper sources of data

Various sources of data are available (65) as described in an earlier chapter. It would require an intelligent thought by the surveillance officer as to what all sources would be optimum.

(b) Specify the method of data collection

Alternative methods can be :

**Passive surveillance**

In passive surveillance, the data recipient has to wait for the data providers to report, (eg, various headquarters wait for AFMSF-73 to be raised by hospitals). Passive surveillance is the most common method of data collection. All the passive surveillance agencies that are required to report should be sensitized and trained. The frequency of reporting should be clearly laid down and a system of issuing prompt reminders established.

**Active Surveillance**

In certain circumstances, data must be obtained by searching for cases (e.g., health workers go into the

community, search for cases of fever and take their blood slide for malarial parasite), and also by periodically contacting those who may know of cases, as RMOs, GPs, etc. For rare disease, or disease on way to eradication, or during outbreaks, active surveillance is necessary, so that cases which could have been otherwise missed, are promptly identified. Since it is expensive, active surveillance is usually limited to specific diseases, and for a specific situation.

**Sentinel Surveillance**

Data is obtained from selected hospitals who agree to report all cases of the disease.

**Special Surveillance teams**

Sometimes, special surveillance teams may be formed for carrying out surveys or epidemic investigations and to undertake clinical examinations Laboratory, Entomological and Environmental assessments.

(c) The forms that will be used

The forms should be simple and as brief as possible. The question should be clear cut, preferably with closed - ended answer categories and pre-coded for computer data entry. An example is the "Disease Notification Form" (AFMSF-73) for infectious diseases or ACO-1 form for notification of HIV infection which is used in the armed forces.

(d) What time/place of diagnosis will be entered

One has to specify as to whether one would go by the time and place a case is actually diagnosed or else the time/place the case would have got the infection, or the time / place when first symptoms appeared. What is important is that one should ensure strict criteria and not fluctuate from case to case. If everything is at disposal, it would be better to ask for the time and place the case actually got the infection and the time / place when first symptoms appeared.

(e) What will be the frequency of reporting?

For a disease like cholera and food poisoning it would be daily (or at the most weekly) report; for HIV infection a monthly report would be reasonable while for cancer, a quarterly or even half yearly report would be required.

(f) Decide the method of transmission of reports

The simplest is a letter. For diseases that may cause public alarm (plague, JE etc), reports by telegram/ telephone may be stipulated. The data originators should give due consideration to possible postal delays that may occur, especially in developing countries or in operational areas and originate the report in time. In addition, the central surveillance node should keep a centralized cross-check mechanism and issue a reminder if timely report is not received from a particular reporting unit.

**Step - 6**

**The Organization and procedures of data Analysis**

The ideal is to have a computerized system, with back-up hard copies on central register. Computerized data should be maintained on a "Database" programme (as ACCESS or Foxpro) or else on a worksheet as EXCEL. For Statistical analysis, the software "EPI-2002" developed by WHO and CDC Atlanta is quite good. Details are given in a subsequent section. It is better to maintain 2 sets of data bases - one provisional and another final. The statistical analysis will include :-

Simple display of data

By means of visual representations through histograms/ bar diagrams/ line diagrams describing the data according to various characteristics of person, place and time. For depiction of "time trends", line diagrams and histograms are the best. (refer to section on Biostatistics).

Descriptive statistics

Give the "summary statistics" (Incidence rates / prevalence / proportions /Mean / Median ) along with the measures of dispersion (SD) and the 95% confidence intervals. This should be done in respect of the important and relevant variables related to person (age, sex, occupation etc), place (differences in geographical distributions, distributions according to place of contracting the infection, etc) and distribution according to time. The tables should be small (ideally a 2 x 2 or maximum 2 x 4 table) and should be accompanied by descriptive notes.

Inferential statistics

Analytic procedures usually are based on comparing the current incidence against the "Upper and Lower Control Limits" (UCL & LCL).

**{A quick method of calculating the UCL and LCL is : UCL or LCL = R ± 1.023 X A ; ( Where R = Average of Incidence rate per 1000 population for the corresponding period for the past 3 years and A is the average of "ranges" for the past 3 years. The resulting UCL and LCL will encompass 99% confidence interval)}.**

Analysing Time (temporal) trends

The comparisons are made between the rates during present period with the rates during the corresponding periods of the last 3 to 5 years; or between the rates or No. of cases reported during current week (or month) with the immediately preceding 4 weeks (or 4 months). For long term secular trends and cyclical trends, the most simple and suitable method is to present a line graph or histogram, indicating the occurrence of disease according to calendar years. More rigorous procedures as "test for linear trends for categorical data" and "time-series analysis" are available. They can referred from advanced texts (see list at end of this chapter).

Place (Spatial) data

This analysis is important to identify the 'places' where significant number of cases are occurring; it may also reveal localized outbreaks. It is always desirable to plot the 'spot maps' according to 'place of contracting the infection' as well as according to the place of reporting.

**Step - 7**

**Making Scientific interpretations out of the results**

It is not really in the analysis of the data but rather in making sensible interpretations that the skill of epidemiologist lies. Firstly, the epidemiologist should consider whether the apparent, statistically significant, increases or decreases in the disease incidence at a given

place and time represent true changes. Fallacious increase or decrease may be due to changes affecting the numerator as improvement in diagnostic procedures, duplicate reporting, or enhanced reporting; or else may be due to changes affecting the denominator as increase in population size. Secondly, one must carefully consider the biases that could have occurred in detecting and reporting at various levels. The epidemiologist should always be cautious of the fact that the cases which have been reported to him MAY NOT be truly representative of the total target population which he has put under surveillance and he should verify this by studying the characteristics of the total population under surveillance and compare it with the characteristics of cases which have been reported.

**Step - 8**

Ensure proper feedback to all concerned

It is extremely important to provide regular (usually monthly) feedback reports to all those who are in a position to take action on your surveillance data (as, SEMO, Station Commander, DDMS of higher formation, MES authorities) and not to forget, all those who have provided you with the data (RMOs, COs of hospital / Field Ambulances, Pathologists and other relevant specialist in the hospital, etc.). This will go a long way in keeping their interest alive.

**Step - 9**

**Periodically evaluate / review the surveillance system**

See whether the case definitions need a change? Are there some problems in the timely and accurate reporting and how can it be improved? Peridic evaluation is important to identify defects and reorient the methodology. Summary of steps involved in developing a surveillance system is given in table-2

**Some Tips for Specialists in Preventive Medicine and Medical Officers of Armed Forces for developing simple and effective surveillance systems**

As a Officer Commanding Station or Field Health organization (SHO / FHO), undertake the following steps :

(a) Yourself or your trained health assistant / Lab assistant should go to the military hospital (s) of the station, daily, early morning and collect the data, for past 24 hours as regards the personal particulars, unit, date of admission, date of discharge, and provisional / final diagnosis, in respect of

- (i) All admissions
- (ii) All discharges
- (iii) All deaths
- (iv) All laboratory investigations from Microbiology / immunology Dept and relevant investigations from Biochemistry (as LFT) and Haematology (as PBS)

(b) All above details should be recorded in 4 separate registers, column-wise, and put up to you as soon as you come to office. You should eyeball the data and underline with red ink, all cases (either admitted or discharged or deaths or found positive on lab investigations) of diseases which are either notifiable (Gp A, B or C) or are of public health / military importance and need to be investigated.

(c) In addition, on reaching your office, ring up the RMOs / MOs incharge of section hospitals in your health cover, and find out the number of cases of major diagnostic categories ( as gastroenteritis, fever, rash, injuries, etc) seen by them during last 24 hours. Have a word on tele with the cantonment hospital, local civil health authority and OC SHO / FHO of sister stations, as regards the occurrences in their jurisdiction.

(d) Now, for all cases which need notification / epidemiologic investigations, undertake the investigations by contacting the patient and later visiting his home or unit, either personally or by your trained health / lab assistant.

(e) Inform your SEMO and Station Commander of the trends during last 24 hrs and any unusual occurrence, by tele or personally.

(f) Concurrently, take action on the "Entomological surveillance" and "water quality surveillance" as per details given in the respective chapters. Holistically analyse the epidemiological surveillance and vector / water surveillance.

(g) Develop a computerized database on either ACCESS or FOXPRO or else on an EXCEL file, as per following

Table - 2 : Summary : Steps in Developing a Surveillance (SVL) System

- Specify the exact spectrum of the disease(s) or health conditions proposed for Svl
- Decide :- Is it really required to establish a svl. System?
- Clearly define the target population.
- Decide the Objectives : Who needs What information for What purpose?
- Specify in detail the organization.
- Specify clear-cut case definitions
- Clearly specify what all information is to be collected
- Define the sources of information.
- Specify who will collect what information and send to whom?
- Specify the modalities of Svl : active, passive or sentinel
- Specify the method and frequency with which information will be sent
- Develop proper forms for reporting
- Centrally train all data collectors & reporters.
- Do a pilot run
- Receive and analyse data
- Ensure feed back reports to all who can take action and to originators of data.

general field-names as shown in Table 3.

(h) For UCL, enter the formula / programme in the concerned column and the same will be calculated automatically

(j) Preferably, link up your database with a power-point file so that weekly number of cases / rates along with the UCL will be automatically displayed as well as auto-updated. Have a look at the trends of various important diseases, whether there has been a sudden increase over just a few days or there is a more sustained increase over past few weeks; if so, get alerted.

(k) Ensure regular feed back to your SEMO and Stn Cdr personally or on tele, preferably daily about the health situation and disease trends. Send simple, well illustrated weekly and monthly reports to them; if there seems to be an impending epidemic, inform them as also others who need to know (MES / Field Engineers, Cantonment Officials, Concerned units, Sister SHOs, medical controller of formation HQ).

(l) As DADH / ADH at a formation HQ, select out the common epidemic prone diseases which you would like to keep under surveillance. Now develop case definitions for these diseases, with adequate trade-off between sensitivity and specificity. You may develop definitions to classify the diseases into three categories (suspected / probable and confirmed). Now, clearly inform the different reporting levels about these case definitions. Next, for each disease selected for surveillance, specify the periodicity and modality of reporting for each of the reporting level (Nursing assistant at the isolated post; RMO; OC ADS, OC Section Hospital; CO, Mid-Zonal hospital; DADsH of subordinate formations HQs; Comdt, Zonal / General hosp; and so on). Depending on the disease you may, for example, specify that any death, any food poisoning, cholera and any meningitis case should be reported by telephone every day in the morning by all reporting functionaries; malaria, hepatitis, scrub typhus and typhoid, by signal on every Saturday; and other selected diseases at the end of the month by a letter. Now, develop your computerized database on Foxpro / Access / Excel as explained earlier, with an additional field for the name of the formation / unit. Analyse the data regularly for any early warning of increasing incidence. Ensure feed back, in the form of an interesting and simple report, duly illustrated, to your formation commander, DDMS of the higher formation, DDsMS / ADsMS of lower formations and not to forget, all functionaries who have sent the data to you right upto RMO level.

Table - 3

| Week starting date | Week ending date | Malaria | | Viral Hepatitis | | Dengue | | Disease - 4 | |
|---|---|---|---|---|---|---|---|---|---|
| | | No of cases | UCL | No of cases | UCL | No of cases | UCL | No of cases | UCL |

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# Epidemiologic Basis of Screening for Diseases

One of the priority duties, not only of a public health physician but for all medical personnel is to ensure an early diagnosis and treatment (i.e, the secondary level of prevention), through "screening for diseases".

## Definition

Screening has been defined by the commission on chronic illnesses (68, 69) as "the presumptive identification of unrecognized defect or disease by the application of tests, examinations or procedures which can be applied rapidly, to sort out apparently well persons who probably have a disease, from those who probably do not. A screening test is not intended to be diagnostic. Persons with positive or suspicious findings must be referred to the physicians for diagnosis and necessary treatment". Objectives of screening are given in Table -1

Table - 1 : Objectives of Screening

Screening in community health care is undertaken with the following broad objectives :-

- To ensure early detection of a disease among individuals, so that prompt treatment may be instituted; eg, screening for cervical cancer, breast cancer, hypertension etc. This is also called prescriptive screening.
- To protect the community from disease that the person being screened has, also called "prospective screening"; eg, screening the blood units for HIV,
- For entry into certain forms of occupations (armed services, industries, etc) with a view to "weed out" those who are unfit, or whose existing health status

## Requirements of tests used for screening :

**Screening test should be :-**

Valid

Test should be "accurate", i.e, should measure correctly what it intends to. It should have high sensitivity, specificity, and positive & negative predictive values.

Reliable

(Precision, consistency, repeatability) i.e, should give consistent results when repeated applications are made.

Yield

It should give enough number of cases to commensurate with the expenditure and inputs involved.

Practical

The test should be easily administered by even persons with ordinary training, should be innocuous, acceptable and should give fairly quick results.

Efficient

The amount of inputs (in terms of expenses and time) should result in reasonable amount of outputs in terms of improved health & satisfaction.

## The following are the important aspects of validity and reliability (See general notations in Table 2)

**Sensitivity**

It is the ability of a test to detect those (i.e., correctly call positive) who really have the disease.

$$\text{Sensitivity} = TP / (TP + FN) = a / (a + c)$$

**Specificity**

It is the ability of a test to identify those (i.e correctly call negative) who do not have the disease.

$$\text{Specifity} = TN / (FP + TN) = d / (b + d)$$

Ideally a test should be both highly specific as well as highly sensitive. However, in practice this is not possible

Table - 3 : A highly sensitive test

- Will have a large number of true positives and very few false negatives.
- Will also give a lot of false positives.
- Helps in "ruling out" the diagnosis
- Is of value when it is negative.
- Is the ideal screening test.

Table - 4 : A highly specific test

- Will have a large number of true negatives and very few false positives.
- Will also give a lot of false negatives.
- Helps in "ruling-in" the diagnosis
- Is of value when it is positive.
- Is the ideal "final diagnostic test.

Table - 2

| Screening Test | Gold Standard (Final Diagnostic Test) | | |
|---|---|---|---|
| | Positive | Negative | Total |
| Positive | TP (a) | (b) FP | TP+FP=Total test+ve (a+b) |
| Negative | FN (c) | (d) TN | FN+TN=Total test-ve (c + d) |
| Total | TP+FN (a+c) = total actually Diseased | (b+d) FP+TN = total actually healthy | N = Total subjected to screening |

(TP = True Positives, FP = False Positives, FN = False Negatives, TN = True Negatives)

and some trade off, depending on the disease under consideration is required. If a disease has serious implications if not treated early and has adequate treatment available, then our aim would be to not leave out any "false negative", even at the expense of getting many false positives; in such instance we would go up for highly sensitive test.

For a screening test in which the result is measured on a continuous scale, the decision regarding cut off point would need consideration by experienced clinicians & public health administrators. For example, if tonometry is being used as a screening test for glaucoma, the results (18, 18.5, 22, 26.8 mm etc) would be measured on a continuous scale. Now, possibly most of the eyes with intra ocular pressure upto 22 may be, in fact, non glaucomatous while most of the eyes with intra ocular pressure more then 26 mm will be, in fact, really glaucomatous. The main problem will be the eyes having ocular pressure between 22 and 26mm Hg, ie., the area of overlap between glaucomatous and non glaucomatous eyes. If we keep the cut off point low, say at 22 mm Hg, we will correctly identify nearly all the glaucomatous eyes (high TP) but will also identify a number of normal eyes as glaucomatous (large FP). On the other hand if we keep the cut off at 26 mm Hg, we would correctly identify nearly all the normal eyes (high TN) but would miss out a large number of glaucomatous eyes (large FN). In the former instance, when we have a low cut off point (i.e, less stringent criteria) we have, thus, higher sensitivity but lower specificity.

On the other hand, in the latter instance, when we have a higher cut-off point (i.e, more strict criteria) we get a higher specificity at the cost of a lower sensitivity. In practice the public health decision regarding the level of cut off is done based on the potential for treatment following early detection, the availability of treatment and the "labeling effect of having a disease", if any. In such cases, advanced statistical techniques in the form of "Receiver Operator Characteristics (ROC) curve analysis" are available to scientifically work out the optimum cut off point, which gives the best trade off between specificity and false-Positives (i.e. 1 - Specificity).

Sensitivity and specificity of any diagnostic test are fixed, i.e, they will not change. However, our interest in screening is not only the sensitivity or specificity but rather the predictive values; i.e, if an individual has tested positive on a screening test, what are the chances that he really does have the disease. This is called the positive predictive value (PPV or PV+)

$$PPV \text{ or } PV+ = TP / (TP + FP) = a / (a + b)$$

Similarly, the probability that an individual with a negative test result will really not have the disease is called the Negative predictive value (NPV; PV-)

$$NPV \text{ Or } PV- = TN / (FN + TN) = d / (c + d)$$

Unfortunately, predictive value are highly dependent on the prevalence of that disease in the population being screened. The same test with the same levels of sensitivity and specificity will give a very high PPV if the prevalence of disease is high but a very low PPV if prevalence is low. The problem can be overcome by calculation of positive and negative likelihood ratios (LRs) as :

$$LR \text{ Positive} = (Sensitivity) / (1 - Specificity)$$
$$LR \text{ Negative} = (1-Sensitivity) / Specificity$$

The optimum prevalence to get a very high PPV as well as NPV is between 30-60%. Thus, the health administrator should aim at getting the population to be screened in such a way that prevalence of the condition for which screening is being undertaken, is between 30% to 60% (70).

**Reliability**

Reliability is ability of a test to give consistent results when repeated applications are made. It is adversely affected by variability; such variations may occur due to Observer (Intra and Inter observer) variations; variations among or within subjects; and variations due to equipment, tools and techniques. The key word for ensuring reliability is 'standardization'. Centralized training and certification of all observers, use of standard instruments and reagents, use of standard techniques, writing down the entire methodology in an operation manual, laboratory and clinical quality control procedures, and frequent cross check on the observations made by data collectors will go a long way in ensuring reliability.

**Yield**

This indicates the amount of previously unrecognized disease that is diagnosed and brought to treatment as a result of screening. Yield will depend on Sensitivity of the test, Prevalence of the disease (If screening is applied to a high risk group, the yield will be better) and availability of medical care (if medical care has not been available to the community being screened, a large number of people with the disease will be diagnosed). Characteristic of diagnostic test is given in Table - 5

Table - 5 : Summary measures of characteristics of a diagnostic test

**(Please refer to 2X2 table and understand that notations; a = TP, b=FP; c = FN; d = TN)**

- Sensitivity = (a) / (a+c)
- Specificity = (d) / (b+d)
- Positive Predivtive Value (PPV) = (a)/(a+b)
- Negative Predictive value (NPV) = (d)/(b+d)
- LR positive = (Sensitivity) / ( 1 – specificity)
- LR Negative = (1-Sensitivity) / Specificity
- Accuracy = (a+d)/(a+b+c+d)
- ROC analyses for optimum trade-off between (sensitivity/ (1-specificity); where (1-specificity) can also be calculated as False positive Fraction (FPF)
- Reliability (Repeatability, Consistencey, Precision) : the ability of a test to give consistent results when

## Serial and parallel screening tests

2 screening tests can be applied in serial one after the other. In fact the same test (eg, ELISA for HIV) can be done two times in serial. This procedure will greatly increase the positive predictive value. Similarly two tests can applied in parallel and the person can be considered as +ve if any one of the test is +ve (increase in sensitivity) or he may be considered +ve if both the test are +ve. (increase in specificity).

## Considerations before launching a screening programme

Screening in public health care should only be launched after carefully considering various aspects, as summarized in Table 6. Detection of cancer of uterine cervix using "pap test" is a procedure which meets all the above 10 criteria. The test is based on the assumptions that, firstly, a high proportion of cancer cervix detected in situ would progress to invasive cancer over time; secondly, most cancers remain in situ long enough for screening at reasonable intervals to detect a high proportion of cancer cases; and, thirdly, Carcmonia in situ is highly curable. Other diseases which are amenable to screening include breast cancer, Hypertension, Anemia during pregnancy, Diabetes Mellitus, growth screening in children, CHD screening in high risk groups, phenylketonuria among new born etc.

Table - 6 : Considerations for a screening programme

- ☐ The condition should be an important health problem.
- ☐ There should be an acceptable and effective treatment.
- ☐ Facilities for confirming the diagnosis and for treatment should be available.
- ☐ There should be recognizable latent / early symptomatic stage.
- ☐ There should be a suitable screening test or examination available.
- ☐ The test should be acceptable .
- ☐ The natural history of the condition, including development from latent to apparent disease, should be adequately understood.
- ☐ There should be an agreed policy regarding whom to treat as patients.
- ☐ The cost of case finding (including final diagnosis and treatment) should be economically balanced vis-a-vis the expenditure on medical care as a whole.

(After Wilson & Jugner) (71).

## Evaluation of screening programmes

Contemporary medical evidence strongly recommends that the effectiveness and impact of screening programmes must be evaluated by Randomised controlled trials (RCTs) by comparing the outcome measures between the screened and unscreened groups.

## Biases in screening programmes (72, 75)

### Lead time bias

Lead time is defined as the interval between the point a condition is detected through screening and the time it would normally have been detected due to appearance and reporting of signs and symptoms. If early detection has no effect on the course of disease then it will be like giving the patient a few more years of sickness and apprehension rather than health! (eg, HIV detection). In such cases, it is possible that screening, through earlier detection, will advance the time of diagnosis without delaying time of death, thereby increasing the "diagnosis to death - time" and tend to show "increased survival" among the screened group as compared to the group not given screening test, though in reality there would be no increase in survival.

### Length bias

It has been observed that cases detected through periodic, early detection programs, tend to have longer preclinical stages then those missed out by screening but self detected between examinations. This preclinical stage is defined as the interval between the time a screening test is capable of detecting disease and the time the patient seeks care as a result of experiencing symptom detected patients. Thus, the length bias tends to spuriously show a better survival among screen detected cases.

### Self selection bias

If the screening program evaluation is not based on a RCT but rather on self selection (volunteers) it is possible that such volunteers may be more health conscious, educated and more likely to give up associated risk factors; hence survival in such a screened group is likely to be better, not due to screening but because of associated factors.

## Medical Officer's Check List while planning a Screening Programme

In the past many screening programmes have been launched simply due to over enthusiasm, without any consideration to the epidemiological facets of proper health planning. The result has been often quite adverse, creating unnecessary public aversion towards screening programmes (due to lack of proper diagnostic test or treatment), and wastage of resources. It is therefore necessary that the Medical Officer in charge of Community health care should check the following list sequentially, while launching a screening programme.

Undertake a quick collection of information, by going through existing records of health institutions and other governmental / non-governmental agencies, or else, collect information by a quick survey, in respect of the community to be screened about the

(a) Demographic profile;

(b) Attitudes towards utilization of existing health services;

(c) Knowledge & practices about disease(s) proposed to be screened;

(d) Prevalence of important diseases with special

reference to the diseases proposed to be screened;

(e) Expected load of population likely to come up for screening, in respect of the community to be screened.

(f) Resource analysis

(i) Available medical and paramedical personnel, buildings, vehicles, equipment (for screening and final diagnosis), etc. What additional resources in terms of men, money and material will be required to smoothly undertake the screening test (and the final diagnostic test for those who are positive on screening)? Are adequate treatment facilities available?

(ii) Reports on previous screening programmes which were undertaken in the same community earlier and the "grey areas" noticed.

(g) Decide whether it is worthwhile and feasible to screen for the disease (s) in question :

(i) These considerations are very important before launching a screening programme. The important questions that you must ask yourself at this stage are :-

(ii) Is the disease proposed to be screened an important health problem?

(h) What are the high risk groups for the disease?

(j) What is the prevalence in these groups?

(k) Is a screening test available and can be administered to the subjects at a place near their home (say within 5 kilometers)?

(l) Will the screening test be acceptable to the clientele?

(m) Have the "diagnostic characteristics" (sensitivity, specificity etc) of the screening test been worked out authentically?

(n) Is a confirmatory test available? Will you be able to administer it to all those who are positive on screening test?

(o) If the confirmatory test is to be given in a specialised center, will that center entertain your referred subjects? Will the subjects be able to afford the travel and stay at the place of final diagnostic test?

(p) Are you sure that there is a proper, proved modality of treatment for the disease you are going to screen?

(q) Will those finally diagnosed be able to "afford" this treatment? Or, will you be able to provide treatment out of governmental funds?

(r) Are you sure that the disease you are screening for does not carry an over-riding "labeling" effect?

(s) Identify the high risk groups :

As we know, the prevalence will be high in high risk groups and hence the PPV and yield will be high; eg, for screening for cervical cancer, "women > 35 years from lower socioeconomic status" may be identified as the high risk groups.

(t) Collect your logistics together :

Remember, not to start a screening programme, in anticipation of the resources you may cut a sorry figure and cause adverse publicity. First get all your required personnel, equipment, reagents, and other logistics ready.

(u) "Standardize" your personnel, instruments and techniques :

The only method of ensuring a high repeatability of screening test is to centrally train your observers/ technicians, pretest and certify them, standardize your equipment and reagents, and establish quality control procedures.

(v) Ensure community participation :

Remember, a good epidemiologist never takes her community for granted. Your finest screening camp may not draw even a few subjects, simply because community participation had not been ensured. Contact the community leaders, Commanders, senior ladies, peer groups and other members of the community who may matter, right in the planning stage itself. Explain to them the importance of the disease to be screened, and the usefulness of screening and early treatment. Emphasise on them that you need their active participation. Take their opinion as regards how they would like to get the camp organized.

(w) Give proper publicity :

Make sure that at least 2 to 3 rounds of wide publicity have been undertaken, with an additional round of publicity for the high risk groups. The last round should ideally be undertaken 2 to 3 days before the start of screening camp. Ensure that those living in the remote, cutoff areas are covered well with your publicity they are usually the ones who will benefit most by your screening programmes but are generally missed out by publicity campaigns.

(x) Conduct the screening programme :

Do not leave things to chance. Be there yourself at the site, or at least ensure that one of your senior subordinates is there to address the "unforeseen" problems.

(y) Evaluate the screening programme :

Set up your "criteria of evaluation well in advance. Write down your evaluation report at an early date while things are still fresh in the mind this will serve as a good reference document for subsequent screening programmes.

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# Epidemiological Basis of Planning and Evaluation of Health Services / Programmes

In contemporary times, the importance of planning and evaluation needs no further emphasis. What is relevant to note, at this point is that epidemiology is central to the successful execution of these key managerial functions. The reason is simple - the indispensable requirement for any planning or evaluation process is "valid and reliable data" and epidemiology is the science which deals with valid and reliable data collection, collation, analysis and interpretation (76).

## The planning process

Planning is a very scientific and systematic process which essentially visualizes as to where we are at present (present situation or baseline), where do we want to go (the future or "outcome"), why do we want to go there and how do we get there (process). It consists of a series of steps and we need accurate data at each of these steps (77).

### Step 1 : Laying down the premises (scope)

This defines the general perimeters or "boundaries", in terms of place, time, population and disease condition(s), within which the health program being planned, will be restricted to (78).

### Step 2 : Situational analysis

Relevant Demographic (age, sex, population distribution etc.), socio-economic (literacy, occupation, economic status etc.) and disease data (mortality and morbidity) is obtained and analysed.

### Step 3 : Resource analysis

Data on available resources (health manpower, money and material) is obtained and analysed.

### Step 4 : SWOT analysis

The strengths (S), weakness (W), opportunities (O) and threats (T) are identified in context of the proposed programme. S and W are permanent phenomena that exist within the organization or community; O and T are temporary, often flitting, phenomena that exist in the external environment. For example, in a proposed programme for prevention and control of HIV in our armed forces, the organizational philosophy of the armed forces to ensure the top level of health and fitness for all personnel is a "strength" which should be utilized to the maximum. At the same time, the often seen tendency to condone sexual promiscuity as an indication of manliness or a basic need is a weakness pitched against us, and we need to either neutralise it or circumvent it. The fact that recently funds have been made available for developing health educational material and that the new incoming President of AWWA is strongly in favour of educating personnel and families for HIV / AIDS, is an opportunity and we should grab this opportunity. However, if there has been some recent resistance and objection from parents against sex education of children, it is a threat and we need to either negotiate it or else bypass it.

### Step 5 : Ensure Community participation

Identify the community leaders, peers and voluntary groups and involve them fully in the planning process.

### Step 6 : Enunciation of the "Community Needs"

We now carefully evaluate our findings of situational, resource and SWOT analyses and decide as to what are the major issues (within the boundaries defined by our scope) which need to be addressed and which can be feasibly addressed by us. We should also work out an optimum trade-off between 'normative" or 'professionally assessed needs" (what we, as Doctors, feel that the community requires) and the "felt needs" of the community (what the community members feel is their need). By way of community participation, educate and convince the community if, in your perception, their felt needs are unscientific or cannot be addressed within the resources (79 82).

### Step 7 : Setting the Priorities

Now, on the basis of our judged community needs and the resources, work out the "priority" areas within the proposed programme, which are the most important requirements and we, given our available (and expected) resources, can feasibly address them. An epidemiological method for according priorities is to consider the following three headings and give marks (1, 2 or 3) to each heading as per following description. Disease which gets the highest score (max possible will be a score of 9) would get the highest priority while the lowest scoring disease (minimum possible score will be 3) gets lowest priority.

(a) Importance of disease, (based on mortality, morbidity, suffering, cost of treatment and loss of productivity) :- 3 marks if high importance, 2 if moderate, 1 if low importance.

(b) Effectiveness of Interventions :- 3 marks if interventions known to be very effective, 2 if moderately effective, 1 if low or non effective.

(c) Cost of interventions : 3 marks if cost is low, 2 if moderate cost and 1 if cost is high. (Intervention could be a treatment or preventive modality).

### Step 8 : Identify the "High Risk" Groups

High Risk groups are those persons, who due to some characteristics, have a much higher chance of being affected by the disease or it's adverse consequences. It is important, at this stage, to identify who are the high risk persons, based on our situational analysis and identification of community needs, so that extra efforts may be directed towards them, Young children, women of child bearing age, the elderly, people living in slums or inaccessible area are some of the usual examples of hisk risk groups. However, it depends on the disease or condition being addressed. For example, in a educational programme to obtain favourable change in lifestyle, the JCOs, the NCOs and the recruits may be identified as high

risk group. The importance of identifying these groups lies in the fact that while we shall direct our activities to all members of the community, special, more focused and more elaborate (targeted) actions will be directed towards these groups. Consequently, large amount of benefit will occur from the programme if these groups are addressed.

**Step 9 : Enunciate the Goal (Aim), Objectives, Indicators and Targets of the Programme**

Once the community needs have been identified within the context of the proposed programme, we enunciate the Aim or the Goal. This is a broad statement of the overall end-point which the programme intends to achieve. Objectives, on the other hand, are specific statements, through which the overall goal would be achieved. Objectives are thus specific, quantifiable and usually relate to a time-plan. Indicators are parameters and targets are numerical quantities written in conjunction with the indicators, which actually quantify the end points which the objectives are to achieve. For example in a program directed towards healthy lifestyle, the statement "to bring about healthy improvement in various aspects of lifestyle and a reduction of lifestyle diseases so that they are no more a significant health peoblem" is the broad goal or aim. The statement "To ensure that by 31 Dec 2008, at least 80% of the personnel undertake 45 minutes of brisk walk daily on at least 5 days a week" is an objective, in which "community members who are undertaking regular aerobic exercise as per defined criteria of 45 mts a day on at least 5 days a week" is an indicator and "80% achievement by 31 Dec 2008" is the qualifying target.

One of the most crucial steps in planning process is to intelligently enunciate the goal, objectives, indicators and targets. A lot of thought process and expert evaluation should go in at this stage. They should be realistically set, should be do-able, neither too ambitious nor too under-achieving.

**Step 10 : Choose a Strategy and Draw an Action Plan :**

With the background of the enunciated goal, objectives, targets and indicators, and duly considering the resources (step - 3), Select out as to what overall strategy you will use in the proposed programme. For instance, in a proposed programme for prevention of HIV, the strategy could be to only have health educational efforts, or else it could be a comprehensive strategy of combination of health education, blood safety, diagnosis and treatment, surveillance and PPTCT. Obviously the choice of strategy will be strongly guided by the programme objectives and your available / expected resources. If you do not have lot of resources, naturally you would select a strategy of limited activities which are likely to give you the best results. Now, having decided the strategy, write down a detailed action plan as to how the programme will be executed. Do ensure that a "time-line" has been given for each objective, target and indicator, giving the date of each end point.

**Step 11 : Address the Issues of Accessibility and Coverage :**

Get detailed spot maps of your areas and work out the aspects of population distribution, roads, communications and transportation. Do remember that very often, those who would benefit most from your programme, are also the ones who are living far off, do not have access to your services, are often thought to be not really in need of the proposed preventive or curative services. Hence at this point, work out where are your high risk persons located and how will you ensure that they are covered adequately.

**Step 12 : Organise the manpower, material & finances**

Place the required manpower, equipment, material, logistics at the required places. If some more resources are expected, make a plan as to where they will be relocated and how. Make out detailed, written "operations manual" including the operative procedures for each activity, i.e., "who will do what to whom and in what manner". Ensure that your personnel have been centrally trained and tested for undertaking the procedures.

**Step 13 : Undertake a "Pilot Run"**

This is another very important step. Do a small scale trial run of your procedures and rectify any defects that are observed.

**Step 14 : Conduct the Programme**

Launch the programme in a full fledged manner. Ensure that you or your dependable deputies are there always at the sites where the services are being delivered. Make it a point to regularly obtain and analyze data on various aspects as the programmme progresses, making changes if required.

**Step 15 : Evaluate the programme**

Evaluation is the process of assessing the extent to which our results are commensurate with our pre-decided objectives. Evaluation should be a continuous process as the programme progresses (concurrent evaluation) and not simply an exercise to be undertaken at the end of the programme (terminal evaluation). For evaluation, we again need valid and reliable data in the same way that we obtained in the planning stage. Broadly, evaluation is undertaken for six different facets, as follows :-

Evaluation of Relevance

This evaluates whether there is need to continue it as such or in some modified manner (concurrent evaluation) or, at the end when we do terminal evaluation, to find out whether the programme was required at all. This requires obtaining and reviewing the data / intelligence about situational analysis, resources and community needs.

Evaluation of Adequacy

Whether the required amount of manpower, equipment, expendables, logistics, other type of material and finances have been provided? Have they been suitably placed?

Evaluation of Process

How are / were the services / activities undertaken? What has been the quality of services? Were the services accessible to or provided to all the beneficiaries or only few segments? For example, are the targeted number of children being vaccinated, have some areas been left out,

the scheduled number of patients being seen and the planned number of health education sessions being taken, and so on?

### Evaluation of Efficacy, Effectiveness and Efficiency

Efficacy answers the question "can the programme or procedure work" (maybe in ideal or controlled situations); Effectiveness addresses the question "Does it work" (i.e., in the real life situations); Efficiency answers the issue "Is it the most economical way (in terms of time or money)". For example the conventional combination regime of Streptomycin, INH and Thioacetazone may still give pretty good results for curing pulmonary tuberculosis if we were to treat patients admitted into the sanitoria for 18 months (i.e., is efficacious), but in the real domiciliary settings, bring about only about 30% cure (is not effective), while MDT would cure 70 to 80% patients in real life domiciliary settings (is effective). Finally, comparison between the total costs of the two regimen (drugs, duration of treatment, requirement of doctors, paramedics and hospital buildings, commuted cost of reduction in human suffering due to earlier cure, etc) vis-à-vis the overall cure rate may finally indicate that short term MDT may be more "efficient". Summary of steps for planning and evaluation of health programme is given in Table -1

Table - 1 : Summary Box : Steps in planning the health programme

- ☐ Laying down the premises (scope)
- ☐ Situational analysis
- ☐ Resource analysis
- ☐ SWOT analysis
- ☐ Enunciation of the "Community Needs"
- ☐ Setting the Priorities
- ☐ Identify the "High Risk" Groups
- ☐ Enunciate the Goal (Aim), Objectives, Indicators and Targets of the Programme
- ☐ Choose a Strategy
- ☐ Draw an Action Plan
- ☐ Work out where are your high risk persons are located and how will you address accessibility and coverage
- ☐ Ensure Community participation
- ☐ Organise the manpower, material, and finances
- ☐ Undertake a "Pilot Run
- ☐ Conduct the Programme
- ☐ Evaluate the programme
  - Relevance
  - Adequacy
  - Process

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# Quantitative Sciences

## Research Methodology & Clinical Epidemiology


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# The Essential "Building Blocks" of Research Methodology

The question that we may, quite intuitively, ask is that we are all very well qualified and experienced; we can conduct research pretty well, with the capability to execute research improving with increasing clinical experience. Why should we have text books or training curriculum in "Medical Research Methodology". In fact, medical research methodology (often referred to as "Clinical epidemiology" to make it more attractive to the clinicians) is nothing but an extension of the wise clinician's intuitively explorative faculties. However, such an extension of this faculty (of educated thinking, observing, analyzing and reasoning) as well as the understanding of essential principles and methods of research does not occur simultaneously and concurrent to the learning and practice of medicine. For instance, history of medicine is replete with examples, wherein results based on unscientifically conducted research (gastric freezing, blood letting, "tape-seton' and so on) have been applied, only to cause harm to the patients, just because they were based on unscientific research methods. It therefore needs, in addition to our qualifications and experience in medicine, a working knowledge of the essential principles of research methodology and biostatistics, that need to be clearly understood by all medical persons who are interested in research. This chapter would be explaining these essential principles.

## The first building block : The research question

Funny though it may sound but as per the collective opinion of a number of expert referees of some of the most esteemed international medical journals, in almost half of the research articles that they get for reviewing, the authors did not seem to be clear as to what they wanted to do! Therefore, the first stepping stone in any effective medical research is to develop a proper research question. An appropriate research question, developed after fair amount of academic reading and discussions, is not only an essential requirement for a good research work but also ensures that a major part of research work is effectively sorted out (1).

### Steps In Developing The Research Question

Step 1 : Find a general area of interest

"General area" means a broad field; eg. 'AIDS' or 'Urinary Tract Calculi'. This would depend on our basic, intrinsic interest, our own clinical observations, discussions with colleagues, and deliberations at medical conferences.

Step 2 : Read 'around' the topic

A superficial, very wide (extensive) (but NOT an in-depth intensive study) in the selected area of general interest should now be undertaken, including papers published in related journals for previous 3-5 years, text books and reference books.

Step 3 : Identify a specific area of interest

The broad reading undertaken in step-2 helps us identify those areas where gaps in knowledge exist (work has not been done) and which we, given our strengths and limitations, can try to fill up, e.g., after a wide reading in the general area "Urinary Tract Stones" we may get specifically interested in "Risk factors for Urinary Tract stone formation among Army soldiers".

Step : 4 Read "into" the topic

Once the specific area of interest has been identified, we must now do an 'in-depth' (intensive) study into this specific area (in contrast to the wide, extensive study of step 3). In addition to text books, reference books and relevant journals, detailed discussions with experts in that particular field should be undertaken and published journal articles dealing specifically with our topic of specific interest should be now studied, using the library and internet.

Step 5 : Formulate a "tentative" research question

We would, by now, after going through step 4, have identified a very specific item where some amount of work has gone by, but still gaps in existing body of knowledge exist which need to be investigated. We would also have acquired substantial knowledge as to what other workers and authorities in this field have already studied, how they have undertaken the studies, what results they have already got and what lacunae remain. We can thus write a statement, indicating our "tentative guess", quite specific in nature, which we wish to prove or disprove, in our proposed research work.

Step 6 : Evaluate the tentative research question for its suitability

This evaluation is based on following four parameters :-

**Feasibility**

Is our proposed work "DO-ABLE" in terms of technical / professional capabilities, manpower, money, equipment, time, availability of subjects and logistic support. Feasibility is, in fact, an extremely important consideration. In case it is not feasible, then either we should try and increase our "capabilities" as by organizing funding, equipment and personnel, or else postpone the proposed work.

**Ethics**

Is there any likelihood of breach on confidentiality of human beings, or, exposure of subjects to potentially hazardous agent, or else deprivation of subjects from a potentially useful agent? Will it be cleared by the Institutional Ethical Committee? In general, the major ethical considerations revolve around the issues of protection of confidentiality of subjects; Physician's obligation to his subjects vs. societal good; and, additionally, in a clinical trial, the issues of informed consent, randomization and the use of placebo (2 8).

**Relevance**

Is the topic relevant to our colleagues in our own speciality and the settings in which we generally practice.

**Novelty**

Is there something new? Or, is it that the research

question been already answered clearly on a large number of occasions previously ?

Step 7 : Make the research question as "Specific" as possible

The more specific a research question, the more fruitful will be the research, e.g. " Can drinking 5 litres water per day reduce the risk of renal stone formation by 25% in young, physically active male soldiers serving in desert areas, after duly considering the confounding effects of primary renal disease, dietary factors, racial background, hypercalciuria, hyperoxaluria and hyperuricosuria?" A specific research question would give an idea of the suspected cause or "exposure" (lack of drinking water), the postulated effect or "outcome" (urinary calculi), the expected magnitude of effect (25%), the dose-response (5 litres water per day leading to a 25% improvement), the potential confounding factors (dietary factors, renal disease etc.), and the subjects / settings (young male soldiers in desert areas).

Step 8 : Write down the research question and its significance

It would be a very fruitful exercise to reduce the research question, once finalised, to writing, in a paragraph or two. This would provide a permanent reference during the entire conduct of study; we may further refine it also. In addition to writing down the actual research question, at this point of time, we should also write down its significance in brief. The same would come very handy when writing the introduction of our dissertation / research paper and is, in any case, an obligatory requirement when we put up our research proposals for allocation of monetary grants. The significance of the research question should briefly bring out the following aspects :

(a) The Research question itself, in adequate detail as explained above and it's importance in contemporary clinical / public health practice.

(b) What is already known about the question, based on review of recent literature, and communication with experts.

(c) What are the "gaps" in the existing body of knowledge in this field which need to be filled up, and which this research question proposes to fill up.

(d) What are the possible problems in executing the research on this question in terms of feasibility, methodological issues and ethics.

(e) How the findings of the present study are likely to resolve the present uncertainties in this area, and influence / improve clinical and public health policy.

## The second building block : one subject or many?

Let us look at an example drawn from a report in a reputed journal published in 1969 "..... a 58 year old woman with moderately severe Parkinson's disease recounted to her family physician that 3 months ago, while taking amantadine hydrochloride 100 mg twice daily to prevent flu (then used as an anti-viral drug), she experienced a remarkable remission in her symptoms of rigidity , tremors and akinesia . These symptoms promptly returned on stopping the drug after six weeks ....."(9). The effect in the patient was striking. At that time, medical world was in desperate need of an effective drug for Parkinsonism . However, this report based on a single case could not lead to immediate change in clinical practice. Clinicians tried out Amantadine in a limited number of patients of Parkinsonism and observed beneficial effects in many of them. They, thereafter, tried out the drug in a standard clinical trial, randomly dividing a group of patients of Parkinsonism into two, giving Amantadine to one group and the existing standard therapy to the other and noticing the much larger beneficial effects in the Amantadine group. From the initial description in 1969, it took the medical fraternity a couple of years before introducing Amantadine into clinical practice as an anti-Parkinsonism drug .

> The major difference between clinical practice & clinical research is that in clinical practice we are concerned with only one subject i.e., the patient while in research our focus is on a "large" number of subjects.

There is reason for such delays, for no inferences regarding a risk factor, or prospective marker, diagnostic agent, therapeutic procedure or preventive agent can be drawn from observations on only one or even a few patients or subjects. Why is this so? Because, there is a well known natural phenomenon of variability - no two human beings are likely to be the same. Hence what happens in a

**Summary : Developing the research question**

A well formulated research question ensures that half the job of research work is well completed. Developing a research question is a very scientific and deliberate process involving comprehensive academic inputs. Developing a good research question involves the following steps

- Find a 'general' area of interest
- Read 'around' the topic : A wide and extensive study in that area
- Find a 'specific' area of interest
- Read 'into' the topic : An indepth, intensive reading in the specific area
- Formulate a tentative research question
- Make the research question as 'specific" as possible specify the exposure, outcome and confounding variables, the settings, the dose response relationship & the expected magnitude of effect
- Test the tentative question for feasibility, relevance, Ethical angle, and novelty.
- Write down the final research question and its background significance in a page or two.

single patient may be simply due to chance just because of this natural law of variability. It may be just because of chance that the first patient of lung cancer whom you see may not have even touched a cigarette over his lifetime but that does not mean that smoking is not a risk factor for lung cancer. Inferences about the role of smoking in causation of lung cancer were based on history taken from hundreds of patients of lung cancer & comparing them with the history taken from another hundreds of healthy persons without lung cancer (10, 11).

Thus, an important building block in research methodology is the concept that while clinical practice and research utilize exactly similar procedures, in clinical practice, our focus is on a single individual - the patient, but in clinical research, the interest is not on a single but large number of patients or subjects. And it is from here that many of the (apparent) difficulties of research methodology originate, because, in research, you have to study a "large" number of patients ("subjects") vis-a-vis only one patient that we are used to study, in clinical practice.

### Third building block : Ultimately, research is the relationship between "Variables"

In the process of medical research, we decide the various headings on which we will make measurements on our subjects. For example in a trial of the efficacy of a new lipid lowering drug, we would note down the age, sex, blood pressure, blood glucose, total / LDL / HDL cholesterol, whether the particular subject was given the standard lipid lowering drug or else the new drug, final level of lipids after, say, 6 months and so on. In research methodology, these various "headings" are called "Variables" (12). Thus, Age, Sex, name of the drug administered, LDL level etc., are all "variables". A variable is thus any quantity or quality of a subject which can be measured and which 'varies', i.e., likely to have a different value from one subject to another. Thus, sex is a "variable" since it is a "quality" which is likely to take some different value (either male or female) between two subjects. In fact, when reduced to the lowest terms, all medical research is simply the study of relationship between variables. We will enter these findings initially on individual forms for each patient and later transfer the information to a chart (manual or computerized) wherein the "value" of each of these "variables" will be entered for each patient. This chart, duly completed with all details for the required sample of patients / subjects is what is known as 'DATA'. Data can thus be defined as an organised collection of information, containing the 'values' of the various variables, obtained from a sample of subjects, and which would be subsequently used to derive conclusions through the process of scientific analysis and reasoning. Depending on how the values of various variables are recorded, the data that we collect can, broadly, be either of two types, viz., "Qualitative" and "Quantitative". Each of them can be of further 3 subtypes, i.e., Continuous, discrete and ordinal numerical for quantitative types and dichotomous, polychotomous nominal and polychotomous ordinal for qualitative data (refer to chapter 2 of the section on "principles of epidemiology" for details). As we shall see subsequently, the various variables in a research work would fall under either of the three broad categories of 'Exposure', 'Outcome' and 'Confounding or Control' variables.

**The process of deciding the study "variables"**

- Read your research question in detail
- Decide what are the :
  - Exposure variable
  - Outcome variable
  - Confounding (control) variable
- Decide how would you measure these variables to best answer your question
  - Quantitative Continuous
  - Quantitative Discrete
  - Quantitative Ordinal
  - Qualitative Dichotomous
  - Qualitative Polychotomous Nominal
  - Qualitative polychotomous Ordinal

It becomes very important for the investigator to specify as to what 'variables' will be studied and what would be the 'measurement scale' for each of them, because the subsequent analysis of data will depend upon the type of measurement scales used for different variables, and because the measurement scales are a by-product of study objectives. For example, the same variable, e.g., Diastolic blood pressure can be measured on a continuous scale (DBP recording); or on a dichotomous scale (Hypertensive / normotensive), or polychotomous ordinal scale (Normal, Mild, Moderate and Severe hypertensive) or a numeric ordinal scale (hypertension grade 0,1,2,3 etc.). The decision as to which scale to use will depend on the research question and study objectives; for physiological effect of nicotine or pharmacodynamic study of a drug, we may record it on a continuous scale; for an initial preventive research (whether alcohol use is related to hypertension) we may record it as a dichotomous variable; for a drug trial on hypertension we may record it as an ordinal variable (normo, borderline, mild, moderate, severe). However, whenever in doubt, remember that a continuous (or discrete) variable contains the maximum amount of information followed by a ordinal scale while the dichotomous scale records least information (DBP of 96 or 130 will be both recorded as 'hypertensive'). If the data has been recorded on a continuous or discrete scale, it can be later collapsed into polychotomous or dichotomous categories

### Fourth building block : The "Data" needs to be summarised

In the process of medical research, we would collect the information on a large number of variables as are relevant to our research work. However, as we have already explained in the section on "Principles of Epidemiology",

this large collection of data does not convey any meaning. Hence, we need to summarize our data into "summary figures" which will convey, in one sight, what our data tends to convey. Depending on the scales on which we have measured various variables, these summary figures would be either "mean", or "median" or, more commonly, a proportion or a rate. In turn, a proportion is generally worked out as "prevalence" while a rate is worked out as "Incidence". We have already clarified these concepts in the earlier section on Principles of Epidemiology. You may go through the same, before proceeding further.

### Fifth building block: Whether to study one group or two groups

"….. Some strokes are caused by cerebral infarction in the area of brain distal to an obstructed segment of the internal carotid artery. It should be possible to prevent stroke in people with these lesions by bypassing the diseased segment so that blood can flow to the threatened area normally. Also, it is technically feasible to connect the superficial temporal artery to the internal carotid artery, distal to an obstruction. Because its value seemed self evident on anatomic and physiological grounds, the procedure was applied on a series of patients who were offered surgery, out of which quite a few showed improvement. With this background, as also the documented success of another analogous procedure, the CABG, this new surgical procedure of extracranial-intracranial arterial bypass became widely used in 1970s & 1980s. (However it may be noted that no control group was studied at that time)…..". In1985, the EC/IC bypass study group conducted a randomized controlled trial in which patients with cerebral ischemia and an obstructed internal carotid artery were randomly allocated to surgical or medical treatment. In the surgical group, the operation was a technical success - 96% of the anastamosis were patent a year after surgery. However, surgery did not help the patients. Mortality and stroke rates after 6 years were, in fact, slightly higher in the surgically treated patients as compared to medically treated patients; Moreover, deaths had occurred earlier in the surgically treated patients ….." (13).

An important building block of research methodology is to realize the fact that final conclusion about the risk factors, therapy, prevention or prognosis can be drawn only after comparative research. While results derived from observations made on only one group of subjects may give valuable suggestions for further exploration, however, putting into action, conclusions based on only one group may be fallacious. Studies which describe certain phenomenon or clinical outcomes on only one group are called descriptive studies; they generate strong suggestions or hypothesis but certainly do not give us the final verdict. For getting the final verdict we have to do a comparative study in which a group having the factor of interest is compared with another group which does not have the factor. If the result is better in the group with the factor, then only we can conclude that the particular factor really makes a difference.

### Sixth building block: quantifying the exposure (cause) outcome (effect) relationship

In the 1970s, an issue in the treatment of pulmonary TB was that the patients who were issued their medicines for the complete month (Domiciliary, self administered ATT) were not showing the desired cure rate despite the documented efficacy of multidrug regimen. It was felt that some form of directly observed intake of drugs, which ensures compliance, may be more effective. To test this question, 300 patients of Pul. TB were divided into 2 groups of 150 each. One group was managed with directly observed regimen while the other with the conventional, self administered regimen. Outcome criteria of cure were based on microbiological, clinical & radiological parameters after six months of treatment. The results were as follows(Table - 1)

Table - 1

| Exposure (intervention modality ) | Achieved outcome (cured) | Did not achieve outcome (not cured) | Total |
|---|---|---|---|
| Given Trial modality (DOTS) | 121 (80 %) | 29 (20%) | 150 (100%) |
| Not given trial modality but given control modality | 59 (40 %) | 91 (60%) | 150 (100%) |
| Total | 180 (60%) | 120 (40%) | 300 (100%) |

It is clear that out of the 150 patients given the exposure, 121, i.e., 80% achieved the outcome (were cured) while 40 % of the non exposed group achieved the outcome. These values of 80% and 40% are in technical language called the incidence of outcome in the exposed and the non exposed groups respectively. If we were to ask you whether DOTS was effective, you would immediately say yes. How many times is DOTS more effective than self administered treatment? : 2 times. How did you work out this figure? : by dividing 80% by 40%. In research practice this value of "2 times more" is called the RR (Relative risk or Risk ratio) and we work it out by simply dividing the incidence of outcome in the exposed group with the incidence of outcome in the non exposed group.

These simple issues are actually one of the most important building blocks in research methodology, describing the exposure - outcome relation and calculating the overall effect through the conventional 2×2 table. We can convert the findings of the DOTS trial that we have just presented into a 2×2 table for the sake of understanding the notation. The 2X2 table is so named

One of the key issues in understanding medical research methodology is to understand and be comfortable with the 2 X 2 table. It is a cross combination of exposue at 2 levels (given or not given) and the outcome also

because it has 2 columns and 2 rows. The two rows divide the subjects according to whether they have the exposure or not while two columns divide the subjects according to whether they developed the outcome or not. Accordingly, we get 4 cells named as "a, b, c, d". Cell "a" denotes all those who have the exposure and also had outcome. Cell "b" denotes all those who were exposed but did not have the outcome. Cell "c" denotes all who were not exposed but developed outcome. Cell "d" denotes all those who were neither exposed nor had the outcome. One thing we would like to emphasise at this point is that you should, at the very planning stage of your research, clearly decide as to how you would define the exposure and non exposure as well as outcome achieved or not achieved. Secondly, never change the format of notation: cells a,b,c,d should represent what we have just explained. For instance cell

Table - 2

| Exposure (intervention) | Outcome | | Total |
|---|---|---|---|
| | Achieved (O+) | Not achieved (O-) | |
| Exposed (E+) | 121<br>**a** ($E^+O^+$) | 29<br>**b** ($E^+O^-$) | 150<br>a+b (all $E^+$) |
| Not exposed (E-) | 59<br>**c** ($E^-O^+$) | 59<br>**d** ($E^-O^-$) | 91150<br>c+d (all $E^-$) |
| Total | 180<br>a+c(all $O^+$) | 120<br>b+d (all $O^-$) | 300<br>a+b+c+d<br>(all subjects) |

"a" should always represent subjects who have both exposure and outcome; and so on. Your statistical analysis will completely depend on how accurately you have put the data in the 2X2 table (Table - 2).

Having given the notation as a 2 x 2 table, we would then proceed to calculate the "incidences of outcome" in the exposed (IE) and non exposed (INE) is as follows

IE = (a / a+b)

IE = 121/(121+29) =121/150= 80%

INE = (c / c+d)

INE = 59/(59+91) = 59/150 =40%

And finally we calculate the "effect" by calculating Risk Ratio or Relative Risk (RR) as

**Cautionary note**

Remember that the 4 cells (a, b, c and d) are very specific and their configuration should not be changed. First of all you have to decide as to how do you define "exposure given or not given" and "outcome achieved or not achieved". Notate these as E+, E-, O+ and O-. Now, cell 'a' will always stand for "given exposure and achieved outcome (E+O+), cell 'b' for E+O-, 'c' for E-O+ and 'd' for E-O-. With this configuration we will calculate incidence of outcome in exposed (IE) and non exposed groups (INE) as (a / a+b) and (c / c+d) respectively and the "effect",

RR= IE/ INE

RR = 80%/40% = 2

In case of a retrospective research, however, the correct measure of comparison is not the RR but Odds ratio (OR), which is calculated as (a Xd) / (b X c) . You are requested to turn back to the chapter on "making comparisons" in the previous section on "Principles of Epidemiology" for a detailed description.

## Building block no. 7: Concept of population and samples and external validity

In the second building block we had agreed that in medical research, to make any valid conclusion, we have to study not one, but many patients or subjects. But then, what do we mean by "many". How many? Ten ? Thousand ? A million ? Or all the patients with that disease in this universe. Let us say, we want to address a very simple issue- What is the seroprevalence of HIV infection among the Indian Armed Forces? For conducting this research, we have to first visualize as to what is that large collection of people whom we have is mind, to whom we would be applying our results? Our answer would be that large collection can be defined as "all personnel of Indian Armed Forces". Well, in research language this is precisely what we refer to as "Reference population" or "Total population" or "universe".

So, whom do we study? Do we do HIV testing on all the 15 lakh personnel of Indian Armed Force to derive our results? Not at all: Not possible! Not required also. We would, probably, study about a 1000 personnel, do their HIV testing and get our results. Let us say, we found 10 out of the 1000 were positive, thereby giving us a seropositivity of 1%. After the study is over, we will start saying "the seropositivity of HIV among Indian Armed Forces is 1%". This is one of the key issues in any medical research. We always keep a large population in mind but actually study only a sample, and we do not restrict our final result to our sample but apply it to the large population. And with this, a very major issue in medical research comes up - that of "population" and "sample". The concept becomes important because two types of serious errors can creep into our research just because we study samples but apply their results on to the large populations.

Let us continue with the above example of HIV seropositivity in Armed Forces. Let us say we decided to study a sample of 1000 service personnel. For the sake of convenience of our study we got in touch with all STD treatment centers and got the data about seropositivity. The result showed that 50 out of the 1000 were HIV positive and so we concluded that HIV seropositivity in Indian Armed Forces is 5%. Doesn't sound quite convincing, as it seems to be pretty high. Yes, there is something gone wrong. We had actually defined our reference population as all persons of Indian armed forces, most of them being healthy people. What we actually studied was STD patients of armed forces and, naturally, had to get such a high seropositivity rate. With this background, the first requirement of a sample is that it should be perfectly representative of the large reference

population. If a sample in not representative, the results will be erroneous since they will be different from the reality in the large population and which we want to estimate. This problem, in research language is known as loss of external validity or loss of generalisability because the results cannot be generalized to the large reference population (14).

How do we overcome this problem? We must firstly, clearly define as to what is our reference population and our actual study population, as explained in the following paragraphs. Secondly, having so defined, we must select our study subjects / patients from the actual study population, using proper methods (probability or random techniques) of selection of sample.

**"Total Population" : (Syn : 'Reference' Population; 'Target Population', 'Universe')**

This is the large and total collection of all subjects or patients that the investigator keeps in mind while planning his study and while defining the "actual (study)" population and on which he proposes to generalise his results, e.g,. in the above example the total population is "All personnel of Indian Army". Often, the 'Total Population' is very large, difficult to define, and more of "conceptual" in nature; e.g., "All patients with acute MI". In a nut shell, it is the investigator's study question / objectives and the clinical and demographic characteristics that define the Actual Population.

**Actual (syn : "Accessible" or "Study") Population**

Since the total population (universe) is often difficult to delimit, the investigator specifies a "reasonable subset" of the universe from which he actually proposes to select his sample, since it may not be at all practical or feasible for her to select the sample directly from the "Total Population". For example, in the above study we may specify "All Army Personnel in Pune and Kirkee" as the actual (study) population out of the reference population of "All Indian Army Personnel". In a nut-shell, it is the similarity to the Actual Population and the geographic and temporal (time related) characteristics that define the actual or accessible population.

**Sample**

The sample is that subset of the actual (study) population which is selected from it, which is of an 'adequate size' (as calculated by statistical methods) and selected in such a way, using laid down procedures, that it is "representative" of the study population. "Representativeness" is ensured by using certain scientific methods which see to it that every person in the study population has an "equal chance" of being selected in the sample and nothing is done by which we systematically depart from this "equal chance" principle, e.g., from the actual (study) population, defined as "all army personnel in Pune and Kirkee", for ensuring the principle of "equal chance" we may get a list of all such persons and select out the required sample size of 1000 by random numbers. However, if we systematically depart from this rule, e.g., by selecting all personnel of AFMC, CH (SC), ALC, and MH(CTC), the sample will not be representative, being biased towards the (more aware) medical personnel and hence would show an underestimate of the seropositivity.

## Eighth building block : concept of random error or chance

In the previous building block, we said that there are two major issues which come up when we study samples. First one is the issue of "representativeness" which affects the external validity. Which is the second issue? Now, in research, the moment we start studying a sample, besides the issue of external validity and generalisability due to a non representative sample, there is another major issue that needs to be addressed that of Sampling error, also called Random error, Sample to Sample error, or more simply, Chance.

Let us take an example of a very simple but stupid study. What is the amount of heads that we will get on tossing a coin. Obviously the reality or truth is well known : it is 50%. However, let us start doing this experiment just for the sake of understanding this concept. You toss the coin only once. You get a tail and so you conclude very erroneously that there is no head in a coin, if you were to make your decision on only one toss. Okay, toss it ten times. You may get 9 heads and 1 tail concluding that 90% of the coin is heads, a conclusion still far drawn from the truth. Toss it 100 times, 1000 times and 1 lakh times. The result that you would get is summarized in Table - 3

Table - 3

| No. of times coin was tossed | No. of heads (%) | Actual reality or truth about heads | Deviation of the results from the truth |
|---|---|---|---|
| 1 | Nil (0%) | 50% | 50% |
| 10 | 9 (90%) | 50% | 40% |
| 100 | 31 (31%) | 50% | 19% |
| 1000 | 605 (60.5%) | 50% | 10.5% |
| 100000 | 47800 (47.8%) | 50% | 2.2% |
| Infinite no. of times deviation | 50% | 50% | No |

The take home message is as long as you are studying a sample, even in the most honest way, the results from your sample are always likely to be different from the truth or reality that exists in the reference population and which you are trying to estimate from your sample. However, as you increase the size of your sample (as happened in the example when we increased the number of tosses) this error will reduce and your sample result will get closer and closer to the truth. However if you want your result from the sample without any error, no different from the real value in the reference population, well, then you have to study the total population itself, like tossing the coin for your entire lifetime to finally get the truth of 50%.

See one more situation. Let us say we decided to estimate the truth about the coin with the sample of one lakh tosses and we decided to do five such experiments. The results

Table - 4

| Expt.No. | No. of Heads | Truth |
|---|---|---|
| 1. | 47800 (47.8%) | 50% |
| 2. | 55301 (55.3%) | 50% |
| 3. | 51980 (51.9%) | 50% |
| 4. | 48002 (48.0%) | 50% |
| 5. | 53067 (53.9%) | 50% |

are as shown in Table - 4.

The next take home message from the above study is even if we study repeated samples of the same size, drawn in the most representative manner, no two samples are likely to give us the same result, nor the result for any sample likely to be the same as the truth which exist in the large population from which the samples were drawn. Why does this occur ? This occurs because of a very interesting natural phenomenon called " Random Error" or "Sample to Sample error" or more simply "chance". As long as we are studying a sample, which we would be doing any way, some error should always be accepted. But we can actually do two things about this error.

(a) Firstly we can minimize this error by using an adequately large sample. Calculation of adequately large sample, using statistical procedures, is dealt later in the section on Biostatistics.

(b) Secondly after the research is over, while analyzing the results we apply statistical procedures to calculate the probability by which our result may differ from the real value in the "total population", because of random error. In fact when we finally say that the "p" value is less then 0.05 we are only saying that from our study we have found that the new drug is better then the existing treatment and the probability that these results would be different from the reality that exists in the large population is less than 5 in a 100 chances.

## The ninth building block : confounding : compare apples with apples, not with oranges

Well, while minimizing the random error by studying an adequately large and representative sample and calculation of the p- value which gives the probability of the random error is all very important, it is just one of the three major errors that we have to guard against, in medical research. In fact, it is more important to effectively neutralize the other two errors rather than only worrying about the p-value and statistics. These two errors are, firstly, confounding error and secondly, systematic error also called bias or loss of internal validity or error of measurement.

Let us take a hypothetical study which evaluated the risk factors of IHD by taking 100 cases of IHD and 100 comparable but perfectly healthy people and obtaining the history of various putative risk factors. One of the

Table - 5

| Exposure (defecation Habit) | Outcome | | Total |
|---|---|---|---|
| | O+ (IHD cases) | O- (Healthy controls) | |
| E+(Privy latrines) | 70 (70%) | 30 (30%) | 100 |
| E-(Open fields) | 30 (30%) | 70 (70%) | 100 |
| Total | 100 | 100 | 200 |

factors which the investigators considered was the history of habitual defecation in privies versus open fields. The findings are displayed in the Table - 5.

70 % of the IHD patients gave h/o defecation in proper latrines, while much less (30 %) of the healthy people gave this history, preferring the traditional "open air" practice. Going to the open fields apparently, seemed to be a great protective factor against IHD while sitting on the pot inside a privy increased the risk by more than two fold! The authors were about to recommend that the entire nation should start lining up in the fields early morning to prevent the oncoming epidemic of IHD when the Prof of Cardiology told them that something seemed to have gone wrong! What had actually gone wrong was the occurrence of a very common phenomenon which occurs in research: that of confounding.

In this case there was another variable which created all the confusion - it was socioeconomic affluence, for the rich who used their privies and had more IHD not because of their hygienic habit but because of the affluent unhealthy lifestyle. This phenomenon occurred because the study in example did not follow the basic doctrine of research which says that the two groups being compared should be similar to each other in all other respects except for the factor being studied. Never compare apples with oranges. In all correctness the authors should have selected the groups whose subjects should have been similar in all other respects like age, sex, race, family history and socioeconomic status except for that one group had IHD, and other did not.

In confounding, an observed association between an exposure (eg, defaecation practice) and an outcome (eg, IHD) is "explained away" by a "third" variable (eg, `socio-economic status, in our example). This creates a `confusion' or a nuisance. The above example also tells few more things. The third variable ie, the `socio-economic status' has created this confusion, i.e., confounded the observed relationship because of the following characteristics (15 - 17):-

(a) It is associated with the exposure (e.g., with the method of defaecation, because socioeconomic status does determine such practice).

(b) It is associated with the outcome, independent of its association with the exposure (e.g. richness and affluent lifestyle can independently cause IHD, whether a rich person defaecates in a toilet or in the open).

**In medical research we should understand where all "errors" can occur, in following manner :**

- Since we study a 'sample" from a "population", error of loss of external validity may occur if representative sample is not taken
- Random error (sample to sample error or chance) will occur because we study samples from a population.
- Error will occur if our basic measurement process is wrong.
- If we systematically differentiate while comparing the two groups (Bias or systematic error or loss of internal validity)
- If the groups being compared are dissimilar in

(c) It is `differently' or `unequally' distributed in the 2 groups - (more of the rich will be found in the group having IHD and using privies as compared to the other group which is not having IHD).

(d) It does not lie in the chain of the relationship between the exposure and outcome variable, (eg., it is not that closed-door defaecation leads to richness & then to IHD).

### The importance of confounding in research

Medical literature is replete with examples when a particular factor has been proved to be a risk factor for a disease simply because the effect of third variable (the confounder) was not thought of, thereby making the entire research work invalid. See the following example. A study was done to see whether consumption of alcohol is a risk factor for oral CA. 100 cases of oral CA and 100 healthy subjects were asked regarding the history of alcohol consumption during past 15 years. The results are presented in Table - 6

Table - 6

| History of Alcohol | Oral Cancer | | |
|---|---|---|---|
| | Present | Absent | Total |
| Present | 80 | 20 | 100 |
| Absent | 20 | 80 | 100 |
| Total | 100 | 100 | 200 |

Since the above is a case-control type of study, we can calculate the odds ratios as

Odds Ratios = ( a X d / b X c )

i.e., (80 X 80) / (20 X 20) = 16

Thus we would conclude that the risk of getting oral cancer is 16 times higher if a person drinks alcohol. Someone would object to our findings, saying that this observed association is false, due to the confounding effect of tobacco use - tobacco use is related to the outcome (oral cancer); it is also related to the exposure (alcohol) since it is a known fact that people who drink, are more often the ones who use tobacco. Apparently with the above objection, the only way left for us is to make two "strata" or groups - the group which uses tobacco and another which doesn't use tobacco. Now, by simple reasoning, if the risk of cancer due to alcohol remains high in both the strata, i.e., the risk of cancer due to alcohol is high whether a person uses tobacco or not, we would conclude that the risk is not due to tobacco but due to alcohol itself. On the other hand, if the risk is not evident in the 2nd strata, then we would conclude that there was a "confounding" due to tobacco; alcohol, by itself does not carry any risk. Let us see what happens when we dissect our hypothetical data into two strata:

Stratum - I : Tobacco users

| History of Alcohol | Oral Cancer | | |
|---|---|---|---|
| | Present | Absent | Total |
| Present | 60 | 15 | 75 |
| Absent | 20 | 5 | 25 |
| Total | 80 | 20 | 100 |

Stratum OR = (60 X 5 / 15 X 20 ) = 1

Stratum - II : Non-users of tobacco

| History of Alcohol | Oral Cancer | | |
|---|---|---|---|
| | Present | Absent | Total |
| Present | 5 | 20 | 25 |
| Absent | 15 | 60 | 75 |
| Total | 20 | 80 | 100 |

Stratum OR = ( 5 X 60 / 20 X 15 ) = 1

Surprisingly, we notice that after making adjustment for the use of tobacco as above, the odds ratios in both the stratum falls down to 1 each, i.e., there is no risk of cancer due to alcohol, after adjusting for the effect of tobacco. The earlier observed association between alcohol and oral cancer (OR=16) was only because of a confounding effect of tobacco. When we made adjustment for this confounding effect of tobacco, we found that alcohol, by itself, has no risk. Had we not done this adjustment for confounding we would have drawn a wrong conclusion that alcohol causes oral cancer. The phenomena of "differential distribution" also becomes more apparent from the above 2 - strata tables. We would appreciate that a very large number of cancer patients who consume alcohol are tobacco users (60 out 80 i.e., 75%) while very few patients who consume alcohol are non-users of tobacco (5 out of 20, i.e., 25%).

### How do we overcome the problem of Confounding

There are various methods by which we can overcome this issue, either while we are planning our research or else during the stage of analysis. However, what remains extremely important is that all the Potential Confounding Factors (PCFs) must be identified and, if the adjustments

are going to be in the stage of analysis, the data on them must be recorded. Now, since all the PCF must be identified before the actual study, one must work meticulously on this issue from the very time he / she is working on the issue of developing the research question itself. In fact, while reading and discussing regarding the research question, one must very specifically start identifying what are the exposure and outcome variables of interest and what all PCF can confound this relationship between exposure and outcome because of their independent and indirect relationship with both the exposure as well as the outcome variable. The following steps should be taken :

### Controlling for confounding

Once the confounding variable(s) have been identified, action must be taken to prevent or adjust for them. Such actions can be taken either during the stage of planning and, secondly, during the stage of analysis.

#### Control during planning (designing) stage

This can be achieved by any one or more of the following methods :

#### Randominsation

If a group of subjects is divided into two, using "random allocation" (syn. Randomization) (described in the section on Biostatistics), the 2 groups will be similar to each other in all respects. The beauty, therefore, is that the 2 groups will be "similar" to each other not only in respect of all "known PCF" (age, sex, blood groups and so on) but also in respect of those factors which may be "confounders" but we are not aware of them (eg, HLA type and, may be, the average number of hair on the head!). Thus the 2 groups will be absolutely similar to each other with the only difference that one group gets the trial modality while the other will get the control modality. Any difference in the outcome between the two groups can be safely assumed to be due to the intervention being studied. The singular drawback of randomisation is that it can be done only in an experimental design (eg, drug trial, vaccine trial etc); however, it is not applicable to most of the "cause - effect" research that we do in clinical practice (you can not "randomise" people into 2 groups, telling one group to "smoke" and the other "not to smoke"). However, when we talk of clinical trials, please remember that the most important, rather essential, tool for control of confounding and equating the 2 groups at baseline is randomization, also known as random allocation.

#### Restriction

We can so plan our study that the subjects having the particular confounding variable(s) are not taken up at all; eg, in a study of the possible association between physical inactivity and IHD, young age (< 35 years) and female sex may be the PCF. In this case we may restrict our study to "only males more than 35 years age". The difficulty with restriction is that one tends to exclude out a lot of potential subjects, thus increasing the cost and effort of study; Secondly, the effect of the variables on which restriction has been done can not be studied - eg, in this example, the role of female sex and younger age can not be studied.

#### Matching

We said earlier, that a confounding variable exerts its nuiscance effect due to "unequal distribution" in the two groups. It stands to simple reasoning, therefore, that if the groups could be made "equal" in respect of the confounder, the nuisance effect can be nullified. This is the basic principle behind the very commonly used procedure in medical research - "Matching". Let us say we are doing the above mentioned study on alcohol and oral CA. Once we identify tobacco use as a confounder, what we can do is that for every case of oral CA, we would take a healthy person as control who has the same tobacco use as that of the case, ie., if the case is a tobacco user, we take the control also who is tobacco user and vice versa. The final result will be that we will have equal number of tobacco user cases and controls as well as equal number of non-user cases and controls in our study and any relation between alcohol and oral CA will now be due to alcohol, without any confounding due to tobacco. This method in which we match "one for one" (i.e., for every subject or case we take a control who is similar to that case in respect of the confounding variable), is called as "Pair Matching". The second method of matching is to do a "group matching" or "frequency matching". Suppose we want to match on 3 variables (tobacco use, age and sex ). Let us say, out of 100 cases we have 25 of them as "40-50 years old female tobacco users". We will then select out an equal number, ie., 25, healthy females who are 40-50 years old and tobacco users. In general, it is advisable for the researcher engaged in usual clinical/health research not to lay too much stress on matching. "Frequency matching" can be done for the 'universal confounders', ie., age and sex and additionally for any particular confounder which can be easily matched. As regards other PCF, which have not been matched, data regarding them must be collected and later adjustment for their confounding effect should be made during analysis (18 20).

#### Adjustment during analysis

If matching has not been done for a PCF (but the data has been collected), adjustment for its confounding effect can be done during analysis by following methods :

#### Stratified analysis

The logic of stratified analysis has been presented earlier when we described that we would make 2 strata, one with the confounder and one without the confounder. If the risk in individual strata is the same as overall risk then there is no confounding. On the other hand, if the odds ratios in the strata are very different from the overall OR (eg, in our very first example of alcohol-oral CA study where the overall OR was 16 but the stratum OR after adjusting for tobacco was 1 each), we would conclude that there is confounding. Finally, if the risk estimates in the two strata are quite different among themselves, then we should think of a more important issue of "Effect modification" (Interaction) rather than confounding.

#### Adjusted estimates (Mantel Haenszel) in stratified analysis

Very often, the interest of the researcher is not simply to see whether there was confounding or not but to actually work out the actual risk, in terms of RR or OR, after "adjusting" for the confounding effect. Eg, in a study to see whether use of Oral Contraceptives is associated with the risk of Thromboembolism, the overall OR was found to be 4.4. However, since age (> 35 versus < 35 years) could have confounded the results, the data was further analysed in two strata (women aged > 35 and women aged < 35 years). The results indicated that there was slight confounding due to age, the risk being 4.16 times in younger women and 4.83 times in older women. However, we would like to have a "summary" figure which gives us the overall risk of TE due to OC use, after adjusting for the confounding effect of age in this relationship. This is what we call the "Adjusted RR" or "Adjusted OR" or "Mantel Haenszel adjusted RR/OR", which is worked by a special statistical procedure (21). Let us say in this example, the overall (crude) OR was 4.43; the OR in the 2 strata was 4.16 and 4.83 respectively and the Mantel Haenszel adjusted OR works out to 4.35. We would conclude that the risk of TE among women who use OC, after duly adjusting for the confounding effect of age, is 4.35 times. We suggest you may take the assistance of a trained epidemiologist or statistician for calculating the same, or else use the statistical software EPI- Info 2002, the use of which is described in another section in this textbook.

**Multiple regression analysis in the control of confounding**

While stratified analysis is very effective in control of confounding during analysis, however, if there are a large number of confounding factors, then a large number of strata will have to be made and the figures in the individual strata will become very small, often zero. This is the limitation of stratified analysis. In such cases one has to resort to regression analysis (22). In very common terms, the results of the estimates (reflected as Beta Coefficients) obtained from regression analysis (Syn : mathematical models, multivariate analysis) are "adjusted" for the confounding effects and hence represent the 'net' effect of that particular variable. Further explanation about the 3 common types of regression analysis is presented in the section on Biostatistics.

### Confounding

**Definition** : A confounding variable is one which throws into confusion, an observed association between an exposure and an outcome variable, since :-

- It is related with the exposure variable.
- Independent of it's association with the exposure variable, is also associated with the outcome variable.
- It does not lie in the chain of sequence between the exposure and outcome variable.
- It is "differentially" distributed in the two groups.

**How do we control for confounding**

The most important step is to be aware of the phenomena of confounding and to identify all potential confounding Factors (PCF) right at the time when the research question is being developed. Once all PCF have been identified, action may be taken to control them either in planning stage or during analysis, by following methods :-

- During planning :- By
  - Randomization (random allocation)
  - Restriction
  - Matching

## The tenth building block: precautions against "BIAS" (Syn : Systematic Error, Measurement Error, Misclassification, Lack of Internal Validity)

Some trials undertaken earlier showed that patients with inguinal hernia who get laparoscopic repair seem to have less post operative pain and more rapid return to work than open conventional surgery. Is this result really correct or might be that laparoscopic repair may appear better because of certain biases as follows :- Perhaps laparoscopic repair is offered to patients who are in a better health or seen to have better tissue strength because of age or general health; or else, may be that surgeons and patients are more inclined to think that his procedure should cause less pain, because it is new. As the scar is smaller, the patients report less pain and the surgeons are less likely to ask for pain or record it in the case sheet; or else, perhaps patients who get laparoscopic surgery return to work earlier, than those who get open surgery, because the surgeons have so guided them. If any of these were so, the favorable result of laparoscopic repair may be related to systematic differences in how the patients are selected for laparoscopic procedure, how they report their symptoms or are asked about them, or how they were told what they can do rather than a true difference in the success rates. A clinical trial conducted after carefully taking care of these possible biases, found that patients given laparoscopic surgery in fact do experience less pain and a more rapid return to work, every thing else being equal (23).

Let us take another example of a simple clinical trial in which we gave a new drug, `A' to a group of patients with headache while the standard existing drug `B' was given to another group. After analysing the data we finally concluded that drug `A' was better in relieving headache than drug `B'. Such conclusion might have been correct, but may also have occurred because we might have selected subjects who were mentally robust in gp `A', or weaklings in gp `B'; or else, the severity of headache in gp `A' as such was lesser than gp `B'; or, perhaps the subjects, knowing that we (their treating physicians) were studying the good effects of drug `A' were too willing to please us, without our knowledge; or, maybe, the nursing officer i/c, knowing our hypothesis, ensured a high level of drug intake (compliance) in gp `A'; it may also be possible that gp `A' was assessed in detail by a highly experienced professor, while the task of assessing gp 'B' was left to inexperienced interns; or perhaps our

questions regarding relief from headache were ambiguous - we were actually asking them "how are you feeling?" Finally, it may have occurred that a much larger number of subjects in gp 'B' who actually finally got relief, also got them discharged before our assessment and so were not available for the final evaluation (selective loss to follow up).

One of the essential requirement in any scientific process is to measure correctly what we actually want to measure. In our above example, we had actually intended to measure "the difference in relief from headache" as brought about by drugs `A' or `B'. However, at a number of points we systematically departed from the correct state, making measures which were different than what we really intended to. It is a surprising as well as concerning fact that while a majority of researchers give due consideration to sample size and statistical analysis ( and, of course, to `p' value), many of us, while planning our study tend to overlook this central and key issue in research - that in our study, we should be measuring what we really intend to measure, and that the information recorded by us should actually reflect the correct state of affairs - in other words, "Any error of measurement must be prevented". Any measurement that we make must have the following two characteristics :-

**It should have `reliability' (Syn : precision, repeatability, replicability) -**

Repeated measurements should give consistent results. Reliability would be compromised in the following situations :

(a) Due to observer

This can occur due to "between observer variations" (2 different data collectors can produce different results from a medical interview or even BP measurement) or may be due to "within observer variations" (same interviewer can get different values of BP on 2 different occasions using the same sphygmomanometer and same patient).

(b) Due to subjects

Again this may be due to "within the subject variations" (circadian-rhythm, mood fluctuations) or "between the subjects variations" (biological variations - no two human beings are alike).

(c) Due to instruments and techniques

Different BP instruments or different techniques (recumbent or sitting position) will produce different BP values.

**It should be `valid' (i.e., accurate)**

It must measure what is really intended to measure. Loss of validity (accuracy) will occur if there is any process, which while making the measurements, will tend to produce results that depart systematically from the true value. This state is also called `Bias'. Whenever we are testing hypothesis regarding associations or differences, we would apparently be comparing two "groups". **Remember that validity will be compromised and bias will occur if at any point, while either selecting the subjects or else while making measurements on them, we tend to systematically depart (consciously or, as happens most of the times, unconsciously), thereby treating the two groups being compared in a different manner (24).** Thus, bias can occur at two points.

(a) Firstly, it may occur if the two (or more groups of patients or subjects) that we intend to compare, are selected in a differential manner. This is called **"Sampling" or "Selection"** bias.

(b) Secondly, it can occur if while recording the information / making measurements, we tend to treat these two groups differentially. This is known as the **"Information"** or **"Measurement"** bias.

Loss of Internal Validity leads to "systematic error" or "Bias". This will occur when we are actually measuring something other than what we actually wanted to measure, as follows

- Basic measurement technique is wrong
- Variations between observers or subjects
- Systematically differentiating between the two groups being compared at the point of
  - Selection (selection Bias)
  - Making measurements (measurement /

The extremely important thing regarding bias is that while the effects of "chance" (Random error or sampling variation) and "confounding" (as discussed earlier) can be assessed quantitatively (by `p' value and adjusted estimates), assessing bias quantitatively becomes next to impossible in the usual settings of clinical research. Bias, therefore, has to be visualised during the planning stages and steps taken to prevent it.

**Selection bias**

Selection bias is a systematic error resulting from the way the subjects are either selected in a study or else due to selective losses to follow up, of subjects. In a case control study, the major source of selection bias is the manner cases or controls or both are selected and the extent to which the presence (or absence) of exposure may influence such selection. On the other hand in cohort and experimental studies, the major source of selection bias is non-response / withdrawal from the study / losses to follow-up. In a cross-sectional study (as also in a case control study), the primary source of selection bias is "selective survival", because only those who are alive can be included in such studies. The following are the ways in which selection bias can occur :

Self selection bias / Volunteers induced bias

In general, as far as possible, avoid volunteers in any research study since they may be systematically very different from the usual population (25, 26).

Berksons' bias (hospital selective admission )

This can be a problem in case-control studies. It occurs because patients with two concurrent diseases or health

problems are more likely to be admitted to a hospital than those with a single condition. For example people who have both peptic ulcers and also smoke are more likely to be admitted to the hospital than people who have either of them. A case control study trying to evaluate the relationship between smoking and peptic ulcers may therefore find a much stronger association between the two than would really exist in the general community.

Another form of hospital admission related bias is the fact that patients who are in the severe part of the spectrum of disease are more likely to be admitted than the mild forms and these severe forms of the disease may be selectively more related to the possible exposure. Thus, an initial case control study found a strong association between high fever and febrile seizures, just because children with seizures actually fall into the severe spectrum of the disease and these children are more likely to have had high fever. (27-29)

Incidence-prevalence bias (Syn : Survivorship bias, Neyman's bias )

This is a major issue in case-control and cross-sectional studies (30, 31). For example, a case control study to evaluate the protective effect of physical exercise on MI was undertaken by taking cases of MI and healthy controls and asking them about the history of regular physical exercise. Surprisingly, a large no. of both the cases and controls gave a history of regular physical exercise; the study concluded that regular physical exercise does not protect against MI. The conclusion was, in reality, a biased one. We know that 25% to 33% of the cases of acute MI die within the first 3 hours. Only those who live get admitted to the hospital and are available as cases. Now, regular physical exercise may be an important factor in helping the person to overcome the acute myocardial episode. Thus, out of the cases of MI those who did not undertake regular exercise died while the ones who did exercise were the ones who lived to give such a history.

Healthy worker effect

A comparison between health status of army and civilian population may show a better health status of the soldiers; one of the important reasons may be because of the initial medical examination during which the `unfit' persons are excluded and only `healthy workers' are included in the army. The basic dictum of selection and comparisons in research should be to "compare likes with likes" (32).

Exposure related bias

This is a special type of Berkson's bias. If the hospital admission probability is different among those who have and those who do not have the suspected cause, such a selection bias can occur. This is specially liable to occur in case control studies. As another example, such an exposure related selection bias was viewed with concern in a case-control study that found an association between use of dietary supplementation with L-tryptophan and "Eosinophilia-Myalgia Syndrome" (EMS). The main criticism was that the initial press publicity about a suspected association may have resulted in a preferential diagnosis among known users of L-tryptophan as compared to non-users. Thus the estimate of risk (OR) obtained from such studies may have overestimated the true effect of risk.

Bias due to loss to follow-up

This is a special problem in cohort and experimental studies. If subjects drop out / are withdrawn / die before assessment of outcome / Do not respond later on / cross over to the other treatment modality in between the follow up phase, then it is also possible that those who were lost to follow up could have been systematically different from those who continued.

Bias due to selection of inappropriate control group

This is another major issue in case control studies. The basic dictum that should be followed in a case-control study is that the controls should be derived from the same source population from which cases have come and that the controls should also be equally at risk (i.e., have equal opportunity of being "exposed" to the suspected risk factor) as the cases. Take the example of a case-control study which desired to assess the risk associated with non-use of condoms (exposure) with the development of STD (outcome). In a hurry, the investigator selected cases from a STD clinic and also controls from the same STD clinic who were found to be free of STD after evaluation, at this clinic. However, many of these controls may not have developed STD probably because they had sex partner who did not himself / herself had STD, and hence these subjects had no chance of exposure (to STD) whether they used condom or not. Hence the right choice of control group in this research would have been to take people who were known sex partners of persons known to be having STD but were themselves found clear of STD, while cases should have been those who had known STD persons as sex partners and were detected to be having STD.

**Information (Measurement) bias**

Information bias is a systematic error that arises because of incorrect information while making measurements on one or more variables in the study. As said earlier, it may occur, firstly, when the basic measurement process is incorrect (Wrong instrument, wrong technique, wrong definitions, and so on). Secondly, it would occur even when the basic process of making the measurement is correct but the measurements are made in a systematically "differential fashion" between the two (or more) groups being compared. This will result in "misclassification" of either the disesase ( outcome) or "exposure" status, or even both of them. Information bias is likely to occur in the following ways :

Recall bias

This is a major problem in case-control as also in cross-sectional studies. The fact that a person has become diseased, he or she is more likely to recall the possible exposure; eg., in a study of X-ray exposure during pregnancy and subsequent leukaemia in children, mothers of leukaemic children are likely to recall more and thus give more history of X-ray exposures (31, 33).

Detection bias

This is more of a problem in prospective studies. Those who are exposed to the factor of interest may also be more liable to be subjected to diagnosis and hence detection of the disease of interest (24, 31); e.g., in a follow up study on the question whether smoking is the cause of emphysema, we would take a group of smokers and another group of non-smokers (both groups free of emphysema at the start of follow-up) and would follow them for a defined period of time to see for development

| Types of bias | |
|---|---|
| **Selection Bias** | **Measurement Bias** |
| Self selection (volunteers) Bias | Recall Bias |
| Berksons Bias | Detection Bias |
| Survivorship (Neyman's) Bias | Observer's Bias |
| Healthy worker effect | |
| Loss to follow-up Bias | |
| Inappropriate control Gp | |

of emphysema. Now, because of various other problems (cough, IHD, dyspnoea etc.), smokers are more likely to report sick and hence more likely to be diagnosed as emphysema, once they report to a medical facility.

Observer's (Interviewers) bias

If the interviewer is aware as to which group is having the particular exposure (in a follow up study) or the disease (in a case control study) then he/she would be more inclined (subconsciously) to interrogate/examine that particular group more exhaustively, to prove the research question (24, 31).

**Prevention of Bias : Checklist.**

The following check list will help in preventing bias in most of the "usual" settings of clinical and health research.

(a) General points for preventing basic errors of measurements

(i) Clearly write down the research question in adequate detail.

(ii) Identify the "variables" in the study, in respect of which the measurements are going to be made. This should be written down as "Exposure", "Outcome" and "Confounding" variables.

(iii) Now, write down clear details of what measurements should ideally be made for each of these variables. This is done by going through the published evidence and consultation with experts. For example, if one of the outcome variables is IHD, the ideal (gold standard) measurement would be either coronary angiography, or a combination of echocardiography and exercise ECG.

(iv) Now, write down how you are actually proposing to measure this variable in your study and whether it is scientifically acceptable. How near does it come to the gold standard. Most of the times the measurement process actually being used may not be ( rather cannot be) the gold standard itself. For instance, in a field / community based research on IHD, it may not be at all possible to do coronary angiography on such healthy, free living subjects. In such case, one may decide to use a combination of symptoms with resting ECG findings as evidence of coronary insufficiency.

(v) Next, discuss with the experts whether the methods of measurements you are planning for each of the variables is scientifically sound / accepted by eminent organisations / has already been used by some eminent workers earlier ? For example, a combination of symptoms and resting ECG, using the laid down Minnesota code criteria, is often used for healthy, population based subjects for evidence of IHD in epidemiological research work which is accepted by WHO and used in earlier large scale community based epidemiological studies.

(vi) Now, write down a detailed "protocol" on how exactly the measurement is going to be made, e.g., how the ECG will be recorded, who will record it, and how it will be read.

(vii) Next, write down how "quality control" will be ensured. For example, one may specify that a random sample of the positively and negatively read ECGs will be reviewed by a cardiologist for independent evaluation and quality control.

(viii) Now, see the equipment, reagents etc., which will be used for measuring this variable. Are they accurate? Standardise them, initially and periodically in between the study, against some standard machine. Remember that questionnaires are also instruments. Develop them properly. As far as possible, use such questionnaires and other scales which have already been used and standardised (e.g., Jones criteria; quality of life questionnaire; MPQ etc.).

(ix) Standardise the method (technique) of making any measurement. Preferably use a standardised technique as recommended by a standard professional body (e.g., WHO, Amer Heart Assn etc. ) or a standard text book. Write down the detailed technique in an "operations manual".

(x) Train all the interviewers/ data collectors centrally about the technique, test them and certify them. If you are yourself the sole data collector, get trained and certified by an expert.

(xi) If possible, take repeated measures (e.g., 3 readings of BP).

(xii) Try to make "unobtrusive" measures so that subjects are unaware; eg., alcohol consumption may be recorded by going through wine bills rather than only asking the subjects.

(b) General points for preventing Selection and Information Bias

(i) As far as possible ensure blinding - definitely in an experimental design; even in a case control study

or cohort study, the observer can be "blinded".

(ii) If possible, do not tell your research hypothesis to the subjects (helps preventing recall bias). In addition, if possible, try and take information about exposure from other sources, in addition to the subjects.

(iii) In a follow up study (cohort study or clinical trial), take a well defined population to avoid loss to follow up; develop methods to retrieve those subjects who are getting lost to follow up .

(iv) Select two or more than 2 "groups" of controls in a case control study (e.g., one from hospital and another healthy group); try and take different categories of diagnoses if selecting hospital controls.

(v) In cohort or experimental studies (follow up studies) specify clearly the future dates of examination and examine all subjects of both groups at the pre-decided dates using "similar" methods of history taking, physical examination and investigations, and make arrangements that losses to follow up are minimized.

(vi) In a case control study, use the correct time frame for recording exposure (e.g., for a study between pneumonia and cold exposure, the time frame should be 6 days and not 6 months).

(vii) See, in a case control study, specifically for

- That the controls come from the same "source" population from where cases have come; and that cases and controls have the same "selection factors" for getting admitted to that particular hospital
- Is there any possibility of "survivorship" bias ?
- Is the disease such that the initial symptoms may have led to a change in exposure? (eg, initial dyspeptic symptoms of gastric CA may cause the patient to give up tobacco)
- Did the controls have a reasonable chance of being exposed to the factor of interest? (hysterectomised women in any case do not have a `chance' of exposure to OC, so do not keep them in controls in an Oral Contraceptives - Thromboembolism study)

(viii) In any type of study, see the "entire spectrum" of the outcome or disease - e.g., in IHD, also see in addition to MI, angina, sudden death and a symptomatic ECG changes.

(ix) In an experimental design (clinical trial), ensure Random allocation, Blinding and Placebo control.

### The eleventh building block : selecting the appropriate "research design"

It is of importance that the correct "Research Design" be selected by the researcher. The various types of designs "Descriptive, Analytic (Case-Control, Cohort, Cross-sectional), Experimental, and Diagnostic test studies have already been described in detail in the previous section (Principles of Epidemiology) and you are advised to refer to the same. However, the following guidelines are given in the succeeding paragraphs to assist you in selecting the design most appropriate to your research question.

First of all read your research question and ask yourself the following question : Am I interested in establishing an association between an exposure and an outcome variable ( as, whether a particular variable is being studied for it's role as a risk factor for a disease, or a prognostic marker, or a treatment / preventive modality, or else as a diagnostic or screening procedure), OR, whether I am only trying to describe a phenomena. If my interest is only to describe a phenomena and not to study any "Exposure-outcome" or "cause-effect" relationship, then I should select the "Descriptive study design". Some examples of situations when we would select out the descriptive design are

(a) In asymptomatic HIV positive persons, how does CD4 cell count decline over time, till death (natural history)

(b) What is the proportion of cases of acute MI out of the total hospital admissions in one year in my hospital; (load of a disease)

(c) How many new cases of measles would occur in one year among infants in the community under my health care (incidence of a disease)

(d) How does weight change occur among new borns over the next one year of life (course of a natural phenomena)

(e) How many cases of adult hypertension or smokers are there in my community (prevalence of a disease)

The above are just a few examples; the basic consideration is that if the focus in our research question is simply to make a description without any intention to make comparisons and prove a point regarding a cause (exposure) effect (outcome) relationship, then the right design for us to do is a "descriptive" study. Depending on the issue at hand, the descriptive study could take the lines of either a case report (description of a single report of an unusual / interesting case), a case-series (description of signs, symptoms or course of disease in a number of cases of the same disease), or a "cross-sectional descriptive (describing the prevalence of a disease in a community or the percentage of some signs / symptoms in a given group of patients of a disease)' or else a "longitudinal descriptive" study (incidence of a disease or such other outcome in a group of subjects or patients followed up over a period of time).

On the other hand, if we realize that our research question intends to make comparisons with a view to analyse some cause (exposure) - effect (outcome) relationship, i.e., we have some "preformed hypothesis" in mind saying "this is the cause of that" or, "this is better than that" then our choice of research design should be out of one of the "analytical" studies. Some examples are

(a) Does presence of a transverse ear lobe crease (as compared to those who do not have it) indicate an

increased risk for developing IHD? Or, are those with waist size 90 cms or more at higher risk of IHD (compared to those with waist < 90) (risk marker or risk factor).

(b) Does occurrence of multidermatomal herpes zoster in an asymptomatic HIV positive individual predict an earlier death (as compared to those asymptomatic HIV positives who do not develop herpes zoster or develop only uni-dermatomal) (prognostic factor)

(c) Will administration of oral Doxycycline to troops proceeding on flood relief duties, be useful for preventing leptospirosis (as compared to those who are not given Doxycycline (prevention)

(d) Is laparoscopic repair of hernia better (as compared to conventional open surgery) (treatment)

(e) Does a combination of "cold intolerance and unexplained weight gain" diagnose hypothyroidism (as compared to when the gold standard of thyroid function test is given) (Diagnosis)

Now, once we have decided that we should be using analytic design, the next question which immediately comes up is which analytic design? To further proceed, ask yourself the question "Do I intend to study the effect of either a preventive procedure (a chemoprophylactic drug or a vaccine or sera or even a health educational measure) or else the effect of a treatment (a new drug or operative procedure or even a ward procedure intended to improve the clinical management). If the answer is yes, the only design we can use is the Experimental i.e., Intervention design. It could take the form of a clinical trial (RCT) or a preventive trial or else a Community Intervention trial.

On the other hand, if the answer to the above question is No, then ask the next question "do I intend to study a prognostic factor, i.e., some variable which will help me predict the course of illness. If the answer is yes, the only design available to me is the "Cohort" design.

Now, if I am neither studying the effect of a treatment nor a preventive procedure nor a prognostic factor, ask yourself whether you intend to study the performance of a diagnostic test (pathological or radiological procedure or even a clinical diagnostic rule) as to how well it would diagnose a disease vis-à-vis the gold standard. If this what your research issue is, then select the "Diagnostic test evaluation design".

Finally, ask yourself whether you intend to study the role of a risk factor (or risk marker) in causing a disease. If this is the issue, then you can select either of the following two designs as follows :

(a) If the disease you are studying is a rare one, enough number of cases of the disease will be available at your hospital, and the hypothesis being tested is relatively a new hypothesis (eg, whether using mobile phones is a risk factor for leukaemia) then select the "Case-Control" design.

(b) If the hypothesis you are persuing has already been tested by a few case-control studies, or the

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# Planning, Design and Conduct of Case Control Studies

We have already deliberated on the situations in which a medical researcher should select the case control design to answer her research question. The case control design is one of the finest and easiest methods of analytical research available to the doctor who has an easy access to patients of a particular disease admitted to the hospitals. At the same time, case control studies may be considered as the "Acid Test" for the capabilities of an epidemiologist and seasoned researcher because of the high potential for 'bias' that they have.

In a case control study, the researcher starts by picking up 'cases' who have already developed a particular disease or 'outcome' of interest, and a comparison group (controls) of subjects who, except for the fact that they have not developed the particular disease, are otherwise similar to the cases. Having assembled the two groups, the investigator finds out the presence (or, the history) of the particular 'exposure' which he thinks is a risk factor and compares the two groups (cases and controls) as regards the presence of exposure.

The case control study has a special value in medical research because of the special advantages that if offers However, the method carries certain distinct disadvantages and the researcher choosing this design must remain careful to take preventive action against them. (see adjoining box).

**Case control studies**

**Advantages**

- Inexpensive, requires only a few subjects gives quick results
- Well suited for diseases which have a long latent period (eg, cancers, AIDS, MI, CVA etc)
- Well suited for an outcome which is 'rare'
- Well suited for conditions in which medical care is usually sought
- Helps in examining multiple etiologic factors - once we have the cases of the disease, we can take history of all the factors that we feel may be risk factors
- Reasonably good for diseases that have a "relatively rapid onset" and are usually hospitalised (eg, most of the acute infections; injuries etc)

**Disadvantages**

- Not a good method for studying rare 'exposures'
- Does not give any idea of 'incidence' or 'prevalence'; it only gives us a measure of Odds Ratio (OR)
- Particularly prone to various forms of selection and information biases, particularly survivorship Bias, Recall Bias and observor's bias.
- 'Temporal relationship' is usually only a matter of conjecture but not a proof

## Designing and conducting a case control study

**Step 1: Specify the total population and actual (study) population.**

Specification of actual (study) population at this stage becomes especially important as it will give us an idea of the "population" from which cases have come and thus we would be able to ensure that our controls should also represent the same population, (an essential requirement of a case control study).

**Step 2 : Specify the major study variables and their 'scales' of measurement**

Firstly, the Outcome variable : In case control study this will be the particular disease or outcome of interest. Most of the times this will be measured on a 'dichotomous' scale (ie., disease present = cases, and disease absent = controls). Secondly, the Exposure variable(s) :- This is the suspected 'cause' that the investigator is studying for the association with the disease under study. Next, Specify the scales of measurement - usually it is dichtomous (exposure present or absent). Finally, the Potential confounding factors (PCF) :- List out all the PCF by thorough reading of the literature and discussion with experts. Specify the 'scales' of measurement of each PCF.

**Step 3 : Calculate the sample size**

The details have been discussed in the section on Biostatistics and "use of Staistical software".

**Step 4 : Specify following selection criteria of cases**

Diagnostic criteria

Enunciate clear cut diagnostic criteria for the disease of interest. As far as possible use criteria given by expert bodies. If there is doubt, make categories like "definite", "probable" and "possible" and analyse them separately.

State the inclusion or exclusion criteria

One of the central issues in a case control study is that cases should have had a reasonable possibility of the disease being induced by the suspected exposure; and that the controls should have had a "reasonable chance" of being exposed to the exposure. This leads to the fact that any case or control who does not meet these criteria should be excluded from the study. Eg., in a study of recent OC use (exposure) and TE (outcome) we would like to exclude "TE cases occurring postpartum/ during pregnancy / post operatively/ post menopausal ladies / ladies on other contraceptives / hysterectomised ladies". One thing the worker must ensure is that the exclusion / inclusion criteria should be clearly defined and must equally apply to cases as well as controls.

Source of cases

The usual source of the cases is "hospital". However, for diseases for which a large number of subjects may not be admitted (low backache; anal fissure etc) the researcher must tap the OPDs, General practitioners or even think of population based cases by searching them in the

population.

Incident or prevalent cases

Specify whether you would like to consider only the newly occurring (incident) cases or all those who are already present including the old cases (prevalent). It is always advisable to take the incident cases since the prevalent cases might have changed their exposure status due to medical advice etc.

Method of sampling

The most common method of sampling is either to take a systematic random sample of cases as they keep reporting; alternatively, if all the cases have already collected and a detailed list is available, a simple random sample may be drawn.

**Step 5 :- Specify the selection procedure of controls**

One of the most important issues in a case control study is the selection of controls. The following specifications are to be made :

Source of Controls : Whether Hospital based or else Population based controls

Patients admitted to the same hospital for diseases other than the one under study can be used as controls. They are easy to obtain, cooperative, and more likely to remember the exposure. The disadvantage is that they do not represent the healthy population and being ill, may be different from the healthy persons in number of ways. While selecting hospital controls, the best is to take a diagnostic assortment, ie., patients from various diagnostic categories. On the other hand, healthy controls from the population would give a very good comparison provided it is logistically possible to study them and provided that they represent the same source population that gave rise to cases. The difficulties are that they are expensive and may refuse to participate.

Exclusion / inclusion criteria :-

The same criteria as for cases should equally apply.

Number of controls per case

In general, 1 control per case is studied. The number of controls per case may be increased to upto 4 or 5 per case with slight increase in statistical precision but the cost of the study will increase tremendously. In any case the number of controls should never be less than the cases.

Number of control groups

Usually, one "control group" is studied. However, if feasible, the worker may study 2 different control groups (eg, one from population and another group from

Summary : planning, design conduct & analysis of a case-control study

- Review your research question and confirm that case-control study is the right design (you should be studying a risk factor and not any prevention / treatment / diagnostic / prognostic factor.
- Specify the outcome, exposure and confounding variables.
- Specify the "reference" and "actual" population.
- Specify the inclusion and exclusion criteria; apply them equally to cases and controls.
- Specify the selection modality for cases :-
  - Diagnostic criteria for cases / case definitions.
  - Source (hospital, OPD, or population based).
  - Sample size for cases
  - Procedure for sampling the cases
  - Incident (new) or prevalent (old & new) cases.
- Specify the selection procedure for controls :-
  - Source of controls (healthy population based or hospital based)
  - No. of controls
  - No. of control groups
  - Method of sampling the controls
  - Matching, if considered.
- Specify the methods of measurement of various variables.
- Set up checks for obviating "biases" :
  - Ensure that controls are derived from same source population from which cases have come.
  - Ensure that controls have same chances of getting the exposure as cases had.
  - See if there is any problem of survivorship.
  - Avoid recall bias
  - If possible, blind the observers to case / control status.
  - If possible, use multiple sources of information and make "unobtrusive" measurements
- Do a pilot study on 5 to 10 cases and controls.
- Conduct the study.
- Statistical analysis
  - Calculate Odds Ratio (OR) as (aXd) / (bXc) and not the relative Risk (RR)
  - Calculate 95% CI of OR
  - Do a Chi-square test for hypothesis testing, or a 't' test, depending on scale of measurement.
  - For control of confounding, undertake stratified analysis using mantel-haenszel" method.
  - For many confounders, undertake multiple logistic regression analysis.
- Make interpretations :- specifically see if "temporal relation" can be shown; is there any possibility of bias remaining; have all potential confounders been

hospital); the procedure will improve the validity of the results.

Matching

The details of 'matching' have already been explained in the chapter on control of confounding. In general, in a case control study it is recommended that one must carefully list out all the PCF; match for the universal confounders, ie., age ( in broad categories of 5 or 10 years of age groups) and sex, using frequency (group) matching. Record the data on all other PCF and adjust for confounding during analysis.

**Step 6 : Specify the procedures of measurement and specially take care to ensure validity and reliability**

The biggest disadvantage of a case control study is its particular susceptibility to various forms of selection and information biases. The detailed methods of prevention of bias and ensuring validity and reliability have been presented in chapter no. 1. In addition, quite often the investigator would be using a questionnaire, in a case control study. The guidelines for preparation of questionnaires have been given in a subsequent chapter.

**Step 7 : Do a pilot study**

Pretesting on 5-10 cases and controls would be adequate in most situations to refine the methodology. If major changes are made following the results of pilot study, then do not include the pilot study cases and controls in the analysis.

**Step 8 : Conduct the study**

Ensure valid collection of data, as described under the details of making measurements.

**Step 9 : Analysis of data**

Calculate the Odds Ratio (OR) and it's 95% Confidence Interval (95% CI). Undertake hypothesis testing by a chi square test, as described in the chapter on Biostatistics. Usually it will be a chi-square for 2X2 table or, at times, a chi-square for linear trentd in proportions. At times there may be requirement of a 't' test instead of chi-square test, depending on the way the variables have been measured. Control of confounding will require stratified analysis using Mantel-Haenszel technique or a multiple logistic regraession. The details are described in the chapter on Biostatistics. If the data is from a “Pair matched” study, use McNemar's procedure for calculating chi square, odds ratio (OR) and 95% CI of OR. Consult a research methodologist for assistance.

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# Planning, Design and Conduct of Cohort Studies

As discussed earlier, a major disadvantage of case control study is that it is prone to various types of selection and information biases. Some of the major problems of case control study are overcome by cohort study, though by paying a higher cost and tremendous increase in logistic effort.

A cohort means a group of people sharing a common exposure. In this study, the investigator starts by picking up two comparable group, one having the exposure (eg, tobacco users) and the other not having the exposure (eg, non users of tobacco). She then excludes the presence of the outcome of interest (eg, lung CA) in both the groups at the start of the study, and then follows up both the groups for a reasonable amount of time, observing for the outcome of interest in both the groups and finally makes comparison as regards incidence of the outcome in the two groups. The cohort study has certain major advantages in medical research.

**Major advantages of a "cohort study"**

- Scientifically a much "stronger" design as compared to case-control or cross-sectional study.
- Temporal association is more convincingly demonstrated since investigator actually starts from exposure, before outcome has occurred and follows up till outcome.
- No recall bias since exposure is objectively assessed by investigator at start of the study
- Can study many outcomes of a given exposure of interest.
- Provides a direct estimate of "incidence" of outcome in exposed and non-exposed groups and hence the "RR".
- Results are not biased due to "survivorship".
- Good for studying 'rare" exposures.
- Any change in exposure status during the course of study can be recorded.

**Major disadvantages of cohort design**

- Quite expensive; needs large number of subjects.
- Results may take very long time to be available.
- Ascertainment bias due to "differential" assessment of exposed and non-exposed groups can lead to bias.
- "Loss to follow up" is a major potential for bias.

## When to select a cohort design

The cohort design should therefore be undertaken if the answer to the following question is "Yes".

Is the disease (outcome) a reasonably common one?

(a) Is the follow up period required "reasonably short", so that you can conveniently complete the study within the time frame?

(b) Has some amount of evidence regarding the association between exposure and outcome been provided by case control studies?

(c) Are the subjects in your two groups (exposed and not exposed) reasonably likely to continue in the study?

(d) Are you sure you are studying risk factors / markers / prognostic factors and not therapeutic/ preventive/ diagnostic procedures?

## Steps in designing, conducting and analysing a cohort design

**Step 1 - Specify the research question, objectives and background significance.**

**Step 2 - Specify the variables of interest and their scales of measurement**

(a) Exposure variable

Usually in a cohort study the exposure variable is measured on a 'dichotomous scale' (ie. exposed or not exposed), or, at times on a 'polychotomous ordinal scale' (not exposed, slightly exposed, moderately exposed, intensely exposed etc).

(b) Outcome variable

The outcome variable would be the disease or other health related outcome which the investigator hypothesises to occur as a result of the exposure. The outcome may be dichotomous (eg, developed / did not develop lung CA) or polychotomous ordinal (remained normotensive/ developed mild hypertension / developed moderate hypertension / developed severe hypertension) or quantitative (eg, serum cholesterol levels, no. of DMF teeth, score of respiratory disability 0,1,2,3 due to occupational exposure).

(c) Potential Confounding Factor (PCF)

Make an intensive search of the literature and contact the experts to find out all the variables that could be potential confounders of the exposure - outcome relationship and record the data regarding confounders during the study.

**Step 3 - Specify the exclusion criteria**

eg, we may like to restrict the study to males with a view to control confounding due to sex, or exclude such subjects who are likely to be lost to follow up or subjects with a disease which may interfere with the occurrence of outcome of our interest.

**Step 4 - Calculate the sample size**

The details have been discussed in the section on Biostatistics and "use of Staistical software".

**Step 5 - Select the study cohort**

The study cohort is the one which has the 'exposure'. This may be either Special exposure groups ( eg, radiologists for studies on effect of radiation; ANC cases having PIH for

studying the outcome of pregnancy, etc.); or else it could be Cohort defined on basis of geographical or administrative boundaries (eg, people living in a given state or district like Framingham heart study). The special advantage of such cohort is that the same group will give an exposed as well as unexposed (comparison) cohort; e.g, for the study on association of smoking during pregnancy (exposure) and low birth weight (outcome) all patients enrolled at an ANC may be followed up. This group will give, within itself, an exposed cohort (smokers) and an unexposed cohort (non-smokers). Thirdly, we may select a study cohort from Groups offering special resources (eg, all registered doctors can be followed up for development of IHD after recording their physical activity levels. They will give special advantage of an accurate reporting as well as ease of follow up).

**Step 6 - Select the comparison cohort**

This is very important. It can be done by either selecting an "inbuilt comparison group" as in example given in step 5 above. This is, in fact, the best method of obtaining a comparison group in general, in the usual settings of clinical research. Secondly, we may make comparisons with general population rates, often done in study of diseases due to occupational exposures. Finally, if required, we may assemble a special comparison cohort - eg, in a study of the association between exposure to petroleum fumes and subsequent bone marrow damage, workers handling the filling equipment at petrol pumps may be taken as exposed cohort while workers sitting in the offices or ancillary workers in the same petrol pumps may be taken as the specially assembled comparison cohort.

**Step 7 - Specify the sampling procedure**

The usual method of sampling both the exposed and unexposed cohort groups is by simple random or by systematic random sampling method. Select about 20% extra subjects, because some will be removed on initial medical examination as already having the outcome and some will be lost to follow up.

**Step 8 - Exclude the disease or outcome of interest in both the exposed and unexposed cohort groups at the outset**

Do an initial medical examination to exclude out all those subjects, in both the cohort groups, who already have the disease (or outcome) of interest.

**Step 9 - Obtain data on exposure level**

This is an extremely important issue. We obtain this data by various methods, including Direct interview of cohort members (e.g., details of smoking, alcohol, sexual activities, personal habits, dietary information, physical exercise, personality type etc). Secondly, by medical examination or diagnostic procedures by examining both (exposed as well as non-exposed) groups similarly; thirdly, by measures of environment (e.g., levels of pollutants in home environment, drinking water pollution levels etc); and fourthly by going through existing "records" (e.g., for recording the levels of exposure to irradiation, use of drugs, etc medical records can be used. Initial medical examination card at the time of entry to school or service can provide valuable details of an exposure).

**Step 10 - Obtain Data on all PCF**

Using methods as described in step 9 above, record detailed data on all the potential confounding factors.

**Step 11 - Consider matching**

Usually, in a cohort study, matching is not important; Data should be collected for all PCF and adjustment for confounding may be made during analysis. However, if considered feasible, the exposed and non exposed cohort groups may be "frequency matched" in respect of important confounders like - age, sex or other important PCF.

**Step 12 - Follow up and ascertainment of 'outcome' of interest**

Follow up should be meticulously undertaken for the period already decided. Due attention should be paid while making measurements for detecting the outcome of interest. The general measures for ensuring validity and reliability have already been detailed in chapter no. 1. In addition, special attention should be paid to the following types of measurement biases that can crop up in the cohort studies :

Measurement bias

This would occur because of 'differential ascertainment' of the outcome between the two groups. For obviating this, inform all subjects of both groups well in advance of the dates and timings of medical examination and ensure that both the groups are examined by observers who have similar type of training and using similar type of instruments and techniques.

Observer bias

This occurs because the investigator is aware about the fact as to which subject is 'exposed' and who is not exposed. For obviating this, if possible, 'blind' the observer to the exposure status, the details of exposure being known only to another co-worker who is himself not making any observation regarding ascertainment of outcome.

Cross over bias

This may happen because those having the exposure (eg, smokers) may cross over to the non exposed group (i.e, become non smokers) and vice versa. Periodic evaluation of both the groups as regards level of exposure, making prompt record entries and subsequent adjustments in the data analysis can help overcoming this problem.

'Loss to follow up' bias

Some subjects in any case are likely to be lost to follow up / drop out. However, at times it may become a substantial problem. It is generally accepted that if more than 30% of the study subjects are lost to follow up, then the results of the study are to be viewed skeptically. The following steps help in overcoming this type of bias :

(a) Take detailed addresses of the subjects as also of their friends and relatives; contact them and make best of efforts to trace those who have been lost to follow up.

(b) If the subjects have migrated, try to get information about them through a mailed questionnaire. If they have died, try and obtain information from medical records and death certificates.

(c) Do an analysis in respect of certain demographic variables (eg, age, sex, education, general health status etc) to see whether those who have been lost to follow up are similar or else quite different from those who have remained in the study.

**Step 13 - Analysis**

In a cohort study we would calculate the relative risk (RR) as (incidence among exposed divided by incidence among non-exposed), the 95% confidence interval of RR, and hypothesis testing, using a chi-square test or a 't' test or such other relevant procedure as described in the section on Biostatistics.

## Certain special types of cohort studies

**Retrospective cohort studies**

The investigator identifies a group of individuals based on their characteristics in the past and reconstructs their subsequent disease experiences upto some defined time in the more recent past (34); e.g., in a study, all military persons who were exposed to "agent orange" many years back during wartime were identified on the basis of records, alongwith another similar group of soldiers who were not exposed to this agent. Both these groups so identified on the basis of records were then traced forward till the more recent past for various organ / system diseases. This type of study thus differs the usual prospective cohort study (as described above) in which the cohort is identified on the basis of current characteristics and then followed forward in time.

**Nested cohort (syn : Nested case control) study**

Combines the advantages of a cohort and a case control study. The investigator identifies a cohort and follows it up for the required period of time, after recording details of exposure in the subjects. As the cases of disease keep occurring, the investigator keeps picking up these cases alongwith equal number of controls from the same cohort and compares them for the exposure history (35). As an example, we may be working on a hypothesis that high serum lithium levels are a cause of subsequent mental illness. The problem is that undertaking serum lithium analysis may be a very costly affair; however, blood samples can be preserved for 15-20 years. So, we can take a cohort of say 1000 persons who are free of mental disease, collect their blood sample, cold preserve them and watch for 15-20 years. Over this period if 20 cases of mental disease occur, we can take out their blood samples alongwith 20 randomly selected samples of those who have not developed mental illness (controls who are "nested" in the cohort), analyse these 40 samples for serum lithium and make comparisons between the two groups (who developed mental illness and did not develop it) as regards lithium levels. The tremendous advantages that have occurred are that firstly, instead of doing 1000 serum lithium tests (as we would have done in a normal cohort study) we have done only 40 samples. Secondly, we can calculate the incidence of the disease which would not have been possible in a usual case control study. Thirdly, the problem of recall bias and that the controls may be from a different source population than cases (which occur in a case control study) have been prevented.

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# Planning, Design and Conduct of "Diagnostic Test Evaluation" Studies

In each and every area of clinical as well as public health practice, "diagnosis" becomes the central issue. The process of making diagnosis involves the use of certain tests, laboratory procedures or a constellation of signs and symptoms, in an effort to find out the truth, i.e., the real pathophysiologic state of affairs that exist inside the body. The common settings of use of diagnostic tests can be microbiological (eg, ELISA for HIV infection), pathological (eg, pap smear for CA Cervix), radiological (Chest X-ray for Pulm. TB), clinical (cold intolerance and weight gain as diagnostic for hypothyroidism) or public health (mammography for mass screening for Breast CA).

## Essential Requirements Of A Diagnostic Test Study

In any diagnostic test assessment with the above mentioned broad aim in mind, there would be, therefore, 3 essential things required, viz., firstly, the diagnostic test, which is to be evaluated; secondly, a `gold standard' criteria of diagnosis, i.e., that diagnostic criteria which, in the current day level of knowledge, can be assumed to be 100 percent accurate in diagnosing the condition. Apparently, a "perfect gold standard" is more of a hypothetical state. For all purposes, we take a pragmatic view and, nearly always, use a "relative gold standard". Thirdly, we would need a group of subjects, each of whom should be subjected to both the tests - the test under evaluation as well as the gold standard test.

> CAUTION
>
> In a diagnostic test evaluation study, all subjects should be put through to both the tests; it should never happen that only those subjects who have tested positive to the test being evaluated are only subjected to the gold

## Parametres On Which A Diagnostic Test Is Evaluated

Broadly, any diagnostic test should be evaluated in terms of three types of parameters. These are Validity or Accuracy (which includes sensitivity, specificity, predictive values and likelihood ratios), Reliability and Efficiency. We have already discussed these aspects in detail in the chapters on "Screening for Disease" and "architecture of epidemiologic Designs" in the section on "Principles of Epidemiology".

In the the usual settings, as above, the results of diagnostic test are recorded in either of the two categories - "Positives" and "Negatives" (ie., a categorical, "dichotomous" scale). Sometimes the research scenario may be a bit different. Let us take the following hypothetical example :- In a hypothetical study to evaluate Alanine Aminotransferase (ALT) as a screening test for chronic parenchymal liver disease, 500 patients attending a gastroenterology centre with symptoms of liver disease were subjected to both, an assay of serum ALT levels as well as a diagnostic liver biopsy which was taken as the gold standard in this case. The results are given in Table - 1.

Table - 1

| Serum ALT levels | Chronic parenchymal liver disease (As diagnosed by Liver Biopsy) | | |
|---|---|---|---|
| Units / Litre | Present | Absent | Total |
| <= 20 | 0 | 120 | 120 |
| 21-40 | 20 | 150 | 170 |
| 41-60 | 40 | 15 | 55 |
| 61-80 | 40 | 12 | 52 |
| 81-100 | 40 | 3 | 43 |
| > 100 | 60 | 0 | 60 |
| Total | 200 | 300 | 500 |

In such situations, various values of sensitivity and specificity will occur depending on the levels of "cut-off point", eg, if we chose a cut-off point of 20 U/L the sensitivity will be 100% (200 / 200), but specificity will be 40% only (180 / 300). On the other hand, if the cut-off point is placed at > 100 U/L, then the values of sensitivity and specificity will be 30% (60 / 200) and 100% (300 / 300) respectively. The conclusion that the above table gives us is that nowhere would we find a cut-off point where both sensitivity and specificity are 100%. If we lower our cut off point (ie., make the diagnostic criteria less strict), there will be an improvement in sensitivity (from 0% at >100 to 100% at >20 units) but this will be obtained at a corresponding decline in specificity (from 100% at >100 units to 40% at > 20); and contrarily as we keep raising the cut off point (ie., make the diagnostic criteria more strict) our specificity will keep increasing but with corresponding decline in sensitivity. The question is, what should be the "optimum cut off point", ie., how do we decide the cut off point which gives us the best combination of specificity and sensitivity. For doing this, we undertake the exercise of constructing the "Receiver-operating-characteristic curve" (ROC curve) in which we plot the values of sensitivity along the Y-axis and the values of (1-specificity) along the X-axis (horizontal axis).

## Steps In Planning A Study On Diagnostic Test Evaluation

### Specify the "Outcome"

This means we should clearly define the disease for which the diagnostic test is being evaluated (eg, chronic parenchymal liver disease, HIV infection etc). As far as possible, include the complete spectrum of disease in your study - the mild, moderate and severe forms; the typical as well as atypical forms; and also those disorders which are likely to be confused with the target disease.

### Give a clear description of the "settings" of your study

This should include the type of hospital where you are going to do the study (eg, specialised centre; secondary level care hospital etc); the demographic profile of the subjects (age, sex, race, education, economic status etc); and the "referral filter" that they have passed through before coming to your hospital (i.e., whether they come directly or passed through a referral filter of peripheral hospital, mid zonal hospital etc.).

**Give a clear description of the "Gold standard" of diagnosis in your study**

Give a clear description of the "Gold standard" of diagnosis in your study why you are adopting it as a gold standard and a clear description of the technique of undertaking the gold standard test.

**Give a clear and detailed description of the technique of doing the diagnostic test under study**

Give a clear and detailed description of the technique of doing the diagnostic test under study so that your colleagues who read your research paper can also undertake it on their patients.

**Clearly mention the Replicability (Reliability)**

Clearly mention the replicability of your diagnostic test in terms of variations that may occur due to observers (inter and intra observer), subjects (inter and intra subject); and, Instruments and techniques.

**Calculate the sample size**

For calculating the sample size, be prepared to give the following information :

(a) What is the expected sensitivity or specificity of the test being standardised (a rough, approximate estimate)

(b) How much "deviation" from this expected sensitivity / specificity is acceptable to you

(c) What is the expected prevalence of the disease (in the population being studied).

**Analysis**

The analytic techniques for a diagnostic assessment study are calculation of sensitivity, specificity, overall accuracy, PPV, NPV, Likelihood ratios, their 95% confidence intervals and an ROC analysis, if warranted. Do not undertake hypothesis testing procedure as a chi-square test in a diagnostic test study. All these tests can be undertaken on statistical software, as described in one of the subsequent sections on EPI - 2002

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# Planning, Design and Conduct of a Randomized Controlled Blinded Trial (RCT) : Clinical Trial

In medial research practice, a clinical trial or RCT represents the strongest design, the ultimate in medical research. The history of clinical trials is not very old. In fact the first scientific clinical trial was done just 250 years ago under the name "Ceterius Paribus", on board the British Naval Ship "Salisbury" when James Lind had tried out various treatment modalities and shown that a ration of fresh lime juice and oranges was curative for scurvy (36).

Actually, what we commonly refer to as clinical trial is just one phase of the entire gamut of clinical trials. In fact, clinical trials have four phases which are sequentially studied on human beings, viz, Phase I to IV (37 - 42). Before phase I is undertaken, the new drug or treatment modality should have passed through the animal and laboratory testing and should have shown to have the desired pharmacological effect, safe and free of carcinogenic and teratogenic effects. Only thereafter can a drug enter the phase I of clinical trials. Phase I is undertaken on a small number of patients or healthy volunteers and refers to dose finding studies, to find out as to how large a dose can be given before an acceptable toxicity is experienced by patients (Maximally Tolerated Dose or MTD). Phase-II can be called as pharmacokinetic and pharmacodynamic studies, undertaken on a small number of patients with the target disorder. It proceeds to evaluate the biological activity and to estimate the rate of adverse events at that MTD. Phase-III is the actual, classical stage of clinical trial which is also known as the Randomised Controlled trial (RCT). Following phase III, the drug is marketed and simultaneously phase IV also starts. Phase IV is also called as "Post Marketing Surveillance". Data on the effect of the drug or procedure is collected from various agencies during this phase. Side effects which did not which appear in phase III, are detected in this phase and the drug may be withdrawn or its usage modified. Classical examples are Thalidomide, Isoprenaline containing bronchodilators, and DES.

## Steps in Planning, Designing and Conduct of a Clinical trial

### Step I : Deciding whether a clinical trial really required? Should it be done? Can it be done?

Undertaking a clinical trail is not an easy affair. It costs considerable amount of specialized manpower, finances, equipment and dedicated efforts. It is therefore advisable that before one starts thinking of a clinical trail one should carefully asses whatever it is really necessary to undertake a clinical trial. Firstly, a detailed review of literature should be undertaken to see whether the question has already been answered by some other workers and whether the findings can be adopted by us for our patients. Meta-analysis of published and even unpublished papers are also advisable because that may answer the issue without actually undertaking the clinical trial. For example reports of 21 randomized clinical trials on the efficacy of the antibiotic prophylaxis for colorectal surgery were published between 1969 and 1987. All of them were small size studies and had given statistically not significant results. However a meta-analysis was done and it clearly showed that antibiotic prophylaxis was, indeed protective. The issue was thus clearly answered without undertaking a time and money consuming clinical trial. (43).

Secondly, decide whether the issue is really an issue. Does it have some novelty and relevance? Thirdly, ask yourself whether it is feasible to do a clinical trial - whether you have the required expertise; the required equipments and expendables; the required infrastructure facilities and manpower; the required finances; and above all - will the required number of patients/subjects as calculated through sample size be available. Finally, ask yourself, whether the trial is ethical? Broadly answer the following questions:- Are the subjects likely to be exposed to an intervention modality which has high probability of causing adverse effects? Is the control group going to be deprived of an intervention modality which is known to be beneficial? Will an informed consent be taken - this means that the subjects will be informed of the scope including the possible side effects and of the fact that, through a lottery (Randomization), they may either get the trial modality or else the control treatment and having been so informed they should then agree to participate voluntarily and willfully without any coercion and unnecessary motivation. Will there be enough safeguards in place to maintain the confidentiality of the subjects? (2 8).

### Step2 : Clearly state the research question and the variables of study

The research question should be developed after lot of reading and deliberations with experts. At times, the researcher may have more then one research question. In such cases one should clearly define out the primary question - this is one in which the investigators are most interested. The main statistical issues including the sample size calculation would revolve around the primary question. The secondary questions are subsidiary to the primary question; or else, sometimes, the data collected for the primary question may also be used for answering the secondary question.

Having clearly defined the research question, the investigator should exactly and clearly list out as to what all "variables" will be studied to answer the research question. Broadly, there are four categories of variables that need to be enunciated:

The exposure variable

This means the "intervention" under study. The complete details including the dosage, method of administration, etc. should be clearly defined. Secondly, the way this variable is going to be recorded should be described. For example, in the clinical trial to study whether oral aspirin prevents the recurrence of acute MI over the next one year,

the recording may be made as a dichotomy (subjects given aspirin 150mg/day are recorded as E+ and those given placebo recorded as E-), or recorded at many levels in a graded fashion (given placebo / 75mg/ day / 150 mg/day / 225 mg/ day). Such clear definitions are important since subsequent statistical analysis will depend on how variables have been recorded.

Co-Interventions

Often co-interventions may be studied in addition to the primary intervention. For example in a trial of new ACE inhibitor as primary treatment of hypertension, the researcher may also desire to study the effect of "life style change" as co-intervention. Co- interventions should be as clearly defined as primary exposure variable.

The outcome variable

The outcome variable is the end point that is of utmost importance to the investigator. Usually it is recorded as outcome achieved (O+ , e.g. patients who got cured) and outcome not achieved (O - , e.g. patients who were not cured). Care should be taken to clearly define one "primary outcome" or the "endpoint" variable which is of most interest to the researcher and around which the analysis and sample size calculation would revolve. In addition, "secondary outcome" or the "other endpoints" variables can be defined. For example, in the trial of Buprepion 300mg/ day vs placebo for bringing about smoking cessation in patients with acute cardiovascular disease the outcome variable was defined as :- Primary outcome: "7 day point prevelance of tobacco abstinence, one year after discharge, self reported and validated by saliva cotinine"; Secondary outcomes:- Cotinine validated cigarette abstinence at the end of treatment (12 weeks) and duration of post discharge abstinence (No. of days till first cigarette smoked after discharge). (44)

The confounder variables

Ideally there should be no need to measure the confounder variables in a clinical trial once randomization has been done, since randomization is itself a very powerful tool for controlling confounding. However, in small size trials, randomization may not have that much effect. Secondly it may also be worthwhile to do a baseline comparison between the intervention and the control group in respect of important confounding variables to show that randomization has been effective. It is therefore advisable, rather necessary, to collect data on major confounding variables i.e. those which are directly related to both the exposure and the outcome variables. For example in a clinical trial on the efficacy of different antimalarial regimens in bringing about Falciparum parasite clearance in 4 weeks among antenatal cases, the confounding factors which were recorded and compared at the baseline were age, gravidity, parity, trimester, evidence of previous chloroquin use, hemoglobin concentration and pre-treatment parasite density (45).

**Step3: Enumerate the inclusion and exclusion criteria**

Clearly define the characteristics of patients who would be eligible for entry into the trial, by specifying the "inclusion criteria" based on demographic, and clinical criteria. The more important aspect are the "exclusion criteria" - those who will not be eligible to be included in the study. More the exclusion criteria, more precise will be the findings and lesser will be the requirement of sample size. However, more the exclusion criteria, more difficult will be for you to find the particular type of subjects, and the generalizability of your study will be restricted. Let us illustrate the guidelines for deciding on the exclusion criteria with the example of clinical trial to assess Tamoxifen for breast cancer. In this trial, the reasons for excluding certain types of patients and the actual exclusion criteria that can be stated are described in Table 1 (46).

**Step 4 : Defining the populations**

We would define the reference population also called the "universe" or the "target population". This is the very large collection of patients or subjects to whom the results of the study would be generalized. For instance, if we wanted to do the earlier mentioned Tamoxifen - breast cancer trial as an Armed Forces Medical Research Committee (AFMRC) project, we could define our reference population as "Wives of serving / retired armed forces personnel, aged 40 to 70 yrs having at least one breast intact, not having history of venous thromboembolism, not taking oestrogen, mentally alert and who agree to participate". The reference population is very large, scattered and difficult to delimit, and hence we cannot directly draw a representative sample from it. For this reason we often specify a well defined subset of the reference population from where we actually draw the sample of subjects. For instance, in our example we may define the actual study population as all the women of the type defined in the reference population "who are staying in Pune Kirkee - Khadakwasla - Lohegaon complex". It is from this actual study population that we finally draw our required sample. Specifying the actual study population is more of a matter of administrative convenience but we must be convinced that the actual study population is a reasonably representative subset of the reference population.

**Step 5 : Sample Size Calculation**

Sample size is a major issue in clinical trials. Too small a sample would produce insignificant results and would be a waste of efforts. With a small sample the chances are very high that the result would be statistically insignificant. Hence an adequately large sample is important. At the same time we must remember that every subject in a clinical trial costs tremendous amount of money, so even one additional subject may mean poor financial management. Keep in mind is that there is nothing like an absolutely adequate sample size. Very often we have an impression that a minimum of 15 patients in each of the study and the control group is good enough to get significant results but this is not true.

Before we go we go to the statistician and ask her as to what should be the size of the sample for our study, or else use the statistical software for calculating the sample size, we should be prepared to specify the following parameters (47). Firstly, the Type 1 or Alpha error. We may, by convention, specify it as 5%. Secondly, the Type 2 or Beta error. By convention you could specify it as 20%

Table - 1: Broad reasons for exclusion criteria with example of Tamoxifen in Breast Cancer

| S No | Broad Reasons for exclusion | Actual Exclusion criteria stated "The following will be excluded" |
|---|---|---|
| 1. | Intervention modality may carry high risk of adverse effects | History of venous thromo-embolic (TE) event (since tamoxifen increases risk of venous TE) |
| 2. | Unacceptable risk of assignment to placebo group in that death during treatment among control group is not acceptable | Cases of oestogen receptor positive breast cancer (since tamoxifen is an effective standard treatment modality, hence in such cases random allocation to "placebo" group would be disastrous) |
| 3. | Do not have the risk of developing the outcome | Patients with bilateral mastectomy |
| 4. | Have a type of disease that is not likely to respond to treatment | Patients with breast cancer susceptibility gene that causes oestrogen receptor negative cancer |
| 5. | Already taking a treatment that is likely to interfere with the intervention being used | Patients taking oestrogens ( which are likely to compete with tamoxifen ) |
| 6. | Subject is unlikely to adhere (comply) with the regime | Patients showing poor compliance during run-in period |
| 7. | It may be unethical to include non-consenters | Patients who do not agree to participate |
| 8. | Unlikely to complete the follow up, or | Patients who plan to move out before trial ends; short life |

and specify the power of the study as 80%.

The next two parameters are more important and only we as researcher can specify these based on our professional experience and academic reading. These are, firstly, the expected proportion of the outcome in the Non-exposed group (p0). To simplify, what is being asked is the percentage of subjects who are likely to improve when on the "control" modality of treatment (i.e. who are not exposed to the intervention). To clarify, let us take the example of a clinical trial wherein we want to study the effect of a new antihypertensive drug and compare it to a drug already in use, say Ramipril. Now p0 is the percentage of subjects on Ramipril who are likely to improve. Let us say, based on your experience and academic reading you know that 70% of the hypertensives on Ramipril will improve, then you state p0 as 70%. The next parameter to be specified by us is "What is the amount of effect due to intervention modality you would consider clinically significant". In the above example of Ramipril, let us say we decide that we would consider the new drug worthwhile only if it produced at least 25% additional effect to what Ramipril already does, you specify a detectable risk as 1.25.

### Step 6 : Detailed Descriptions Of Measurement Protocols

The most important facet of clinical trials is to ensure that the measurement process is accurate. So, at the stage, develop the detailed protocols of clinical procedures, laboratory investigative procedures, as well as the details of questionnaire and interview protocols. For each and every variable (intervention, co-intervention, confounders and major and minor outcome variables), write down very clearly and explicitly , in great detail as regards Who will make the measurement ? When will it be made ? What equipment / instrument will be used ? What technique will be used ? How the equipment, techniques and personnel be standardized and validated ?

For example, a trial was conducted to study the efficacy of Dopoxetine for treatment of premature ejaculation. The primary outcome( major end point) variable was defined as " Intravaginal Ejaculation Latency Time (IELT)". The measurement process for this primary outcome variable was described in the final published article as follows:

"Couples were supplied with the stopwatch and instructed about their use in detail. The female partner was to activate the stopwatch immediately on penovaginal penetration and to stop the watch immediately at the point of intravaginal ejaculation or at the point of withdrawal without ejaculation and this time in the stopwatch was noted by the female partner to give the IELT. This technique has already been validated in other studies. If ejaculation occurred even before the penetration the IELT was noted as zero" (48).

You would note that the investigators took pains to describe the exact measurement process of this variable, though they may be sounding a bit immodest.

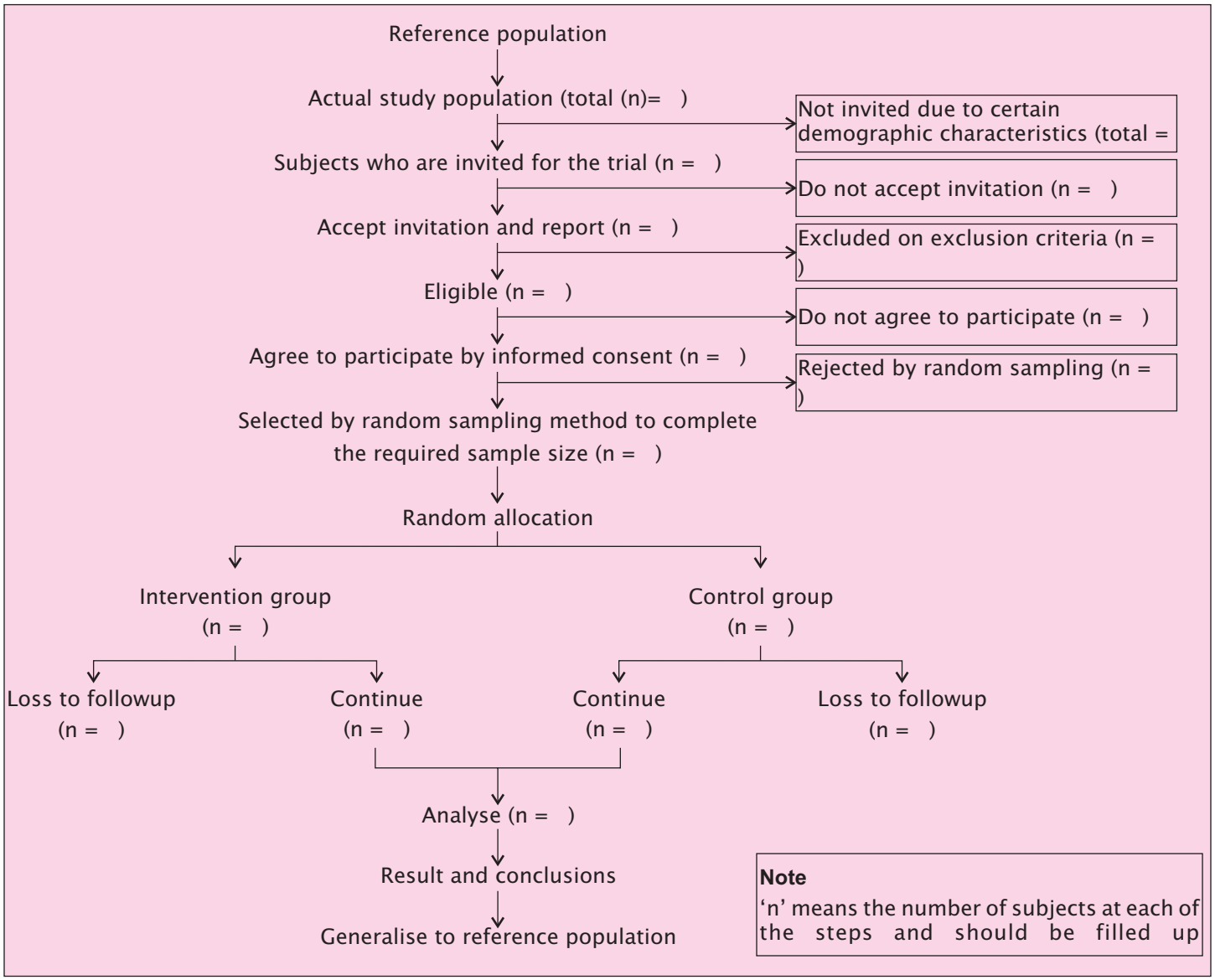
### Step 7: Enrolling The Participants

Once the minimum sample size has been calculated the next step is to enroll a representative sample of the patients from the actual study population. Let us take a hypothetical example: Suppose that a specialist in Venereology desires to put up an AFMRC project to

replicate the clinical trial on dopoxetine 30mg (daily) in treating premature ejaculation in our settings. He has defined the reference population as all married personnel of Indian Armed Forces staying with family and who self report or give a history of premature ejaculation ( defined as IELT of <1 mt.). Subsequently he has defined the actual study population as all Indian Armed Forces personnel with the above characteristics who are seen at MI rooms, OPDs and speciality clinics at Pune and Kirkee. By way of statistical procedures, he has worked out that he will need 400 subjects in each of the dopoxetine group and the placebo control group. Now, to actually enrol the participants for this trial, we will make a list from available records of all such subjects who have been diagnosed as premature ejaculation during the past one year. Of all the patients who have been invited, some may have been posted out and some may not turn up due to other pressing commitments, while the others will report.

In the next stage we will see who are not eligible by applying the "exclusion criteria" (Having erectile dysfunction, psychiatric illness, using tricyclic anti-depressants or using other pharmacological or behaviour therapy for premature ejaculation). This will further reduce our list to now include those who are "eligible". Now, those subjects who are eligible will be informed of the details of the study and asked if they would like to participate under informed consent. Out of the ones who agree to participate, 800 will be selected by random sampling process (say, every third patient) and we will keep randomly allocating them to receive either the intervention modality (Dopoxetine) or the control modality (placebo). In fact, during the planning and conduct of a clinical trial as well as during writing your research paper, it is important to present the " Recruiment and Participation Flow Chart" giving the numbers ('n') at each step, as per following format (Fig - 1):

Fig - 1



**Step 8: Randomisation**

The basic dictum of any research is that the groups being compared should be absolutely similar to each other except for the factor which is being studied. In methodological terms, it means that all confounder variables must be controlled. There are various methods of control of confounding. When it comes to clinical trials the method is randomization or random allocation. So essential is randomization that the other name is 'RCT' (Randomized Control Trial). The procedure is quite simple. Random number tables available in any book on statistics or computer statistical packages are used to generate random numbers. Accordingly the subjects are allocated to either, receiving treatment A (the intervention under trial) or else treatment B (the control modality). The power of randomization is such that, the two groups are similar to each other. Let us see an example as to how randomization equally divides subjects into two groups:-

"….In a clinical trial, to evaluate the protective effect of hormone supplementation with estrogen plus progesterone on the risk of fractures and the bone mineral density , a total of 16608 women who were eligible and finally agreed to participate were randomly allocated into 8506 women who received hormonal supplementation and 8102 receiving a placebo. The comparison regarding the major characteristics of the two groups is presented in Table-2 and shows how effectively randomization has created two identical groups……" (All figures in percentage) (49).

Table - 2: Example of equal distribution of characteristics following Randomisation

| Characteristics at baseline | Estrogen Plus Progesterone Gp.(8506) | Placebo group (8102) |
|---|---|---|
| Age 70-79 yrs | 21.3 | 21.8 |
| White skin | 83.9 | 84 |
| BMI<25 | 30.5 | 30.8 |
| Total Cal. Intake < 600 mg./ day | 24.4 | 24.2 |
| Smoker | 10.5 | 10.5 |
| >= 2 falls in past 12 months | 12.8 | 12.4 |
| Fracture | 38.8 | 39.1 |

However, there is a note of caution. Randomization works well to create 2 similar groups only when the sample is adequately large. In a small sample, the effect diminishes and may become erratic (50).

**Step 9 : Introduce The Intervention And Placebo Control Modalities**

Having created the two groups by random allocation, the investigator now needs to intervene with the trial modality in one group, and the control or the baseline modality in the other group. Certain aspects to be ensured at this stage are:

(a) Ensure ways and means to bring about compliance in both the groups. Give adequate amount of medicines to all the subjects in both the groups and instruct them clearly on the dose, mode of administration, frequency of intake, etc.

(b) Develop procedures for checking compliance as for example check count of balance pills, testing the urine/ other excretions for metabolites and so on.

(c) Brief both the groups clearly about co-interventions in the trial, if there are any.

(d) Ensure a placebo control, so that the control group who are not getting the trial intervention cannot make out that they are not getting it. Ensure that they get the placebo drug in the same shape, colour, size and taste and is also administered using similar procedures.

**Step 10 : Ensure Blinding**

What if the subjects know they are getting a new drug? They may start feeling better just because of this knowledge! They may report improvement just to please their Doctor! And those not getting the new treatment may not feel relieved thinking that they have been deprived of some new, good treatment. And may be, just because of this awareness, some of them may quietly start taking the new regimen or some other co- intervention. More bias may be introduced if the investigator is aware of the status of the subject. The investigator may differentially probe or investigate more in one group or less in the other group.

To overcome these biases in the standard clinical trial, Blinding is used as an essential requirement. In single blinding, the subject is not aware of his status but the investigator is aware. The ideal of course is double blinding, in which neither the investigator nor the subject is aware as to which group a particular subject belongs to. Only the codes are given and these codes are handled by the data manager. The gold-standard in contemporary times for clinical trials is double blinding. Double blinding may sound difficult but can be implemented even in testing situations.

Take for example the clinical trial undertaken to assess the efficacy of Ancrod, a natural defibrinogenating agent from snake venom, when given within first 6 hours of an acute ischemic stroke. Patients were randomly allocated to receive Ancrod (608 patients) or placebo, isotonic sodium chloride(618 patients). Identical looking 1 ml ampoule containing Ancrod or isotonic sodium chloride solution were prepared in sequentially numbered pre packs. The randomization scheme was handled through a centralized interactive voice response system. An independent blinded physician adapted the infusion rates, on the basis of regularly obtained fibrinogen concentration of individual patients. The clinical researchers received no information about the method of randomization or the group (Ancrod or placebo) to which a given subject belonged to. Fibrinogen data was provided

only to the different independent unblinded supervisors based at each site who monitored adjustments to the infusion rates, based on a dosing algorithm provided by the investigator. (51)

In surgical trials double blinding may become difficult at times. In such situations, we may ensure that the surgeons who evaluate the outcome, should be independent of the research group and preferably different from the surgeon who operated. The operating surgeon may, however, keep monitoring the patients for purpose of management, not for research. We may also make the outcome criteria as objective as possible.

**Step 11: Follow Up And Assessment**

The last but one step in the conduct of clinical trial is to follow up the subjects till the end point, or the period of trial, whichever is earlier and to make ascertainment. The key issue in follow up is to avoid losses to follow up, which may otherwise seriously bias the study results as seen in the following example:- "A trial of nasal calcitonin spray to reduce the risk of osteoporotic fractures reported that the treatment reduced the risk of fractures by 36 %. However, critical evaluation revealed that 60 % of those who were originally randomized were lost to follow up and it was not known whether fractures had occurred among those who were lost to follow up. Because the overall number of fractures was small, even a few fractures among participants who were lost to follow up could have altered the results of the trial. This uncertainty diminished the credibility of the findings (52). It is therefore imperative that actions be taken right from the planning stage to retrieve those getting lost to follow up. The following general steps are worthwhile:

(a) At the very start, inform the participants of the scope of trial, and the time and place where they should report for follow up.

(b) Exclude, in the beginning itself, those who have a very low probability of continuing.

(c) Note down the detailed telephone numbers and addresses of the participants, their close friends, relatives and employers and their permanent home addresses to retrieve them.

(d) Treat them properly when they come for follow up; don't make them wait too long.

(e) Every time they come for follow up, talk to them about their condition and also about the progress of the trial to keep their interest alive.

(f) Even if some participants violate the study protocol or discontinue the trial intervention, they should still be followed up so that their outcomes could be used in "Intention to treat Analysis"

During ascertainment, take care to fill up all the headings in the form fully and correctly and examine all subjects, irrespective of their trial status, with equal methodology and vigor. Do ensure that every subject has a file where follow up records are filed and that these are checked by an independent data manager at least once a month. Enter the data from these forms to the computer database within a week to detect any missing data points. And, finally during the follow up stage, keep the "Stoppage Rules" open. In brief there can be three reasons for prematurely stopping a trial

(a) Evidence comes up in between against the intervention modality :- The Atrial Fibrillation Anticoagulation Study was initiated to study the role of warfarin in decreasing the rate of strokes over 3-5 years. However the trial was stopped after 1-2 years since, by then, strong published evidence had come up in support of the intervention modality (53).

(b) Evidence of clearly high mortality or complication in the intervention group comes up

(c) The Cardic Arrhythmias Suppression trial was initiated to study the role of Anti ventricular dysarrythmia drugs Encainide or Fecainide in patients of Ac MI over a 5 year period. Trial was stopped after 18 mnths since interim results showed clearly high mortality in the treated group (54).

(d) Statistical, Methodological or Sample size assumptions are proved wrong

The Physicians Health Study was initiated to assess the protective effect of oral aspirin 325 mg alternate day in preventing cardiovascular disease. Trial was stopped midway since as against an expected of more than 700 cases, only 88 had occurred and hence the trial was left with hardly any statistical power. ( However, protective effect on occurrence of MI was clearly demonstrated by then) (55).

**Step 12 : Satistical Analysis**

Statistical analysis is indeed a very important aspect of any research design, clinical trials included. Let us start with an example of a clinical trial which has been published in one of the recent issues of Lancet (56). The DREAM Project was a clinical trial to evaluate whether Rosiglitazone (RG), a thiazolidinedione drug said to improve insulin sensitivity can prevent the onset of diabetes type 2 among subjects who were having IGT or impaired fasting glucose. 5629 samples with IFG were randomly allocated to either receive Rosiglitazone 8 mg per day (2635 subjects) or a placebo (2634 subjects) for a follow up period of 3 years. The primary clinical end point was development of diabetes. Those who did not develop diabetes were taken to have achieved the outcome. The final data is

Table - 3 : Summary results of Rosiglitazone data

| Exposure | Outcome | | Total |
|---|---|---|---|
| | O+ (Did not develop Diabetes) | O- (Developed Diabetes) | |
| E+ (Given RG) | 2329 (89%) | 306 (11%) | 2635 (100%) |
| E- (Given Placebo) | 1948 (74%) | 686 (26%) | 2634 (100%) |
| Total | 4277 (81%) | 992 (19%) | 5269 (100%) |

summarized in Table - 3

The data shows that as much as 88.4 % of the exposed group, i.e, given Rosiglitazone remained free as compared to much lesser 73.45 among the placebo group. As the data apparently shows, Rosiglitazone is an effective chemo prophylactic against Diabetes. So the first question is , why at all should we do a statistical analysis? .

We undertake statistical analysis to estimate the effect of "chance" (random error or sample to sample error or sampling variations). It has been very clearly brought out earlier that due to a natural phenomenon of random error, as long as we are studying a sample drawn from the population, which anyway we shall always be doing, the results from the sample are likely to be different from the reality that exists in the large population. What we should, therefore, do is that we estimate the probability with which the results from our study may be different from the reality which exists in the large reference population to which our sample refers to. This probability is estimated by statistical procedures. Please do note that statistical results are only a probability statement about our sample results being different from the reality in the large population due to the natural phenomenon of random error. We presume that your study had no measurement error, no bias and no confounding. Very good statistics is no panacea for data which has been collected by poor measurement methods, or is differentially biased against one group or is suffering from confounding.

Another decision to be taken at this point is whether we want to undertake an "Intention to Treat Analysis" or else a "Per-protocol" analysis. In the former, which is being often undertaken these days, the outcome is analyzed among subjects according to the group into which they were originally randomized ("analyse as you randomize"). Thus, even if participants assigned to the original intervention group may have discontinued or even crossed over or some of the placebo control group may have finally ended up taking the intervention modality, the analysis will be as per the subjects' original randomization plan. On the other hand, the per-protocol analysis will include only those participants in both groups who undertook at least 80% of the assigned study medication, completed a certain percentage of their expected follow-up visits, and had no other protocol violation (1).

The first thing in undertaking statistical analysis of a clinical trial is to present the participant's recruitment and flow chart, giving the actual data at each step, as explained in Step 7. The next step is to give a table showing baseline comparison between the intervention group and the placebo group as we have given earlier in the step of randomization. The next step is now to clearly visualize what are your primary exposure and outcome variables and what is meant by exposure present or exposure absent and by outcome achieved or outcome not achieved. Now, make a 2X2 table and place your data in the 2X2 table exactly as per the specifications for cells a, b, c and d that we have already discussed. (Table 4)

In the DREAM clinical trial, out of 2365 who were exposed to RG, 2329 achieved the defined outcome while in the non exposed(Placebo) group, 1948 out of 2634 achieved the outcome. Please do take care to indicate both the numbers and percentages in the cells. Now, having placed the data in the 2X2 table, calculate the incidence of outcome in the exposed and non exposed group as :- $I_E$ = a/a+b = 2339/2635 =89% and $I_{NE}$ = c/c+d = 1948/2634 =74%. And, as the next step, calculate the risk ratio (RR) i.e, the "effect" of the intervention as RR (Effect) = $I_E$/ $I_{NE}$ =89/74 =1.20. This calculation of the effect size is a simple but extremely important parameter which you must calculate. In our example, it means that patients of IFG who got Rosiglitazone will be 1.2 time more likely to remain free of diabetes as compared to those on placebo, over 3 years.

In the next step, calculate the 95% CI of RR. In the DREAM trial example, the RR was 1.20 and its 95% CI was 1.16 to 1.23. The interpretation is like this: "our sample results show that the effect of Rosiglitazone is to bring about 1.2 times more improvement". We do not know what the real effect would be in the 2 large populations but we are 95% confident that the real effect in the two large population would be an improvement between 1.16 times to 1.23 times improvement as compared to placebo.

And, in the basic presentation, finally calculate the numbers needed to treat as : NNT = 100/ ($I_E$ . $I_{NE}$) . (57). In our example, it works out as : 100/(89-74) = 100/15 =7. It means that we will need to treat 7 patients with Rosiglitazone to get one additional case of cure (prevented diabetes) as compared to placebo.

Having presented the basic statistics, the next step in statistical analysis is to undertake probability testing procedures. In deciding the statistical procedure, we should first of all see which is the exposure variable and which is the outcome variable. Next we should clearly make out as to how the exposure and outcome variables have been recorded. The correct statistical procedure will depend on which way the recording has been done for the exposure and outcome variables. In the above example, both the exposure as well as the outcome variables have been recorded on a dichotomous scale. In such exigency, a chi-square test for 2 X 2 table will be done, and the 'p-value' worked out against a degree of freedom (df) of 1. For further details on statistical testing procedures, please refer to the section on Biostatistics in which a detailed table has been given indicating the correct statistical test, depending on how the exposure and outcome

Table - 4 : 2X2 Table for initial presentation of results

| Exposure | Achieved outcome (Did not become Diabetic)(O+) | Not achieved Outcome (became Diabetic) (O-) | Total |
|---|---|---|---|
| Given RG (E+) | 2329 (89%) **(a)** | 306 (11%) **(b)** | 2635 (100%) |
| Given Placebo (E-) | 1948 (74%) **(c)** | 686 (26%) **(d)** | 2634 (100%) |
| Total | 4277 (81%) | 992 (19%) | 5269 (100%) |

Col RajVir Bhalwar

# Research in Economic Aspects of Health Care

Till about 3 decades back, medical research was mainly directed towards the etiology, risk factors, natural history, prevention and treatment of various diseases. Once the results indicated that a particular preventive or therapeutic measure is efficacious, no further questions were asked about its usefulness. Things are different today. For almost any health care procedure, we are required to be ready to answer questions like- "At what cost?"; "Can't the same result be achieved with a lesser cost?" These questions, all of which pertain to the area of "health economics" assume importance because of the ever increasing cost of health care and the fact that somebody has to pay for it, be it the individual patient or else the entire community (by way of taxation). These issues do not simply involve straight forward questions like " Is norfloxacin more effective, cost for cost, than gentamycin for UTI", but often more complicated issues like :

(a) Should a private practitioner routinely undertake opthalmoscopic examination of all her patients aged > 35 year , irrespective of the signs / symptoms?

(b) Should the health administrator take away "scarce" Auxiliary Nurse Midwives (ANM) from the well baby clinics and, instead, ask them to pay home visit for nutritional education?

(c) Should the hospital administrator buy a newly marketed imaging equipment or continue with what she already has?

The above are just a few examples of often asked questions regarding research into issues of "health economics".

## Types of evaluation

Broadly speaking, there are three types of evaluations in respect of any health care procedure :-

### Efficacy

This answers the question " can the procedure work at all, given the ideal settings?" For example, if we randomly divide a group of 10 patients with pulmonary TB and give streptomycin + INH + Thioacetazone to one group and only a placebo to the other group , we may find that the 3 drug combination definitely cures pulmonary TB as compared to placebo. In other words, when the settings are ideal ( Patients are well supervised, compliance is ensured and so on ), the 3 drug combination is "efficacious".

### Effectiveness

In contrast to efficacy, evaluation of "effectiveness" is intended to answer the question "Does the procedure actually work in the real life situations, when the settings will be subject to the various constraints" rather than being ideal. For example, the 3 drug combination of strepto, INH and thioacetazone may be highly "efficacious" (almost 90 to 95% against pulmonary TB), but when it is actually put into practice on a large scale in the community, the overall cure rate in the community is just about 40% , mainly due to lack of compliance. Thus , while the efficacy of strepto + INH + Thio may be as much as 95%, the actual "effectiveness" is just about 40%. On the other hand, four drug combination (Strepto + INH + Rifampi + Pyrizinamide) administered under direct supervision, is not only 95 to 100% "efficacious" but is also 70% to 80% "effective" possibly due to a better compliance consequent to a shorter duration of therapy.

### Efficiency

Efficiency evaluation answers the issues related to "costs". In a layman's language, it answer the question "Is this the "best" way of doing the things? Can the same results be achieved in some other way, paying a lesser price?" .

## Definition

An economic analysis can be defined as the comparative analysis of alternative courses of action, in terms of both the costs (inputs) and results (outputs) and comparing the costs and the results of the alternatives being considered.

## Architecture Of Health Economic Research Studies

The architecture of health economic research studies can be described on the basis of cross combination of the following two basic questions :-

(a) Are both the costs (i.e. inputs) as well as results (i.e., the outputs) of the alternatives being examined.

(b) Are two (or more) different alternatives being compared or only a single alternative is being considered.

Depending on the answer we get to our above questions the various types of economic research designs are being described in succeeding paragraphs and being summarized in the summary (Box 1)

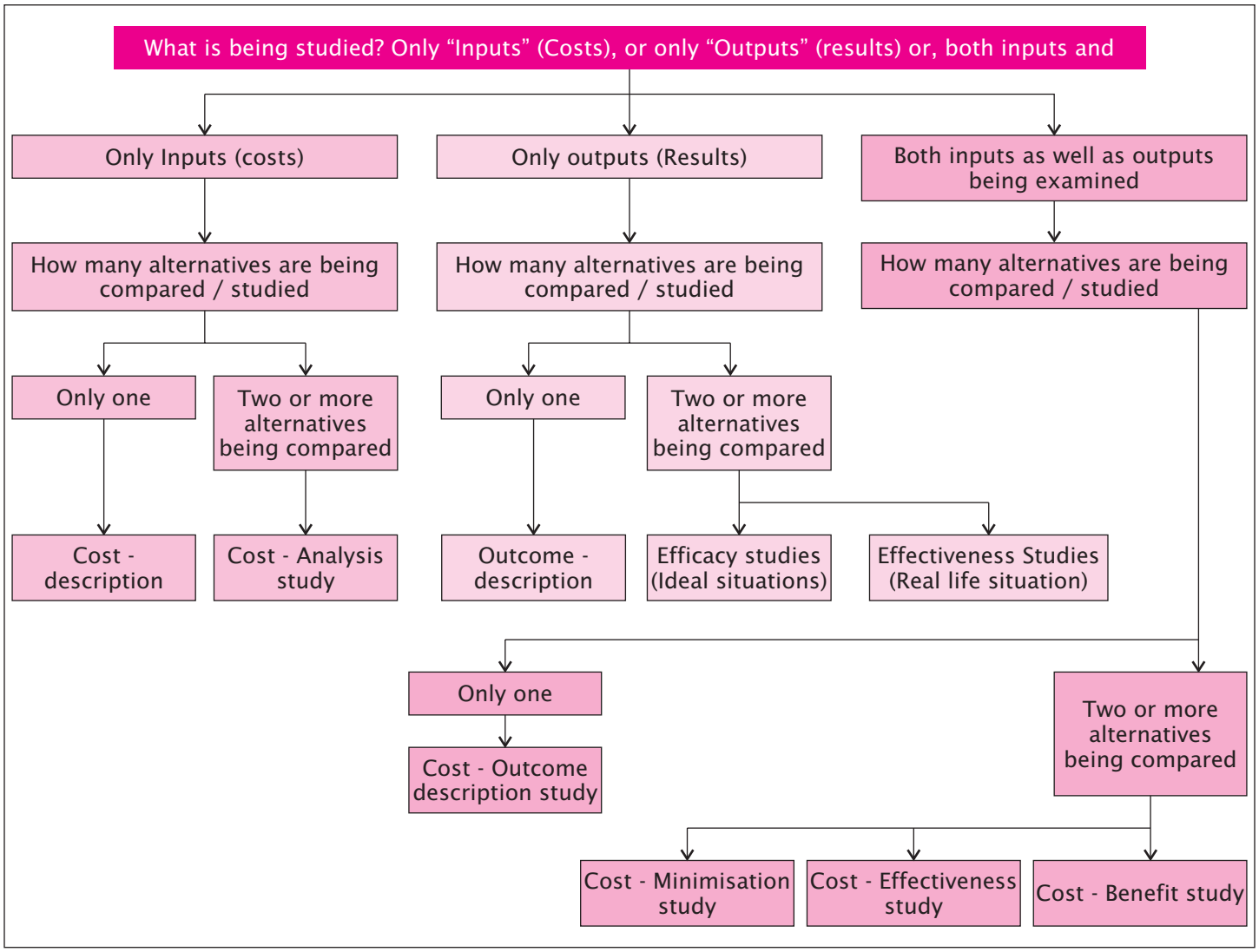
### Situation 1

Only the cost (inputs) but NOT the results (outputs) are being studied. The two situations that can further arise are :

(a) Only one alternative is being considered : For example, we may work out the total cost (per patient) of treatment with a latest antibiotic (total cost includes cost of drug , overhead expenses, cost of syringes, commuted cost of hospital stay and so on). However, we would not work out the total benefit that occurs with this antibiotic, neither we would compare the cost so calculated, with the cost of any alternative antibiotic, say penicillin. Such a type of study is called as **"Cost Description Study"**.

(b) Two or more alternatives are being compared : In the above mentioned study we could compute the cost of treatment with the newer antibiotic (of course, without considering the economic aspects of results) and compare this cost with that of ampiclox and augmentin. Such a study is called **"Cost Analysis Study"**

Box - 1: Summary description of health economics research studies




**Situation 2**

Only the results (outputs) are being examined but NOT the cost (inputs). Once again, two situations can further arise :-

(a) Only one alternative is being considered : For example, we may give a group of patients, in one hospital, a newer antibiotic and describe only the outcome (say in terms of cure rate, hospital days, acute-period days and so on). However, we would not describe the cost of the newer antibiotic , nor do we have any other group of patients receiving another antibiotic with which we could compare the result. Such a study is called as **"Outcome Description Study"**.

(b) Two or more alternatives are being compared :- For example, in the above mentioned type of study, we could have another group (s) of patients on penicillin / ampiclox and make comparison of the "result" of this group with the results of the new antibiotic, without considering the cost of any of the antibiotic regimens. This type of study is a **"Efficacy"**, or **"Effectiveness" Study** (depending on whether we are making the comparisons in the ideal settings (for efficacy) or in the real life settings (for effectiveness). Most of the experimental designs concerning RCTs (drug trials, clinical trials, preventive measures trials) fall in this category of economic evaluation.

The four different types of studies mentioned in situations 1 and 2 above are called as **"Partial Economic Evaluation".** Partial economic evaluations are quite important; however, they do not answer the issue of "efficiency".

**Situation 3**

Both the inputs (Costs) as well as results (outputs) are being studied : Once again we can have 2 types of situations in this group :

(a) Only one alternative is being examined : For

example we may take a group of patients and give them newer antibiotic. We work out total costs (in terms of cost of antibiotic, hospital stay costs etc) as well as the results (Cure rate, satisfaction level, etc). However, we are not having any other alternative (as penicillin or ampiclox) to make comparisons. Such a type of study is known as **"Cost Outcome Description Study"**. Such studies are also a type of partial economic evaluation."

(b) Two or more alternatives are being compared For example, in addition to having a group of patients on the newer antibiotic , we have another group on penicillin for making comparison. We work out both the costs (inputs) as well as results (outputs), as above, for both the groups and make comparisons. This is the classical **"Full Economic Evaluation"** or **"Efficiency Study"**. In general , such studies can be of three types:

(i) Cost Minimisation Analysis

(ii) Cost Effectiveness Analysis

(iii) Cost Benefit Analysis

Cost minimistation Analysis

In such a study, the result (outputs or consequences) of the two (or more) alternatives are identical and we compare the cost of the two (or more) different alternatives. For example, we may have the research question : "Whether to keep a patient hospitalized overnight after an Incision and Drainage for a carbuncle, (1st alternative), or else, perform a day-care surgery and discharge after a few hours of observation (2nd alternative). Here, the "outcome" (i.e, consequence or output or result) is assumed to be the same for both the alternatives, ie., " operation has been successfully performed without any immediate or delayed sequelae". We would now work out the costs for both the types of strategies and see as to which carries the smaller cost. Statistical issues would involve comparing the "mean cost" for the two strategies by a 't' test (or, ANOVA if there are more than 2 alternatives being compared).

Cost effectiveness analysis

Let us say, our outcome of interest is "Years of life gained after onset of renal failure" and we are comparing the costs to achieve this outcome through "periodic hospital based dialysis" (Strategy No. 1) with "kidney transplantation" (Strategy No.2). Now, in this setting, the outcome of interest is common to both the strategies. However, the two different strategies may bring out different achievements of this outcome (ie. the average years of life gained may be different for the two strategies, as also the total costs of the strategies may be different. Thus we would calculate the "Costs (i.e., inputs) per unit of the result" (i.e, output). More precisely, in this example we will calculate the "total costs in rupees per additional year of life gained" for the two different alternatives and make comparisons. Alternatively, we can calculate the "results (outputs) per unit of the costs (inputs), i.e, we can calculate the "life years gained per rupee (or per one lakh rupees) spent" for both the strategies and make comparisons. The latter approach is more appropriate when we are working under certain budgetary constraints. The statistical issues would involve comparison of the two "mean" outcomes using a 't'-text. Cost effectiveness analysis are, thus, such studies wherein costs (inputs) are related to a single, common outcome (output); however this single common output (e.g. "life years achieved" in the foregoing example) would differ in magnitude between the alternative strategies that are being compared. Cost effectiveness studies may also be performed for comparing widely different alternative strategies which have a common effect; for example, if the common outcome of interest is "life years gained" as in the above example, we can compare not only dialysis vs renal transplant but even "dialysis" vs "education programme to ensure crash helmet use" to decide whether scarce public funds be diverted towards educating the community in use of crash helmets to prevent head injuries or towards renal units for undertaking dialysis of renal failure cases.

Cost benefit analysis

In a cost effectiveness analysis we make comparison between the costs of two strategies on the basis of a common (single) outcome of interest (e.g, "life years achieved" in the above example). However, often it may not be possible to measure the consequences of the alternative strategies by a single, common effect of interest. Broadly, two different types of issues may come up :-

(a) We may be interested in consequences which, though common to both the alternatives, are multiple. For instance, in the above example of renal disease, we may be interested in answering, in addition to "life years gained", such other consequences as "quality of life" and "incidence of medical complications" etc.

(b) Secondly, we may be interested in comparing two different strategies which produce entirely different outcomes. For example, we may be comparing a cervical cancer screening programme among middle aged women having the outcome of interest as "life years added due to early treatment" with a pulse-polio immunization campaign among infants, the outcome of interest being " improvement in the quality of life of children due to disability prevented"

Here, in both the above situations, the outcomes of interest are either multiple (situation 'a') or else, differ between the various alternatives (situation 'b') and hence a meaningful cost effectiveness comparison is impossible. In situations like these, we need a common denominator to facilitate comparison of outcomes. We therefore attempt to go beyond the consideration of specific effects alone, and try to work out a measure of "value" to the various "consequences" resulting from the different alternative strategies. One such measure of these "values" could be the currency expressions as "rupees". Thus, the various results or consequences of a particular strategy may be worked out and expressed in terms of "rupees benefit" in order to facilitate comparison to the costs of

the strategy. This would, of course, require that we convert such abstract outcomes as "quality of life" or "patients' satisfaction" into their "rupee benefit", which may be quite a difficult task. Such analyses which measure both the inputs as well as outcomes in terms of money, for making comparison between two different strategies are called "cost benefit analysis", the methods of analysis of these studies is to work out the "rupee cost to rupee benefit" of each of the 2 (or more) different strategies, so as to get a "relative benefit". Alternatively, the absolute difference between the benefit of the two strategies can be calculated. Let us dilate on the example given above on the "overnight hospitalization" vs "OPD treatement" for incision and drainage. We randomly divided 100 patients into 2 groups of 50 each receiving either of the two strategies. The costs of the two procedures included cost of drugs, surgeon's fees, hospital stay charges, money spent by relatives of patients on transport and visits, and so on. The various outcomes were cure, occurrence of complications, pain and inconvenience at home/work place as an after effect of operation, patient's satisfaction, loss of work days and wages, as so on. All of these various outcomes were commuted to "rupees" by " expert and sensible "value judgement". The data set would look like as given in Table - 1.

Next, calculate the means and standard deviations of "Rupee cost to Rupee benefit" for both the groups. Let us assume these are as follows :

(a) Strategy 'A' (Admission) : Mean (X1) = 1.36, SD1 = 0.24, no. of subjects (N1) = 50

(b) Strategy 'B" (OPD groups) : Mean (X2) = 1.65, SD2 = 0.26, no. of subjects (N2) = 50

(c) Ratio of "average rupee cost to rupee benefit " of OPD group over admission group = 1.65/ 1.36 = 1.21. The interpretation is that strategy No B. (OPD

Table - 1

| Patient No. | Strategy (A=OPD) (B=Hosp) Adm. | Age | Sex | Baseline Condition | Other Diseases | Total Input cost (c) | Total Benefit in Rs. (b) | Rupee cost to Rs benefit ratio (b/c) | Absolute Diff. (b-c) |
|---|---|---|---|---|---|---|---|---|---|
| 1 | A | 36 | M | Fair | No | 181.50 | 257.82 | 1.42 | 76.32 |
| 2 | B | 40 | F | Fair | Yes | 348.90 | 384.10 | 1.10 | 35.20 |
| 50 | B | 58 | M | Poor | Yes | 310.10 | 526.70 | 1.69 | 215.80 |
| 100 | A | 24 | F | Fair | No | 257.10 | 318.20 | 1.24 | 61.10 |

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## Questionnaires and Interviews

In a large number of clinical measurements (pain, fear, satisfaction, attitudes, practices, beliefs, etc.), there is no clear cut physical standard. The usual approach in such settings is to construct a questionnaire, consisting of a group of questions designed to measure these specific phenomena. The first thing to remember is that one should do an extensive reading and find out if any questionnaire is already existing which caters to one's requirements. It is best to use an already existing questionnaire in toto (or, use it after slight modifications) because the same has already been standardised / validated by earlier workers. However, if one has to devise a new questionnaire, one should work out the details of the items and specific questions to be included by the following methods.

(a) Recapitulate from your own theoretical knowledge & your observations in clinical practice, in this field, thinking extensively on what all should be included.

(b) Do an extensive study of research works done in the past 5-7 years (at least) to get an idea of the variety of topics /questions that need to be included.

(c) Consult experts in the field for their opinion regarding various items/ questions.

If the outcome is to be recorded on a "continuous" scale, try to record the answer on a Visual Analog Scale (VAS), to get the maximum possible information. E.g., for a question on pain, we can draw a line of 100 mm, with '0' indicating 'no pain' and 100 indicating 'pain of the most extreme type" and ask the patient to put his finger at the point he feels optimally describes his severity of pain.


If the response is to be recorded on a "nominal" scale (i.e., as "categories), the optimum is to keep 5 to 6 categories. Also try and change the order of response in successive questions; e.g. if Q.1 is recording the response from "high" to "low" try to record the response on Q.2 as "low" to "high". "Likert's" type of scales, in which the responses are framed on an "Agree - Disagree" continum can often be used in such situations. E.g., for a question "Is the OPD giving satisfactory service?", the responses could be

| strongly agree | Agree | No opinion | Disagree | strongly disagree |
|---|---|---|---|---|

Decide whether you want to have a "structured" or an "unstructured" questionnaire. In the former, the interviewer asks the same questions in the same way and in the same order from all subjects; in other words there is a pre-designed schedule on which questions are already written down in sequence. On the other hand, in "unstructured" questionnaire, there is lot of flexibility and the questions asked from the study subjects may vary at the discretion of the interviewer (e.g., interviews taken by a journalist; psychiatric history taking). By and large, it is always desirable to have a structured questionnaire since it ensures standardisation and reduces variations. Now decide whether you want to have a "closed ended" or "open ended" questions.

**Specifically check the following points while making the questions**

(a) Avoid ambiguity :- Avoid statements or questions which are likely to be interpreted differently. E.g. instead of the question "Have you been on leave recently?", it will be more apt to ask " Have you been on leave since 01.01.2007?".

(b) Avoid "double-barrelled" questions : e.g., "Do you have precordial pain and dysonoea while walking?". Now, what if the subject has any one of them? In such cases make two different questions.

(c) Avoid technical jargon : The question "Are you hypertensive" may be interpreted by a layman as "too much mentally tense" .

(d) Avoid "value-laden" words or hypothetical questions : e.g., In the question "Would you like to move to a better hospital?" would evoke various judgement responses because of words "like" and "better" which are hypothetical. In such cases, increase the number of questions and be more specific, eg :-

(e) Do you want to move out from this hospital? Yes/No.

(f) If Yes, to which hospital?

(g) Why do you want to move to that hospital? Better administration/ better doctors/ better investigations / less expensive/ any other (specify)

(h) Avoid questions that are not self explanatory : e.g. The answers to question "What type of home do you have?" may bring out different answers like "happy", "concrete", "well ventilated", "small" and so on. In such cases specify the question in details or give closed / semi closed answers in front of the question.

(j) Do not ask about events which most people will not remember : e.g., "How many times per week did you drink milk when you were between 6 and 10 years old?" may be quite difficult to answer. In such cases, if you must ask about such a long past, try to verify/ supplement this information from other sources (records, parents, friends, siblings, spouse etc.).

(k) If you are using interviewers to carry out the interview, train them centrally, test them and

certify them to ensure standardisation. Do a 20% cross chick on the filled proforma by cross checking information yourself. Do a random check on how the various interviewers are carrying out the interview.

(l) If possible, ensure "blinding".

(m) Start with general questions and gradually move on the sensitive questions (e.g., sexual practices, family violence, etc.) later on in the questionnaire.

(n) Ensure "pretesting" your questionnaire as well as interview technique by pilot study.

(o) To start the interview, establish rapport with the subject. Do not forget to assure him of confidentiality- this will itself greatly increase the validity of information.

(p) Alternate questions which are likely to bring out 'yes' answers with those likely to bring out 'no' answers.

(q) Keep some "Dummy, check questions" in the questionnaire. These questions may not be related to the study but may enable us to cross check the validity of information. E.g., in a study on sexual practices, tobacco use and details of postings may not be directly relevant to study objectives; however, answers to such questions may be cross checked with records, friends, senior officers etc. and would give an overall idea of the validity of information being provided by the subject.

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# Writing the Research Findings

The discussion in the present chapter is intended to serve as general guideline for writing a research paper or dissertation. The researcher is advised to obtain a copy of specific guidelines from the journal to which he or she intends sending the article (or the academic council or research body in case of a thesis or project report) and adhere to the finer details provided in such instructions. For instance, in so far as Medical Journal of Armed Forces of India (MJAFI) is concerned, the guidelines for authors are published in the January issue every year.

The general sequence of presentation in an original research paper or thesis is usually as follows :

(a) Title
(b) Abstract (Summary in case of thesis)
(c) Key words
(d) Introduction
(e) Aim and objectives
(f) Review of literature
(g) Material and Method
(h) Findings (Results)
(j) Discussion
(k) Conclusion
(l) Recommendations
(m) References
(n) Annexures
(o) Other Enclosures.

All or most of these headings should be sequentially covered up, whether you are preparing an original research article or a thesis, keeping one major difference in mind, that in a thesis or project report, the various aspects are dealt with in great detail while in a research article, these are condensed. As a general guideline, try and restrict your research paper to 8 to 10 double spaced A-4 sized typed pages and your dissertation/project report to 125 to 150 pages.

### Title

A large majority of the readers of medical journals generally browse through the list of contents and tend to select the article whose title attracts attention. The take home message is that you must select the words in the title in such a way that it attracts attention. Do not keep the title either too long or too short. A good method is to write down a few titles, revise and modify them a number of times till you get the one which appears to be the best. The optimum number of words in a title are between 15 and 25. The title should be, in fact, a very short, "telegraphic form" summary of your objectives . In addition, the title may also give a very brief indication of the place and general settings of the study and the type of study design; e.g., "A randomized Controlled Clinical Trial (i.e., the "design") of the effectiveness of acetazolamide in preventing Acute Mountain Sickness (i.e., the research question)among young healthy soldiers inducted to high altitude in Northern Himalayas (i.e., the general settings).

### Abstract

In a research paper, the title is followed by the Abstract. In case of a dissertation or project report, there is an additional page giving the Index (list of contents) interspersed between title page and the "Summary". In a dissertation / project report you would write a Summary which occupies approximately 5% to 7% of the total pages that are present in the report. The abstract is a short crisp summary of your entire research paper. Usually, it should be limited to 200 to 300 words (about one typed page in double spacing). Some of the standard journals, including MJAFI, want the Abstract section to be further subdivided into four sub-headings namely Background significance, Material and Method, Results and Conclusion. The abstract should start with a sentence or two on the background of your research question followed by your actual research question (i.e, objectives) summarised in a sentence or two. Thereafter the salient features of methodology are summarised in about three or four sentences, so as to give an idea of the general settings, the reference population, the sample size, sampling method, type of design, the methods used in making measurements / obtaining information from the subjects and the intervention procedure if any. This is followed by the salient findings (giving the measures of effect like OR and p value in brackets) and finally the main conclusions drawn from the study. In case of summary, the above aspects are explained in slightly greater detail, paragraph wise, in about five to seven typed pages. Avoid including aspects pertaining to "Review of literature" or "Discussion" in the abstract/summary.

### Key words

After the Abstract, indicate four or five key words that will help "indexing" your article in Index Medicus or computer based databases.

### Introduction

Keep it as brief, but, at the same time, as clear as possible. The optimum space for introduction is about half page in your typed manuscript; in a thesis/project report the optimum space is 3 to 4 pages. The Introduction should bring out, systematically, the definition of the disease/health problem that you have studied, its "magnitude" in terms of morbidity, mortality and suffering, a brief note on what is already known in this area and finally the facets where gaps exist in the present body of knowledge and which have prompted you to take up the present research work.

### Aim and Objectives

In a research article, aim and objectives are usually covered in the last one or two sentences of introduction, without giving any separate heading. In a thesis/project report, a separate heading must be given and the aim and objectives should be spelt out in detail.

### Material & Methods

This section is the "backbone" of your entire study. Write your methodology with great care and accuracy. It would be worthwhile devoting half to one complete page to material and methods in a research paper, and up to 12 to 15 pages in your thesis/project report to this aspect. Coverage of all the headings described in material and method section of the next chapter (on research proposal) must be ensured, in detail when writing a thesis and in a summarised form when writing a research paper.

### Review of Literature

A review of literature is not required in a research paper. On the other hand it is a must for thesis / project report, wherein it should be a detailed review of recent literature (generally covering the past 5 years). In a dissertation / project report the review of literature may generally occupy 30 to 40 pages. The order of proceeding with the review of literature usually takes the following sequence :-

(a) Definition(s) of the condition(s) of interest in the present research.

(b) Historical review of the condition of interest.

(c) Magnitude of the problem due to the condition of interest, in terms of mortality, morbidity and suffering

(d) Major risk factors for the condition.

(e) Other (minor or possible) risk factors for the condition.

(f) Review of diagnostic/therapeutic strategies (in case of a study addressing issues of "therapy" or "diagnosis") Or Review of preventive strategies (in case of study addressing issue of "prevention" or "risk').

### Findings (Results) and Discussion

The findings should be "grouped" into broad headings, commensurate with the study objectives. Graphical presentations should be made using appropriate types of figures (diagrams) or tables. Each figure should be appropriately referred to in the text. Each table should have a table number, usually in Arabic numerals, which should be clearly referred to at the appropriate place in the text. The table number should be followed by a clear but concise heading, and the actual findings. It is always a good practice to indicate the percentages along with the number. Do not forget to indicate 100% besides or below the number out of which you have calculated the percentage. Also make sure that the totals of the columns as well as the rows have been presented. Following the table, you must give the abbreviated statistical findings as "t = 3.21, df = 28, $p < 0.05$ (significant)". An example of a table is given as Table - 1.

Following the table, describe your own findings in two or 3 sentences. Do not leave it on your examiner or the reader to make interpretations from the tables. Having given an overview of your findings, bring out such studies which have given similar findings. Next, give a brief account of studies which have obtained findings that are dissimilar from your findings, and "reason out" the possible causes as to why your findings could be different from theirs. Finally, in a sentence or two, summarise the overall findings and how your findings would affect the clinical or preventive policy.

Table - 1 : Comparison of cases of IHD and controls regarding smoking

| Smoking History | Cases No. (%) | Controls No. (%) | Total |
|---|---|---|---|
| Present | 67 (76.1%) | 54 (42.5%) | 121 |
| Absent | 21 (23.9%) | 73 (57.5%) | 94 |
| Total | 88 (100%) | 127 (100%) | 215 |

X2= 23.9, df = 1, $p < 0.001$ (very highly significant)
(OR = 4.3; 95% CI of OR = 2.4 to 7.7)

### Conclusions and Recommendations

A point which needs to be emphasised is that the conclusion should be drawn from the premises of your study and not from possible factors which you have not studied. Similarly, while making your recommendations, make sure that they are based on facts which you have studied and not simply a repetition of standard recommendations given in some text book or by some other author. Moreover, the recommendations should be "do-able" (practicable).

### Annexures and Enclosures

In general the annexures that are attached in a thesis/project report are the same as have been explained subsequently in the chapter on writing a research proposal. In addition, if necessary and possible, in a thesis/project report, interesting ECG tracings, Skiagrams etc may be attached as separate enclosures. Annexures and enclosures should be properly referred to at appropriate places in the text.

### References

The references should be serially numbered in Arabic numerals, in a chronological order, as they appear in the text. Do make sure that a particular reference number should appear in the text for the first time, only after the immediately preceding reference number has appeared in the text at least once. For example, reference number 9 should appear in the text only after reference number 8 has appeared in the text at least once. The style of writing the reference should conform to the one used in Index Medicus. The details are provided in the guidelines for authors which are included in every January issue of the MJAFI and all researchers should go through the same. For example, for writing a reference of an article published in a journal, the format is as follows : "Reference No. Name of author(s). Title of article. Name of journal & Year; Volume : Pages from - to". A hypothetical example is - "18. Singh BB, Kumaran R. Epidemiological study of murine typus in a rural area. Indian Jr Biology 1968; 37: 368-73". If there are up to 6 authors, then give the names of all; if more than six, give the names of first three, followed by "et al".

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# Writing the Research Proposal

This chapter lays down the general guidelines for writing a research proposal. Apparently, researchers should also abide by the format which are specifically laid down by the respective agencies as AFMRC projects, ICMR, or by the concerned University. The specific guidelines for writing down the AFMRC proposals are given in Office of the DGAFMS letters and one should refer to the same as and when required (Latest letter which can be referred is Office of DGAFMS letter No. 15965/ 46th / 2008 / DGAFMS / DG 3B dated 14 Mar 07).

## Introduction

This the first group heading. In a nutshell, the introduction should give a good overview of two aspects - firstly, the background importance about the area of study and secondly the relevance of the proposed work. The introduction should generally be limited to within 300 to 600 words (2 to 3 double spaced A-4 size typed pages). The introduction should have specific paragraphs which should logically and sequentially bring out the following aspects :

(a) Definition of the problem in which the research is going to be undertaken.

(b) Magnitude of the problem in terms of morbidity, mortality, disability, suffering and socioeconomic consequences.

(c) A brief statement of what is already known about the condition, depending on the review of literature.

(d) A statement on what is not known, or areas where gaps in knowledge still exist and which need to be filled.

(e) What is the research question to be answered in this proposed study. This will include a paragraph giving general statement, enunciating the broad issue of the study.

(f) A final paragraph should be written on how the study findings will contribute to the existing knowledge, and help in improving the health care or clinical practice.

## Aim and objectives

The AIM is a general statement about the research question. The OBJECTIVES are very specific issues through which the aim is going to be achieved. Be very careful while writing down your objectives, since any funding agency will examine them very closely and you are also expected to fulfill these objectives at the end of your research.

## Review of Literature

Brief review of literature of 3 to 4 double spaced typed pages should be given. The review should generally be of the "recent literature" (i.e., past 5 years or so). The review should bring out the definition of the condition of interest, the magnitude of the problem, a review of what is already known about the topic of research and finally a review of the gaps which exist in the present body of knowledge as far as it pertains to the proposed research.

## Material and Method

This is the "heart" of the research protocol. Great care should be exercised while writing this part. In general, the following aspects should be clarified in adequate detail, point wise.

(a) **General Settings** - Define the general settings, ie, whether the study will be done in a hospital or in general community, the type of hospital (primary / Secondary/ tertiary level or OPD), or the community (Urban, Slums, rural) etc, and the time-line.

(b) **Study design** : Specify the exact study design (eg, "cross- sectional analytical study"). In a few lines, describe as to why this particular study design is being used as compared to the other available study designs.

(c) **Reference and Study (Actual) population** : Define the reference (total) population on which the study results will be generalised. Next, define the actual (study) population from which the study sample will be drawn. Add a line to justify that the actual (study) population is a reasonably representative subset of the total (reference) population.

(d) **Sample size** : Clearly specify the statistical procedure that you have followed for calculating the sample size. Do consult a epidemiologist or statistician since this heading is quite thoroughly scrutinized by various research bodies.

(e) **Sampling method** : Describe as to what will be the sampling ratio and by which particular method (simple random, systematic random, multistage, cluster, stratified random, etc) will the sample be drawn from the actual (study) population.

(f) **Exclusion criteria** : If you are having “exclusion criteria”, then be very specific in defining them; e.g., "all cases who have undergone hysterectomy will not be included in this study".

(g) Specify the variables of interest under the headings of Exposure variable(s) of main interest, Other exposure variables, Outcome variables (Primary outcome variable and secondary ones, if required) and the Potential confounding variables.

(f) **Instruments** : Give a clear description of all instruments that will be used to collect the data. This should include the physical instruments (eg., sphygomanometer), or laboratory instruments (eg., stereoscopic microscope) or special instruments (eg., portable 12 lead ECG machine) and the Questionnaire (Remember, Questionnaire is also an instrument).

(g) **Techniques** : Give a clear description of the technique of using the instruments and making

the measurements. In addition, give a description of who will collect the data (e.g., by the principal worker, trained interviewers, trained laboratory technicians etc). Finally make a mention as to how training in data collection will be imparted and how testing and certification of the data collectors will be done.

(h) **Details of randomization, blinding and Intervention :** If the study involves any intervention (eg, drug, vaccine, program, therapeutic procedure, etc.) then give a very clear and detailed description of the process of Random allocation, the details of blinding (single / double) and the "intervention" which is going to be studied (who will do what to whom, how and how frequently). Even minor points like dose, formulation and frequency of administration of the drug or details of operative procedure must be mentioned. Similarly, details of "Placebo" in case of a clinical trial should be mentioned.

(j) **Follow up procedures** : In a cohort study as well as a experimental design, mention the details as to how the follow up of the two groups will be done, including details as who will be ascertaining the final and interim outcomes, when and where. In addition, give a clear description of modalities of "retrieving" those who are getting lost to follow up.

(k) **Description of gold standard test in diagnostic test study :** In a study proposing to evaluate the performance of a diagnostic test, including clinical algorithms, a detailed description of the "gold standard" against which the current test under study will be evaluated, should be given.

(l) **Pilot study** : In case a pilot study would be done to refine the material and methods, then give a clear description of how many subjects will be required for the pilot study, how will they be sampled, and whether the pilot study subjects are likely to be included in the main study or not, going a brief justification for the same.

(m) **Issues of analysis** : A general description must be given in the protocol as to what statistical procedures will be used for the basic analysis or for advanced issues like control of confounding. In case the help and guidance of a research methodologist or biostatistician will be taken for handling issues of advanced analysis, then the same should be mentioned. In addition, if data management by computerisation is planned, then a brief description of computer packages should be given. In clinical trials, details of stoppage rules and "intention to treat analysis" if applicable, should be clearly brought out.

(n) **Ethical issues :** Most research bodies now need the proposal to be cleared by the Institutional Ethical Committee and this should be ensured and, for animal experiments, separate clearance by Institutional Animal Experiments Ethical committee, should be taken

(o) **Financial Details :** This paragraph is mandatory for any study which seeks "funding" from any Governmental (including AFMRC projects) or Non Governmental organisation. A detailed description of financial requirements, according to instruments, regents, drugs, salaries, office contingencies etc should be made, phase-wise or financial year wise. Work out the financial requirements meticulously, catering to the inflation rates. Contact the various dealers and make an on -ground estimate of prices as well as availability of the equipment, reagents etc. Remember, do not simply go by guessworks or estimates made by some other workers or in the past; such an action has been a cause of major embarrasment for many workers.

## References

This is the last section. The details of writing the references have already been presented in earlier chapter on writing a research paper.

## Annexures

Annexures may be attached to clarify in greater detail, the following

(a) A particular aspect which has not been clarified adequately in the "Material and Method" section because the same would have become unnecessary voluminous.

(b) Detailed description of terms and phrases

(c) Detailed techniques of making clinical measurements

(d) Minute details of the intervention measure to be used in the proposed study

(e) The questionnaire or schedule for recording the data.

(f) Clearance certificate from ethical committee

(g) Minute details of expenses or equipment, instruments etc.

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# Critical Appraisal of a Published Article

The issue of critical appraisal of a published article in a journal is of much importance to every Doctor. As Post-Graduate students in the respective specialities, we have periodic "journal clubs" during which research articles are critically evaluated. As practising Doctors, we need to advance our knowledge constantly, by reading the various articles. Similarly, as senior level health care administrators, we have to keep abreast regarding the contemporary practices in health care administration, therapies, equipment, diagnostics and the financial implications. From the research methodologist's perspective, reading a journal needs a series of well planned sequential steps. The following is a check list proforma :-

**Step 1 : Deciding whether I should read this article**

(a) Look at the title : Is it interesting ? Likely to be useful in your practice? Yes/No.

(b) Look at the Abstract : Will the conclusions (if valid), likely to be useful to you, in your area of clinical practice or research areas? Yes / No.

(c) Quickly browse through the 'Materials and Methods' section. See if the 'settings' are similar to your own settings of practice (may be dissimilar because of different facilities, different technological availability, grossly different demographic profile of patients, or the level of medical care in which the study was done) - Yes / No

If answers to 1 (a), (b) & ( c ) are Yes for two or more question, go ahead and start reading the article. Keep giving your comments as per the following general check-list :-

**Step 2 : Assess the research question of the authors**

(a) Is there a clear cut/specific research question?

(b) Was it feasible for the authors to study this question, given their technical expertise, available facilities etc.

(c) Does the research question has some element of novelty (is likely to add to existing knowledge rather than reconfirming the already well established facts).

**Step 3 : Assess the issues of Internal / external validity and bias in the study**

(a) Have the authors made a mention (explicit or, at least, implicitly) of the :

(i) Total (Whole; Reference) Population ?

(ii) Actual (study) Population ?

(iii) Is the actual (study) population from which sample was drawn likely to be a "representative subset" of the total population (If no, then external validity/generalisability will be restricted)

(b) Have the authors :

(i) Calculated the sample size ?

(ii) Whether they have specified the parametres like Type-I (alpha), Type-II (Beta) errors, OR or RR to be detected, expected P0, or mean and SD, and acceptable deviation (as applicable to the study design), while calculating the sample size?

(iii) Are the above parametres, if specified, likely to be correct / realistic .

(c) Have the authors :

(i) Described the method of sampling ?

(ii) Is the method of sampling based on some random (probability) method ?

(d) Have the authors explicitly mentioned :

(i) The exposure variable(s) (only for an analytic design).

(ii) The outcome variable(s) (for all types of designs).

(e) Have the authors

(i) Clearly identified all the potential confounding factors (PCFs)?

(ii) Have they adequately covered for all PCFs by taking action during designing (Randomisation/ Restriction/ Matching) or during analysis (Standardisation / Stratified analysis/ Mathematical modelling) ?

(iv) What are the PCFs which have either not been considered at all, or else not controlled during design / analysis ?

(f) Have the authors clearly described the following items used by them in this study :

(i) Physical instruments and reagents ?

(ii) Questionnaire ?

(iii) Any other scales (eg, psychological assessment scale) .

(iv) Definitions of terms and criteria for various diseases etc used by them ?

(v) Techniques of using the instruments, questionnaires, scales etc ? Yes/Na/NA.

(g) Have the authors mentioned as to how they have standardized / validated :

(i) Physical instruments ?

(ii) Questionnaires ?

(iii) Any other "scales" used by them ?

(iv) Quality control procedures during the conduct of study ?

(h) Could any of the following biases have occurred in

the study ?

If yes, briefly comment as to how ?

(i) Selection bias
- Referral
- Self selection
- Berksons
- Survivorship
- Healthy worker
- Exposure related

(ii) Information Bias
- Recall / reporting
- Detection
- Observers
- Cross over
- Contamination
- Co-intervention
- Loss to follow up

**Step 4 : Analysis**

(a) Has the data been presented in a simple, intelligible form ?

(b) Are the statistical tests " correct" for the type of variables ?

(i) Have the authors worked out the measures of 'effect' (i.e., RR or OR) (as applicable to the research question ) ?

(ii) Have the authors worked out the 95% CI of the various estimates?

(iii) Have the authors correctly controlled for confounders, in analysis, and worked out the independent, adjusted estimates ( e.g., by stratified analysis)

(iv) Have the authors assessed effect modification?

**Step 5 : Conclusions**

(a) If the findings are `statistically significant', are they also of clinical/ public health significance/relevance?

(b) If the findings are `statistically non significant' is it possible that a real effect may have been missed due to "low study power" as consequence of low sample size (Have the authors back calculated the study power; alternatively calculate it yourself)?

(c) Are the conclusions drawn by the authors based on the actual findings of the study ?

(d) Do you think the study results can be gainfully utilized in your clinical / preventive practice?

**Step 6 : Additional actions for specific situations**

Check the following additional points depending on the type of study objective.

For a study assessing the efficacy of a therapeutic or preventive procedure

(a) Was allocation to the intervention and control groups done by Randomisation' ?

(b) Were the 2 groups similar on baseline comparison ?

(c) Were all the clinical/health relevant outcomes (good as well as bad) considered ?

(d) Was the therapeutic / preventive procedure tried out, described in adequate detail ?

(e) Were all the subjects who entered the study accounted for in the final analysis?

(f) What was the level of control ? Placebo control/Non placebo control/ Uncontrolled.

(g) What was the level of blinding ? Triple / Double/ Single blinding / Unblinded.

(h) Was the trial ethical ?

(j) What was the proportion of "lost to follow up"

For a study assessing the role of a risk factor / causal factors

(a) What was the strength of the design itself ?

(b) Very strong (experimental) / Reasonably strong (Cohort) / Moderately Strong (Case control, Cross sectional analytic) / Weak (Ecological)

(c) What is the strength of association (as seen by RR or OR) ?

(d) Is the association "significant" (as seen by test of significance and 95% CI of RR)

(e) Is the temporal relationship (cause or exposure definitely preceded the effect or outcome) definitely shown?

(f) Does the association stand to reasoning ?

(g) Is there a dose response relationship ?

For a study dealing with clinical course and prognostic factors.

(a) Was an 'inception cohort' assembled ?

(subjects should be identified at an early and uniform point (inception) in the course of their disease, such as when they develop unambiguous symptoms or receive their first definitive therapy)

(b) Was the "referral filter" of the subjects to the present location adequately described ?

(c) Was clinical status of all patients who entered the study accounted for in the end ?

(d) Were the prognostic outcomes clearly defined ?

(e) Was the outcome assessment done by physicians who were blinded' to the other features of patients ?

**For a study on Diagnostic tests evaluation**

(a) Was a proper `Gold Standard' of diagnosis

described and used?

(b) Was the evaluation of test results done by observers who were `blinded' to the results of Gold Standard test?

(c) Were all subjects subjected to both the gold standard as well as test under study?

(d) Did the subject sample contain an appropriate `spectrum' of the target disease?

(mild, moderate, severe, atypical, other closely related diagnoses).

(e) Were the "settings" of study adequately described?

(f) Was the "referral filter" through which subjects passed before reaching the settings of present study adequately defined?

(g) Was the reproducibility of test (the range of variations due to observers, subjects, instruments and techniques) adequately studied and defined?

(h) Were the techniques of carrying out the test under study adequately described?

(j) Was the "utility" of the test determined? Yes/No.

(ie., whether the authors went beyond the issues of validity and reliability to describe the consequences of the test - whether it really contributed to better patient management or favourably changed the disease outcome for which the test is designed).

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## Further Suggested Readings

**A. For the Beginners:**

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**B. Advanced Level**

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# Quantitative Sciences

## Biostatistics


## Authors

## Mrs Seema R Patrikar, Col RajVir Bhalwar

**Mrs. Seema R Patrikar & Col RajVir Bhalwar**

# Introduction to Biostatistics

Statistics are everywhere. Statistics is becoming increasingly more important in modern society with passing time. We are constantly being bombarded with some fact or figure, charts and graphs quoted in the media or newspaper prints. In order to realistically understand the subject of statistics it is important to appreciate the rationale behind why and how statistics is used at large. Once you collect information in your area of interest you need to carefully study the information to come to valid and rational conclusions. This is where statistics plays an important role.

*Statistics is nothing but learning from data. It guides the way we collect, organize, present and interpret data.* It helps us to weigh the evidences and draw conclusions. It should not be considered as merely pushing numbers through formulas and computers.

Statistics can be broadly split into two categories Descriptive Statistics and Inferential Statistics. Descriptive statistics deals with the meaningful presentation of data such that its characteristics can be effectively observed. It encompasses the tabular, graphical or pictorial display of data, condensation of large data into tables, preparation of summary measures to give a concise description of complex information and also to exhibit pattern that may be found in data sets. Inferential statistics however refers to decisions. Medical research doesn't stop at just describing the characteristic of disease or situation. It tries to relate and determine whether characteristics of a situation are unusual or if they have happened by chance. Because of this desire to generalize, the first step is to statistically analyse the information.

In order to begin our analysis as to why statistics is necessary we must begin by addressing the nature of science and experimentation. The characteristic method used by researcher when he/she starts his/her experiment is to study a relatively small collection of subjects, as complete population based studies are time consuming, laborious, costly and resource intensive. The researcher draws a subset of the population called as "sample" and studies this sample in depth. But the conclusions drawn after analyzing the sample is not restricted to the sample but is extrapolated to the population i.e. people in general. Thus Statistics is the mathematical method by which the uncertainty inherent in the scientific method is rigorously quantified. We have already discussed, in detail, these concepts in the Seventh Building Block (Population and Sample) and the Eighth Building Block (Random Error and Chance) in chapter 1 of the previous section on Research Methodology and it would be desirable that you have a quick revision of that chapter before proceeding with this section on biostatistics and the next section on statistical software.

**Measurement**

Before we start collection of information regarding the characteristic that we want to study in the general population a research hypothesis needs to be formulated. A problem has to be stated clearly before it can be solved. **Your research hypothesis should be specified prior to the collection of any data**. Once the hypothesis is stated with clarity, the researcher starts collecting facts and figures to prove the hypothesis. The facts and figures or the information is called as 'data'. Data can thus be defined as an organized collection of information, containing the 'values' of the various variables, obtained from a sample of subjects, and which would be subsequently used to derive conclusions through the process of scientific analysis and reasoning. The data that we collect can, broadly, be either of the "Quantitative" or of "Qualitative" type. Further quantitative data can be of 3 subtypes (Discrete numerical, continuous numerical and ordered numerical. Similarly the qualitative data can also be of 3 subtypes (Nominal dichotomous, nominal polychotomous and ordinal polychotomous). We have already given detail description of these various types in the third building block of our previous chapter on Research Methodology and in the section on Principles of Epidemiology and you should go through the same.

Mrs. Seema R Patrikar & Col RajVir Bhalwar

# Presentation of Data : From Chaos to Order

The information collected on the subjects one after the other is called as **raw data**. Raw data is often little more than jumble of numbers and hence very difficult to handle. Hence we need to find ways to make sense out of this chaos of data such that we can extract information from the data and communicate it to others. This is possible through data depiction, data summarization and data transformation. The techniques for data depiction and data display are too numerous. However, they generally fall into categories of tables, charts or graphs. The process involves moving from the "chaos" of hundreds and thousands of raw numbers to the relative order of a table or graph. We shall discuss few of the presentations which are important in describing medical data. Tables are used to categorize and summarize the data while graphs are used to provide an overall visual representation.

## Tabular presentation of data

By reducing raw data into tabular form, we can quickly learn a lot about nature of the distribution, the range of values and where the most common values lie. This representation is also called as frequency distribution table.

### Ordered array

When the data is organized in order of magnitude from the smallest value to the largest value it is called as ordered array. For example consider the ages of 11 subjects undergoing tobacco cessation programme (in years) 16, 27, 34, 41, 38, 53, 65, 52, 20, 26, 68. When we arrange these ages in increasing order of magnitude we get ordered array as follows : 16, 20, 26, 27, 34, 38, 41, 52, 53, 65, 68. After observing the ordered array we can quickly determine that the youngest person is of 16 years and oldest of 68 years. Also we can easily state that almost 55% of the subjects are below 40 years of age, and that the midway person is aged 38 years.

### Grouped Data - Frequency Table

Besides arranging the data in ordered array, grouping of data is yet another useful way of summarizing the data. We classify the data in appropriate groups which are called **"classes"**. The basic purpose behind classification or grouping is to help comparison and also to accommodate a large number of observations into a few classes only, by condensation so that similarities and dissimilarities can be easily brought out. It also highlights important features and pinpoints the most significant ones at glance.

To group a set of observations we select a set of contiguous, non overlapping intervals such that each value in the set of observations can be placed in one and only one of the intervals. These intervals are usually referred to as **class intervals.** For example 0-19, 20-29, 40-59, 60-79 and 80-99 are called class intervals. The class interval 0-19 includes the values 0, 1, 2, .....upto 19. The smallest value 0 is called its **lower class limit** whereas the highest value 19 is called its **upper class limit**. The middle value of 0-19 i.e., 9.5 is called the **midpoint or class mark**. The number of subjects falling in this range of 0-19 is called its class frequency. Such presentation of data in class intervals along with frequency is called frequency distribution. When both the limits are included in the range of values of the interval, the class interval are known as inclusive type of class intervals (e.g., 0 – 19, 20 – 39, 40-59 etc.); whereas when lower boundary is included but upper limit is excluded from the range of values, such class intervals are known as exclusive type of class intervals (e.g., 0 – 20, 20 – 40, 40 – 60 etc.). This type of class intervals is suitable for continuous variable.

### How to decide on the number of class intervals?

When data are to be grouped it is required to decide upon the number of class intervals to be made. Too few class intervals would result in losing the information. On the other hand too many class intervals would not bring out the hidden pattern. The thumb rule is that we should not have less than 5 class intervals and no more than 15 class intervals. But to be specific, Sturg has suggested a formula for number of class intervals denoted by k as follows :

$K = 1 + 3.332 \log_{10} n$ rounded to the nearest integer, where n is the number of values or observations under consideration.

For example if n=25 we have, $K = 1 + 3.332 \log_{10} 25$ i.e. approximately 5 class intervals.

Having decided the number of class intervals the next step

$$\text{Width} = \frac{\text{Maximum observed value - Minimum observed value (= Range)}}{\text{Number of class interval (k)}}$$

is to decide the width of the class interval. The width of the class interval is taken as

The class limits should be preferably rounded figures and the class intervals should be non-overlapping and must include range of the observed data. As far as possible the percentages and totals should be calculated column wise.

An advantage with frequency table is that even categorical type of variable can be presented in frequency table. For example Table 1 depicts the findings of a hypothetical research work intended to describe the pattern of blood groups among patients of essential hypertension.

Table - 1

| Blood Group | Number of patients (frequency) | Percentage |
|---|---|---|
| A | 232 | 42.81 |
| B | 201 | 37.05 |
| AB | 76 | 14.02 |
| O | 33 | 6.09 |
| Total | 542 | 100.00 |

Table - 2

| S. No | Data set 1 | | Data set 2 | | Data set 3 | | Data set 4 | |
|---|---|---|---|---|---|---|---|---|
| | X | Y | X | Y | X | Y | X | Y |
| 1 | 10.00 | 8.04 | 10.00 | 9.14 | 10.00 | 7.46 | 8.00 | 6.58 |
| 2 | 8.00 | 6.95 | 8.00 | 8.14 | 8.00 | 6.77 | 8.00 | 5.76 |
| 3 | 13.00 | 7.58 | 13.00 | 8.74 | 13.00 | 12.74 | 8.00 | 7.71 |
| 4 | 9.00 | 8.81 | 9.00 | 8.77 | 9.00 | 7.11 | 8.00 | 8.84 |
| 5 | 11.00 | 8.33 | 11.00 | 9.26 | 11.00 | 7.81 | 8.00 | 8.47 |
| 6 | 14.00 | 9.96 | 14.00 | 8.10 | 14.00 | 8.84 | 8.00 | 7.04 |
| 7 | 6.00 | 7.24 | 6.00 | 6.13 | 6.00 | 6.08 | 8.00 | 5.25 |
| 8 | 4.00 | 4.26 | 4.00 | 3.10 | 4.00 | 5.39 | 19.00 | 12.50 |
| 9 | 12.00 | 10.84 | 12.00 | 9.13 | 12.00 | 8.15 | 8.00 | 5.56 |
| 10 | 7.00 | 4.82 | 7.00 | 7.26 | 7.00 | 6.42 | 8.00 | 7.91 |
| 11 | 5.00 | 5.68 | 5.00 | 4.74 | 5.00 | 5.73 | 8.00 | 6.89 |
| **Mean** | **9.0** | **7.5** | **9.0** | **7.5** | **9.0** | **7.5** | **9.0** | **7.5** |
| **Correlation coefficient** | **0.82** | | **0.82** | | **0.82** | | **0.82** | |
| **Coefficient of determination($r^2$)** | **67%** | | **67%** | | **67%** | | **67%** | |
| **Regression Equation** | Y=0.3+(0.5)(X) | | Y=0.3+(0.5)(X) | | Y=0.3+(0.5)(X) | | Y=0.3+(0.5)(X) | |

### Graphical presentation of data

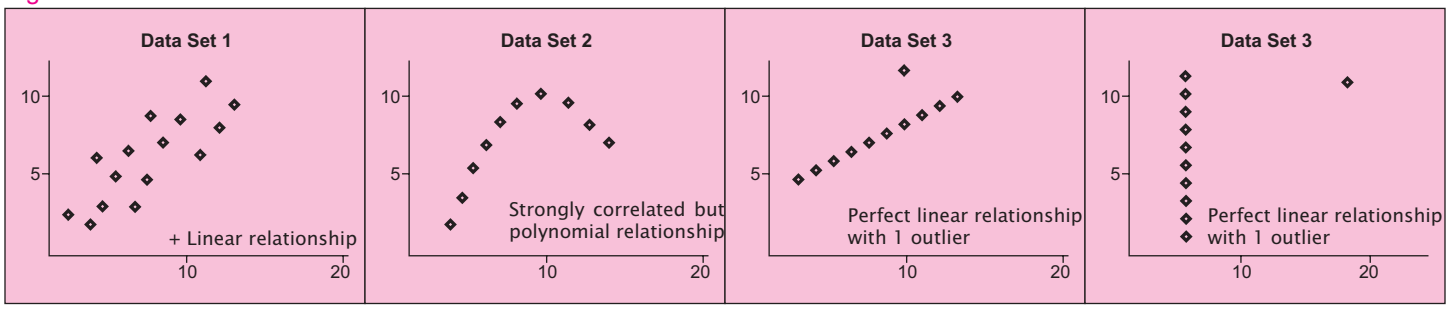
A frequency distribution discussed above shows distribution of subjects in various groups or classes. This tabular representation of the frequency distribution is useful for further analysis and conclusion. But it is difficult for a layman to understand complex distribution of data in tabular form. Graphical presentation of data is better understood and appreciated by humans. Graphical representation brings out the hidden pattern of the complex data sets. To understand the concept of graphical presentation of data let us consider an example where the data is collected on 11 subjects. (Table - 2)

Suppose we have four sets of observation on two variables X and Y. Each of the set has equal number of observations (n=11) with readings as given in Table - 2.

If you observe the data set, each of the set has 11 readings on X and Y. Certain statistical measures like means of X and Y, Correlation coefficients between X and Y along with $r^2$ and regression equation is also provided. Look carefully at the data sets and try to find out the hidden pattern existing in the data.

You will realize that it is difficult to bring out the characteristics of each of the data set or the relationship that exists in the two variables by just looking at the table. Now if we visually depict the same information in the simplest form i.e. scatter diagram representing one variable (X) on X-axis and other variable(Y) on the Y-axis.

Fig - 1



For each of the four sets we have following scatter diagram (Fig - 1).

We now appreciate that all the four data sets have very different pattern of relationship despite the fact that their summary figures (Means, Correlation coefficient, Regression equation etc.) as shown in the tabular form are the same. However, the hidden pattern in each of the data sets is revealed when they are represented by graphs. Thus the reason for displaying data graphically is two fold:

(a) so that as investigators we can have a better look at the information collected and the distribution of data

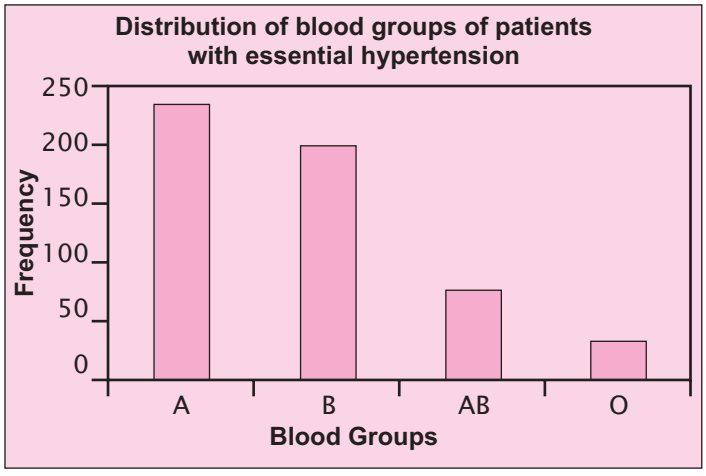
(b) to communicate this information to others quickly

We shall discuss in detail some of the commonly used graphical presentations.

Bar Charts

Bar charts are used for qualitative type of variable in which the variable studied is plotted in the form of bar along the X-axis (horizontal) and the height of the bar is equal to the percentage or frequencies which are plotted along the Y-axis (vertical). The width of the bars is kept constant for all the categories and the space between the bars also remains constant throughout. The number of subjects along with percentages in bracket may be written on the top of each bar. When we draw bar charts with only one variable or a single group it is called as simple bar chart (Fig - 2) and when two variables or two groups are considered it is called as multiple bar chart. In multiple bar chart the two bars representing two variables are drawn adjacent to each other. Equal width of the bars is maintained. Third type of bar chart is the component bar chart wherein we have two qualitative variables which are further segregated into different categories or components. In this the total height of the bar corresponding to one variable is further sub-divided into different components or categories of the other variable.

Fig - 2




A simple bar chart in respect of the data (Table - 1) on blood groups among patients of essential hypertension is represented in Fig - 2.

Pie Chart

Another interesting method of displaying categorical (qualitative) data is a pie diagram. A pie diagram is essentially a circle in which the angle at the center is equal to its proportion multiplied by 360 (or, more easily, its percentage multiplied by 360 and divided by 100). A pie diagram is best when the total categories are between 2 to 6. If there are more than 6 categories, try and reduce them by "clubbing", otherwise the diagram becomes too overcrowded.

A pie diagram in respect of the data on blood groups among patients of essential hypertension (Table - 1) is presented in Fig-3 after calculating the angles for the individual categories as follows

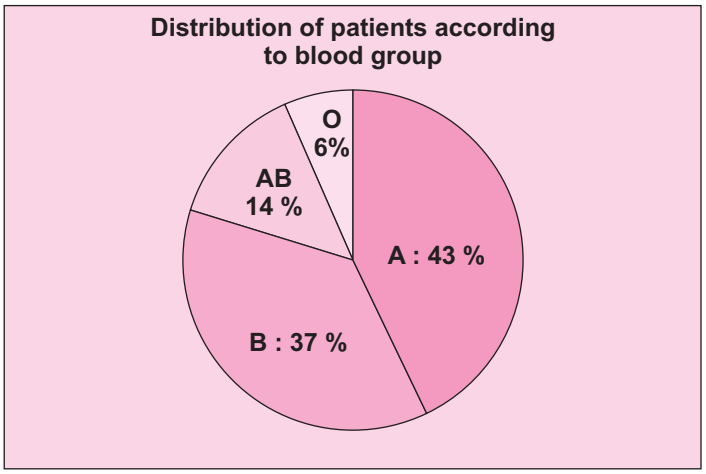
Blood group A = $\frac{42.81}{100}$ X 360 = 154 degrees

Blood group B = $\frac{37.08}{100}$ X 360 = 134 degrees

Blood group AB = $\frac{14.02}{100}$ X 360 = 50 degrees

Blood group O = $\frac{6.09}{100}$ X 360 = 22 degrees

Fig - 3



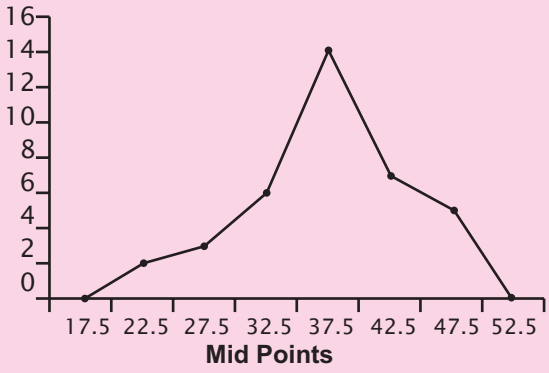

Frequency Curve and Polygon

To construct a frequency curve and frequency polygon we plot the variable along the X-axis and the frequencies along the Y-axis. Observed values of the variable or the midpoints of the class intervals are plotted along with the corresponding frequency of that class interval. Then we construct a smooth freehand curve passing through these points. Such a curve is known as frequency curve. If instead of joining the midpoints by smooth curve if we join the consecutive points by a straight line then it is called as frequency polygon (Fig.-4). Conventionally, we consider imaginary one value immediately preceding the first value

Table - 3

| Age | Number of subjects | Midpoints |
|---|---|---|
| 20-25 | 2 | 22.5 |
| 25-30 | 3 | 27.5 |
| 30-35 | 6 | 32.5 |
| 35-40 | 14 | 37.5 |
| 40-45 | 7 | 42.5 |
| 45-50 | 5 | 47.5 |

Fig - 4




Note that the imaginary frequency of the immediately preceding class interval (15 to 20, mid pt 17.5) and immediately succeeding ( i.e., 50 – 55, mid pt 52.5) has been plotted as zero.

and one succeeding the last value and plot them with frequency = 0 )Table - 3.

Stem-and-leaf plots

This presentation is used for quantitative type of data. To construct a stem-and-leaf plot, we divide each value into a stem component and leaf component. The digits in the tens-place becomes stem component and the digits in units-place becomes leaf components. It is of much utility in quickly assessing whether the data is following a "normal" distribution or not, by seeing whether the stem and leaf is showing a bell shape or not. For example consider a sample of 10 values of age in years:

21, 42, 05, 11, 30, 50, 28, 27, 24, 52. Here, 21 has a stem component of 2 and leaf component of 1. Similarly the second value 42 has a stem component of 4 and leaf component of 2 and so on. The stem values are listed in numerical order (ascending or descending) to form a vertical axis. A vertical line is drawn to outline a stem. If the stem value already exists then the leaf is placed on the right side of vertical line.

0 |
1 |
2 |
3 |
4 |
5

The value of each of the leaf is plotted in its appropriate location on the other side of vertical line as follows.

0 | 5
1 | 1
2 | 1 4 7 8
3 | 0
4 | 2
5 | 0 2

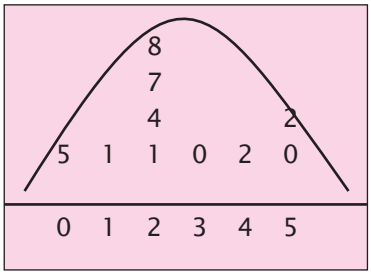
To describe the central location, spread and shape of the stem plot we rotate the stem plot by 90 degrees just to explain it more clearly

8 → Rough estimate of the center or
7 middle observation i.e., median value (27.5)

4 2
5 1 1 0 2 0
0 1 2 3 4 5 → Spread of the data

Roughly we can say that the spread of data is from 5 to 52 and the median value is between 27 and 28. Regarding the shape of the distribution, though it will be difficult to make firm statements about shape when n is small, we can always determine:

(a) Whether data are more or less symmetrical or are extremely skewed
(b) Whether there is a central cluster or mound
(c) Whether there are any outliers




For the given example we notice the mound (heap) in the middle of the distribution. There are no outliers

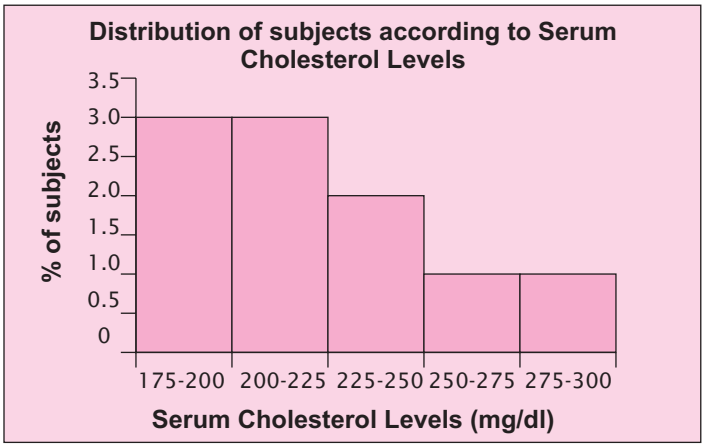
Histogram

The stem-and-leaf is a good way to explore distributions. A more traditional approach is to use histogram (Fig - 5). A histogram is used for quantitative continuous type of data where, on the X-axis, we plot the quantitative exclusive type of class intervals. On the Y-axis we plot the frequencies. The difference between bar charts and histogram is that since histogram is the best representation for quantitative data measured on continuous scale, there are no gaps between the bars. Consider an example of the data on serum cholesterol of 10 subjects ( Table - 4)

Table - 4

| Serum cholesterol (mg/dl) (mg / dl) | No. of subjects | % |
|---|---|---|
| 175 - 200 | 3 | 30% |
| 200 - 225 | 3 | 30% |
| 225 - 250 | 2 | 20% |
| 250 - 275 | 1 | 10% |
| 275 - 300 | 1 | 10% |
| Total | 10 | 100% |

Fig - 5




The Guassian Distribution or Normal Curve

If we draw a smooth curve passing through the mid points of the bars of histogram and if the curve is bell shaped curve then the data is said to be roughly following a normal distribution (Fig - 6). Many different types of data distributions are encountered in medicine. The **Gaussian or "normal"** distribution is among the most important. Its importance stems from the fact that the characteristics of this theoretical distribution underline many aspects of both descriptive and inferential statistics. The normal distribution is defined by following characteristics:

(a) It is a bell shaped symmetric (about the mean) curve.

(b) The mean, median and mode are all co-incident or equal to one another.

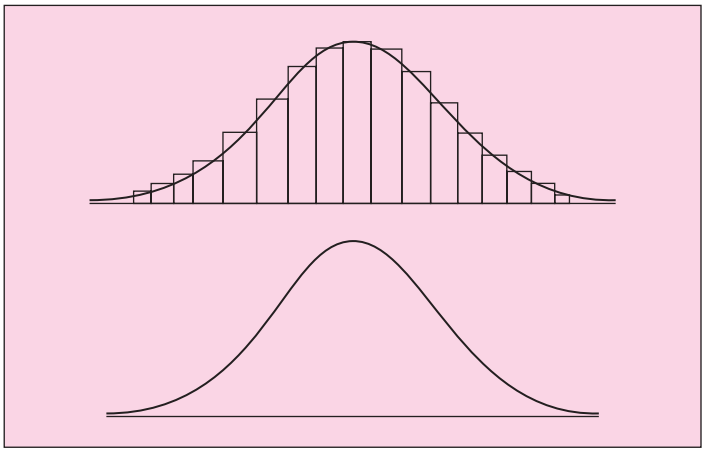
(c) The total area under the curve is equal to 1

(d) It follows the 68-95-99% rule i.e. the distribution is shaped such that 68% of the values fall between ± 1 standard deviation (SD) from the mean, 95% of the values lie within ± 2 SD from mean and 99% lie within ± 3 SD from mean.

If these criteria are not met then the distribution is not a Gaussian or normal distribution.

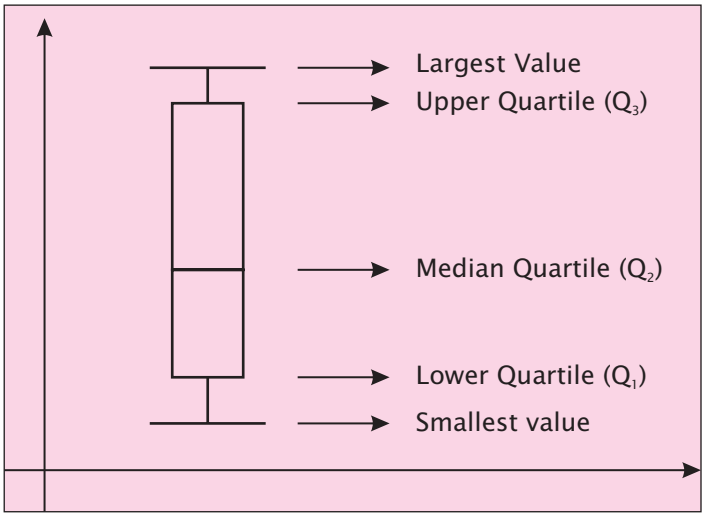
**Box-and-Whisker plot**

Fig - 6



A box-and-whisker plot reveals maximum of the information to the audience. A box-and-whisker plot can be useful for handling many data values. They allow people to explore data and to draw informal conclusions when two or more variables are present. It shows only certain statistics rather than all the data. Five-number summary is another name for the visual representations of the box-and-whisker plot (Fig - 7). The five-number summary consists of the median, the quartiles (lower quartile and upper quartile), and the smallest and greatest values in the distribution. Immediate visuals of a box-and-whisker plot are the center, the spread, and the overall range of distribution.

Fig - 7




Line chart

Line chart is used for quantitative data. It is an excellent method of displaying the changes that occur in disease frequency over time. It thus helps in assessing "temporal trends" and helps displaying data on epidemics or localised outbreaks in the form of epidemic curve. In a line diagram, the rate of disease are plotted along the vertical (y) axis. However, in localised outbreaks, with a well

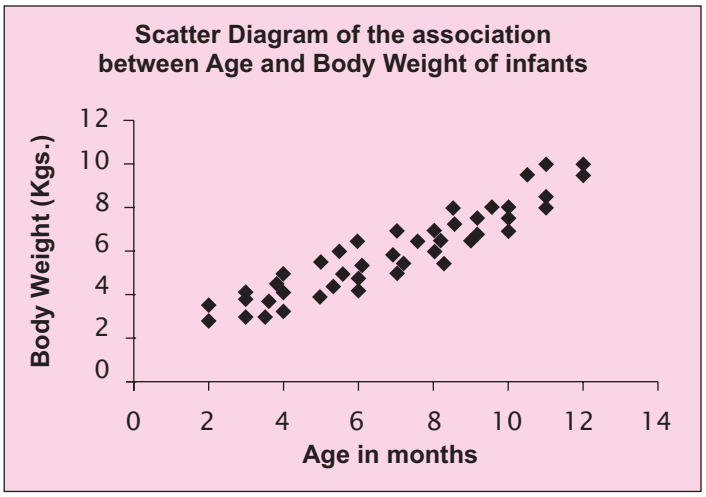
demarcated population that has been at risk (as sudden outbreaks of food poisoning) the actual numbers can be plotted on Y-axis, during quick investigations. The unit of time, as applicable to the disease in question, is plotted along the "X"-axis (horizontal). This unit of time would be hours-time in food poisoning, days (i.e, as per dates of the month) for cholera, weeks for typhoid, malaria or Hepatitis-A, months for Hepatitis-B and in years (or even decades) for IHD or Lung Cancer.

### Scatter Diagram

A scatter diagram gives a quick visual display of the association between two variables, both of which are measured on numerical continuous or numerical discrete scale. An example of scatter plot between age (in months) and body weight (in kg) of infants is given below. (Fig - 8)

The scatter diagram in fig - 8 shows instant finding that weight and age are associated - as age increases, weight increases. Be careful to record the dependent variable along the vertical (Y) axis and the independent variable along the horizontal (X) axis. In this example weight is dependent on age (as age increases weight is likely to increase) but age is not dependent on weight (if weight increases, age will not necessarily increase). Thus, weight is the dependent variable, and has been plotted on Y axis while age is the independent variable, plotted along X axis.

Fig - 8



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# Data Summarization

Compiling and presenting the data in tabular or graphical form will not give complete information of the data collected. The way the disease is described by certain characteristics, the data set is described by summary measures. Summary measures provide description of data in terms of concentration of data and variability existing in data. Thus data is described by two summary measures namely, measure of central tendency and measure of variability.

### Measures of Central Tendency

This gives the centrality measure of the data set i.e. where the observations are concentrating. There are several measures of central tendency.

(a) Mean (average)

Mean is most appropriate measure for data following normal distribution but not for skewed distributions. It is summing all the observations and then dividing by number of observations. It is the simplest of the centrality measure but is influenced by extreme values. When the data is skewed, another measure of central tendency called median is used.

(b) Median

Median is a locative measure which is the middlemost observation after all the values are arranged in ascending or descending order. The mean and median are the most commonly used measures of central tendency, while the third measure mode is used rarely.

(c) Mode

Mode is the most common value that repeats itself in the data set. Mode is used more often as a descriptive term.

### Measures of Variability

In contrast to measures of central tendency which describes the center of the data set, measures of variability describes the variability or spreadness of the observation from the center of the data. One of the simplest measures of variability is range.

**Range** is the difference between the two extremes i.e. the difference between the maximum and minimum observation. One of the drawbacks of range is that it uses only extreme observations and ignores the rest. A better measure than range is mean deviation.

**Mean deviation** is the mean of the difference from a constant 'A' which can be taken as mean, median, mode or any constant observation from the data. The formula for mean deviation is given as follows:

$$\text{Mean deviation} = \frac{\sum |x_i - A|}{n}$$

where

A may be mean, median, mode or a constant

$x_i$ = the value of individual observations

n = the total number of observations

$\Sigma$ = a sign indicating "sum up".

The main drawback of this measure is that it ignores the algebraic signs and hence to overcome this drawback we have another measure of variability called as Variance.

**Variance** is the average of the squared deviations of each of the individual value from the mean ( ). It is mathematically given as follows:

$\bar{x}$

Most often we use the square root of the variance called

$$\text{Variance} = \frac{\sum (x_i - \bar{x})^2}{n}$$

**Standard Deviation** to describe the data as it is devoid of any errors. Variance squares the units and hence standard deviation by taking square root brings the measure back in the same units as original and hence is best measure of variability. It is given as follows:

The larger the standard deviation the larger is the spread

$$\text{Standard Deviation (SD)} = \sqrt{\frac{\sum (x_i - \bar{x})^2}{n}}$$

of the distribution.

Note: When n is less than 30, the denominator in variance and standard deviation formula changes to (n-1).

Besides these measures of variability, we have one more important measure called the **coefficient of variation**

**Coefficient of variation** compares the variability in two data sets. It measures the variability relative to the mean and is calculated as follows:

Any information that is collected by the researcher needs

$$\text{Coefficient of Variability (CV)} = \frac{SD}{Mean} x100$$

to be described by measure of central tendency and measure of variability. Both the measures together describe the data. Measure of central tendency alone will not give any idea about the data set without measure of variability. Descriptive Statistics is critical because it often suggests possible hypothesis for future investigation.

The calculation of mean and standard deviation differ slightly for grouped data. We will consider a hypothetical example to get more familiarized with mean and standard deviation calculations for grouped data. Given in Table - 5 is the weight distribution (in kgs) of 40 faculty members of a department. The data is grouped as below

Table - 5

| Weight ( in kgs) | No. of faculty members |
|---|---|
| 50-55 | 5 |
| 55-60 | 9 |
| 60-65 | 13 |
| 65-70 | 10 |
| 70-75 | 3 |

Since this is a grouped data we cannot use simple mean formula (i.e. $\bar{x} = \frac{\sum x_i}{n}$) .
But, we use the modified formula given as

$$\bar{x} = \frac{\sum f_i x_i}{\sum f_i}$$

where

$f_i$ is the frequency of the class interval

$x_i$ is the midpoint of class interval.

$\sum f_i$ = N (total number of observations)

For the above example we make columns for mid points (class mark) of the class interval and then calculate the mean value.

Table - 6

| Weight (in kgs) | Mid points Class mark($x_i$) | No. of faculty members ($f_i$) | $f_i x_i$ |
|---|---|---|---|
| (a) | (b) | (c) | (b) X (c) |
| 50-55 | 52.5 | 5 | 262.5 |
| 55-60 | 57.5 | 9 | 517.5 |
| 60-65 | 62.5 | 13 | 812.5 |
| 65-70 | 67.5 | 10 | 675 |
| 70-75 | 72.5 | 3 | 217.5 |
| Total | | 40 | 2485 |

Thus, $\bar{x} = \frac{2485}{40} = 62.125$

The standard deviation for the same set of data is calculated by

$$SD = \sqrt{\frac{\sum f_i (x_i - \bar{x})^2}{\sum f_i}}$$

$$SD = \sqrt{\frac{5(52.5 - 62.125)^2 + 9(57.5 - 62.125)^2 + ..... \\ ... + 3(72.5 - 62.125)^2}{40}} = 5.63$$

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## Inferential Statistics : From Sample to Population

The second broad category for which statistics is used is Statistical Inference. As we have already said that research most often is conducted using samples of individuals from larger populations. It is impractical if not impossible to study all people, so we select a sample of people for study. We collect data on these subjects, draw conclusions from the data and make inferences to the larger population. Of course, if we did not measure the whole population, there will always be some error in our conclusions regarding the estimates of the population which we call as "error". The concept is best understood by an example of a court decision in a crime case. When a case is presented before a court of law by the prosecution, the judge has to start with the presumption of innocence. The prosecution has to present adequate evidence against the innocence of the person tried. If the evidence is not sufficient the person is acquitted, whether the crime was actually committed or not. Thus, the permutation and combination between the exact reality (or, truth) and our verdict (decision) can be presented in Table - 7.

Table - 7

| Our judgment about Mr. X (based on evidence produced before us) | The reality about Mr.X | |
|---|---|---|
| | Is not guilty | Is guilty |
| Found guilty Reject $H_0$ | Type I error Wrong decision | Correct decision |
| Found not guilty Accept $H_0$ | Correct decision | Type II error Wrong |

When we do medical research, we take a sample of people, representative of the study we wish to do. For example we may wish to study the effect of new drug in reducing cholesterol levels. Any results we get from our research are only estimates of the true effect that medication will have in the population. The participants are called as sample. Since we know our results are just estimates, we may be wrong in giving our conclusions. Statistically these are called as errors. The research question is formally converted into a formal scientific hypothesis, which has two parts : the **null hypothesis** (denoted by $H_0$) and the **alternative hypothesis** (denoted by $H_1$). In case of statistical decision making the assumption initially made unbiasedly is that the new medication is not effective in reducing cholesterol levels which is equivalent to the presumption of innocence in the judicial setting. In the settings where two treatments (new drug and placebo) are administered to two different samples the null hypothesis would be that there is no difference between cholesterol levels in the two groups i.e. "Persons treated with new drug will have same cholesterol levels as persons not treated with new drug". If this null hypothesis gets rejected then the hypothesis that gets accepted is called as alternate hypothesis. Thus the alternative hypothesis is the assertion accepted when null hypothesis is rejected.

The alternate hypothesis would be phrased as, "Persons treated with new drug have different (higher or lower) cholesterol levels than persons not treated with new drug". This alternative hypothesis is called as a **two-tailed** hypothesis. If the alternative hypothesis would have been stated as "Persons treated with new drug have lower cholesterol levels than the persons not treated with new drug", then such an alternate hypothesis, which considers only one direction or effect (either lower or else higher), is called as **one-tailed** alternative hypothesis.

To prove the hypothesis stated by the researcher, he starts accumulating data from the selected sample. The values observed in the sample serve as evidence against Ho. The error of rejecting the true null hypothesis is equivalent to punishing an innocent person. This is serious type of error and is called as **Type I error**, denoted by $\alpha$ and referred to as p-value. Thus p-value is probability that a true null hypothesis is wrongly rejected. The maximum p-value allowed in a research problem is called the level of significance or $\alpha$-level. The type I error is the probability that we reject the hypothesis that there is no difference between the cholesterol levels in the two groups (i.e., we conclude that there is a difference), when actually there is no difference. In other words these are false positive trials; it is like when there is no difference we conclude that there is difference. (An innocent person is hanged). Being serious, this error is kept at a very low level, mostly 5% or 0.05.

There may be other type of error in taking decision called as **Type II error** which is the probability that we accept a false null hypothesis. In other words this is equivalent to letting a culprit go free. This error is denoted by $\beta$. In medical research this is equivalent to false negative trials i.e., though there is significant difference between the drugs we conclude that there is no difference and declare the new drug as ineffective. This error is not as serious as type I error. If today we are not able to prove that the new drug is effective someone else would prove it in some other trial tomorrow. The effect of type-II error is that it may delay the introduction of the new drug, though effective, in the market but not deny it. Type-I error is pre-decided before the research is undertaken. Depending on type-I error and the alternative hypothesis the type-II error is calculated. Type-II error can occur when our sample size is too small to detect the difference that really exists between those treated and those not treated. This brings us to the concept of power.

Power

The complimentary of Type II error is called power (Power = 1 - $\beta$). Thus the power of a test is the probability of correctly rejecting Ho when it is false. In other words power means that we readily detect true difference when it exists. Power of a test is high if it is able to detect a small difference and thus reject $H_0$. You will get more power with a larger sample size.

P - value

P-value is calculated under the assumption that the null hypothesis is correct. R. A. Fisher first proposed the P-

value in the 1920s. Fisher proposed this as an informal index to be used as a measure of discrepancy between the data and the null hypothesis. It is the probability of the test statistic (a function of sample values) as extreme as or more than one actually calculated. Since it is a probability it lies between 0 and 1, (or, from 0% to 100%). If it is 0% it implies that the chances of our having gone wrong from our study sample are absolutely nil and on the other hand, if it is 100% it means that we are absolutely wrong in our conclusions. But how small should we consider the p-value is a difficult question to answer. The answer to this question will vary from one situation to the next, and will depend on many factors. If adopting a new drug would be very expensive, or expose patients to severe side effects, as compared to the already available cheap and low toxicity drugs, then one might demand a very high standard of evidence (that is very small p-value). On the other hand, the shortcoming to adopting the new treatment may be quite low, and may offer advantages over an existing treatment, in which case we may agree to even higher p-value for taking the decision. This could be the situation when we are trying out a vaccine against HIV infection against "no vaccine" against this frightening and potentially fatal condition. Thus what we need therefore is a rule to help us decide if a result is likely due to chance alone, meaning it is not statistically significant, or if it is unlikely due to chance alone, meaning it is statistically significant.

Statistically significant = unlikely due to chance alone

Not statistically significant = likely due to chance alone

To make a decision, you need a point such that any P-value larger than that point will lead to one conclusion and a P-value smaller than that point will lead to the opposite conclusion. That point is most often set at 0.05 and is called as alpha or Type I error.

When alpha is =0.05, a P-value of 0.10, for example, indicates the result of the study are not statistically significant and the conclusion will be that chance is a likely explanation for the observed results. The conclusion will be that the observed results are unlikely to represent real treatment differences.

When alpha is =0.05, a P-value of 0.03, for example, indicates the result of the study are statistically significant and the conclusion will be that chance is an unlikely explanation for the observed results. The conclusion will be that the observed results are likely to represent real treatment differences. Table 8 provides a reasonable interpretation of P-values.

This interpretation is widely accepted, and many scientific journals routinely publish using such an interpretation for the result of test of hypothesis. However, our readers need to be cautioned at this point. Random error or chance which is estimated by p-value is just one type of error that can occur in research. One needs to be more cautious about the other 3 types of errors in research, i.e., error of basic measurement, systematic error (Bias) and Confounding error, all of which have been discussed in detail in the previous section on Research Methodology. Even the most highly significant p-value is of no avail if the data has flaws of measurement error, systematic error or confounding.

Table - 8

| P- value | Interpretation |
|---|---|
| P<0.01 | Very strong evidence against null hypothesis ($H_0$) |
| 0.01 to 0.05 | Moderate evidence against null to hypothesis |
| 0.05 to 0.10 | Suggestive evidence against null hypothesis |

Confidence Level

Most of the research results rely on the premise that what is true for the randomly selected sample from the population will be true for the population from which the sample is selected. The reliability of the results obtained is addressed by Confidence Intervals (CIs). A CI is the range of values that encompass the actual or true population value. They provide information about how precise the estimate is. Wider CIs indicate lesser precision and narrower CIs indicate greater precision. Also P-value and CIs are related to each other. When P-value is less than 5%, the 95% confidence interval will exclude the hypothesized null value. Hence confidence intervals can also tell you whether null hypothesis is rejected or not.

In order to understand the concept of confidence intervals we must understand the concepts expressed in the central limit theorem (CLT). Let us use the example of height of a population of AFMC students. (In reality the population itself is a sample of students). The students in AFMC who graduated in 2006 were asked to draw a random sample of size 5 and another random sample of size 10 each and calculate the mean height of each sample. We then plotted the mean heights from all the students' samples. This plot of mean heights from all the samples is called as "sampling distribution"-because it is the distribution of a statistic (mean) from series of samples. The CLT states that if we take many random samples from a population and then calculate means from each sample and plot the means, then the plot will follow a normal curve. The mean of the sample means is equal to the population mean and the standard deviation of the sampling distribution is dependent on standard deviation and sample size. The standard deviation of the sampling distribution has a special name called as "standard error of mean" (SEM). Since the sampling distribution of mean follows a normal curve, 95% of all AFMC medical students sample means would be expected to fall within 2 SE of true population mean. It implies that the true population mean must therefore fall within 2 SE away from true mean. This information is used to calculate the confidence interval.

The confidence interval is interpreted by imagining many samples being drawn and many means being calculated. 95% Confidence Interval is that these confidence intervals calculated will have the true population parameter included in the range. In reality we do the study only once, we don't repeat the experiment, but by virtue of CLT we state that despite the random error inherent in our sample, we would expect to be about 2 SE from the true answer in 95% of research studies that we conduct.

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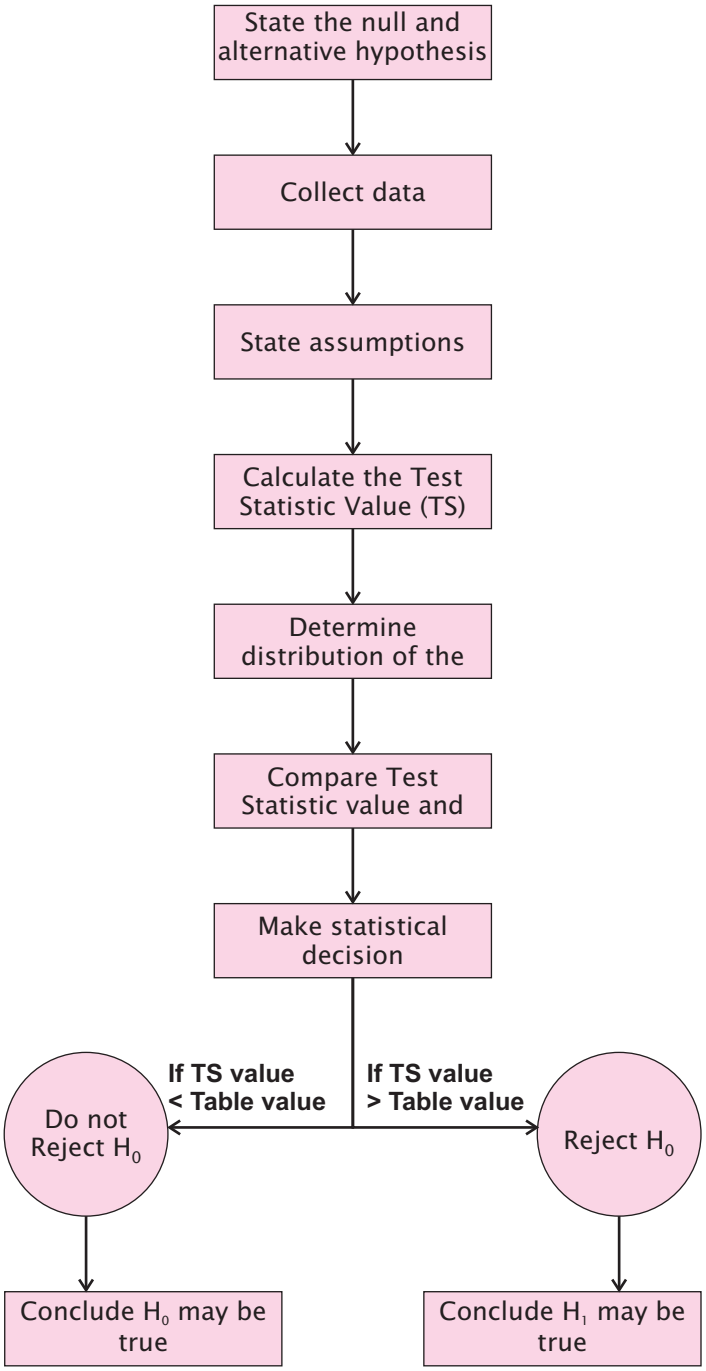
## Statistical Procedures for Hypothesis Testing

'P' values are generated by a formal process called hypothesis testing. Before directly jumping to any conclusions from the sample one should always ask oneself as to what could be the explanations for the findings. Are the findings just due to chance alone or otherwise? The whole of the theory of statistical analysis tries to determine the role of chance as an explanation for our observed findings. This quantification is done by calculating a P-value. Hypothesis testing aids the clinician and researcher in reaching a conclusion concerning a population by examining a sample from that population. At this point the difference between a statistically significant result and a clinically significant result must be thoroughly understood. Statistical decision should not be interpreted as definitive but it has to balance with the clinical and medical significance. Clinical significance relates to the magnitude of the observed effect while statistical significance answers the question of whether or not the results are due to chance alone or otherwise. The hypothesis testing procedure follows certain steps which are as listed in the flow chart (Fig - 9). In this chapter we will explain in detail, the methods of statistical hypothesis testing in the most common situations. Inferences from single mean and proportion, difference between two means (paired and unpaired t test) and differences between two proportions. We will also deal with chi square test. For the remaining situations, we will give a guide as to which test should be used in a given situation and later, in the subsequent chapter on common statistical software (EPI - 2002). We shall demonstrate as to how all these test can be done on computer using EPI 2002 software.

Fig - 9 : Steps in Hypothesis testing




### Hypothesis Testing: A Single Population Mean

Here we consider two situations about a population mean ($\mu$)

(1) When sampling is from normally distributed population and population variance is known. (Population may not be normally distributed but if sample size $\geq$ 30, replace population variance by sample variance)

(2) When sampling is from normally distributed population but with unknown population variance.

#### Situation 1

When sampling is from **normally distributed population** and **population variance is known.** (Population may not be normally distributed but sample size $\geq$ 30, replace population variance by sample variance)

In the first situation the distribution of the test statistic under null hypothesis follows a standard normal distribution. The test statistic value which is a function of null hypothesis and the sampling distribution of the sample mean

$$z = \frac{\bar{x} - \mu_0}{\sigma / \sqrt{n}}$$

.....(Equation 1)

If the sample on which we base our hypothesis test about population mean comes from a population that is not normally distributed but if we have large sample drawn (n≥ 30) then by virtue of central limit theorem we use the test statistic value as

$$z = \frac{\bar{x} - \mu_0}{s/\sqrt{n}}$$

where $s$ is sample standard deviation ..... (2)

which under null hypothesis follows standard normal distribution.

Let us consider a hypothetical example. Researchers claim that the mean age of population having a certain disease 'A' is 35 years. To prove their claim, a researcher collected information from a random sample of 20 individuals drawn from population of interest. Population variance is known and is equal to $\sigma^2 = 25$ with mean age of 20 individuals as 29.

Hypotheses

Null hypothesis is that the mean age of the population is equal to 35. The alternative hypothesis is that the mean age of the population is not equal to 35.

$H_0 : \mu = 35$ against $H_1 : \mu \neq 35$

Data

From the sample the mean age was computed as $\bar{x} = 29$.

Assumptions

It is assumed that the parent population from which the sample is drawn follows a normal distribution. We also assume that $\alpha = 5\%$ and population variance is known and is equal to

$\sigma^2 = 25$

Test Statistic

Since we assume that population is normally distributed and since population variance is known, our statistic will be given by equation (1). Thus

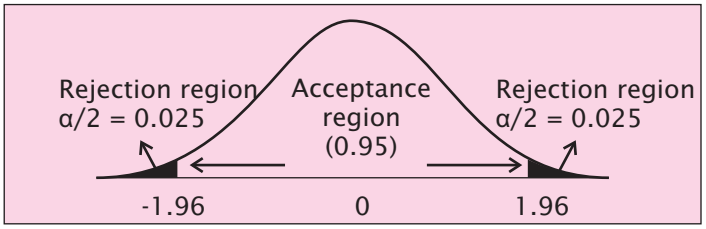
$$z = \frac{\bar{x} - \mu_0}{\sigma/\sqrt{n}} = \frac{29 - 35}{5/\sqrt{20}} = -5.36$$

Distribution of test statistic

The test statistic if $H_0$ is true follows standard normal distribution with mean of 0 and variance of 1.

Decision Rule

The statistical decision is taken by comparing the calculated test statistic value with the table value of standard normal curve against predecided value of $\alpha$ and type of the alternative hypothesis. If the alternative hypothesis is two tailed then $\alpha$ is divided in the two tails of the standard normal curve into equal parts of $\alpha/2$ each.




These areas are called as rejection areas. The decision of rejecting the null hypothesis is taken if the calculated value of absolute test statistic falls in this area i.e. rejects $H_0$ if calculated value of absolute test statistic is = $Z_{1-\alpha/2}$ or = $Z_{\alpha/2}$

From the standard normal table for $\alpha = 0.05$ two tailed the table value is 1.96. Whereas for one tailed alternative hypothesis, $\alpha = 0.05$, $\mu < \mu_o$ type the table value is -1.64 and for $\mu > \mu_o$ type the table value is 1.64. So we may reject $H_0$ if calculated value of the test statistic is ≥1.96 or ≤-1.96 otherwise we do not reject $H_0$. In the given situation we take the statistical decision to reject the null hypothesis since absolute value of test statistic (5.36) is greater than the table value (1.96) Tables are provided at the end of section.

Conclusion

We conclude that the mean age of the population with a specific disease 'A' is not equal to 35 years ($p<0.05$).

**Situation 2**

When sampling is from **normally distributed population** but with **unknown population variance**.

In practice we rarely know the population variance. Quite often we face the situations where the sample size is less than 30 and population variance $\sigma^2$ is not known. In such cases we calculate the sample standard deviation (s) and use this as an estimate of $\sigma$. This adds another element of uncertainty to our inference. Z statistics do not consider this additional uncertainty. Therefore, we use a modification of z procedures based on **Student's** t **distribution**. Student's 't' distribution was discovered by William Gosset who was working for Guinness brewing company. He was not allowed to publish scientific research, so he used the pseudonym "Student" to publish his work. t distributions are similar to z distribution, but have broader tails and less peaked at the center. As 'n' increases, t distribution approaches normal distribution. t tables are set up different than z tables. Each row is for a particular degrees of freedom. Columns show cumulative probabilities.(Tables are provided at the end of the section)

$$t = \frac{\bar{x} - \mu_0}{s/\sqrt{n}}$$

When sampling is from normally distributed population but unknown population variance the test statistic for testing

$H_0 : \mu = \mu_0$ is given as

.....(3)

which under $H_0$ follows Student's t test with (n-1) degrees of freedom (dfs).

Consider a hypothetical situation. Suppose the researcher wants to know as to what extent the diabetics are over weight. He collects information on the body weight in terms of % of ideal body weight in 18 diabetics.

Hypotheses

We convert the claim to null hypothesis. Null hypothesis is that "Diabetics are not overweight". (Not overweight = 100% of ideal body weight). Therefore,

**$H_0$: μ = 100** and alternative hypothesis can be **$H_1$: μ ≠ 100 (two-sided)**

Data

{107, 119, 99, 114, 120, 104, 88, 114, 124, 116, 101, 121, 152, 100, 125, 114, 95, 117}

We calculate sample mean $\bar{x}$= 112.78 and sample standard deviation (s) = 14.424

Assumptions

It is assumed that the parent population from which the sample is drawn follows approximate normal distribution.

We also assume that α = 5% and population variance is unknown.

$$t = \frac{\bar{x} - \mu_0}{s/\sqrt{n}} = \frac{112.78 - 100}{14.424/\sqrt{18}} = 3.76$$

Test Statistic

Since the population variance is unknown and n<30 the test statistic is given by equation (3). Thus substituting the values we get the calculated test statistic value as

Distribution of test statistic

The test statistic if $H_0$ is true follows student's t distribution with (n-1) dfs.

$t_{n-1,1-\alpha/2} = t_{18-1,1-.05/2} = t_{17,.975} = 2.11$ (t table)

Decision Rule

The statistical decision is taken by comparing the calculated test statistic value with the table value of student's 't' distribution. Since our calculated 't' value is more than table value at that particular df (17) and at that particular "two-tailed level of significance" (0.975), we reject the null hypothesis at 5% level of significance.

Conclusion

We have significant evidence against $H_0$. Hence we conclude that diabetics are not having the same weight as normals. (p<0.05)

Consider another situation. We know from our background knowledge that the mean fasting blood sugar level of non pregnant young adult women is 88 mg/dl. With this background, we conducted a study on a sample of 100 ladies in 2nd / 3rd trimester of pregnancy, attending the obstetric department. We found that the mean fasting blood sugar of this sample of 100 ladies was 102 mg/dl with a standard deviation (SD) of 14. Apparently, our sample shows that the fasting blood sugar, on an average is higher by (102-88) = 14 mg/dl among pregnant ladies, as compared to non pregnant ladies. We now want to see, statistically, whether this is a significant finding or simply a matter of chance, i.e, simply due to random (sample to sample) variations. To summarize, this is a situation in which we are studying only one sample and trying to compare the mean from this

$$t = \frac{\bar{x} - \mu_0}{s/\sqrt{n}} = \frac{102 - 88}{14/\sqrt{100}} = 10$$

sample with a known population mean. This is the "single population mean" (or, one sample) situation. The statistical procedure is followed as mentioned above. The test statistic is

The `t' value so calculated is compared with the `t' table value at degrees of freedom = (n-1)

df = (n - 1) = (100 - 1) = 99.

On looking at the `t' table we find that the `t' table value at 0.05 level corresponding to df = 99 is approximately 1.98 and at 0.01 level it is 2.62. Since our calculated `t' value (10) is much higher than this value we say that our results are highly significant (p < 0.01); the higher average fasting blood sugar that we have seen among our sample of pregnant ladies is not likely to have come up simply because of "chance" (the probability of its having occurred simply by chance, i.e., random error is less than 1 in 100). We finally conclude, clinically, that pregnancy definitely leads to a rise in fasting blood sugar level.

## Hypothesis Testing: The Difference Between Two Population Means

One of the commonest situations that a medical researcher faces while testing his/her hypothesis is when his/her interest is to see whether the two samples that he/she has drawn, differ significantly from each other as regards the "mean" of a particular variable of interest. Apparently, the above situation will be possible when we have recorded the data, in respect of that variable, on a "numerical discrete", or on a "numerical continuous" scale. At this point, it would be worth emphasizing that in case the data has been recorded on a "numerical ordinal" scale (eg, dyspnoea scores, cancer grades etc.), we would NOT do testing for difference between "means". This is for the simple reason, that though these figures (eg, dyspnoea score 1, 2, 3 etc.) obviously look like mathematical figures, they are not "mathematically meaningful" numbers. In such cases, we should use non-parametric tests for the differences between "medians". In testing the

hypothesis whether the means of the two populations differ significantly or not we have one of the following hypotheses formulated for our research:

1. $H_0$: $\mu_1 = \mu_2$ against $H_1$: $\mu_1 \neq \mu_2$ which is equivalent to saying
   $H_0$: $\mu_1 - \mu_2 = 0$ against $H_1$: $\mu_1 - \mu_2 \neq 0$
2. $H_0$: $\mu_1 - \mu_2 \geq 0$ against $H_1$: $\mu_1 - \mu_2 < 0$
3. $H_0$: $\mu_1 - \mu_2 \leq 0$ against $H_1$: $\mu_1 - \mu_2 > 0$

Again we consider different situations about difference between two population means ($\mu_1 - \mu_2$)

(1) When sampling is from **normally distributed population** and **population variance is known.** (Population may not be normally distributed but if sample size ≥ 30, replace population variance by sample variance)

(2) When sampling is from **normally distributed population** but with **unknown population variance.**

**Situation 1**

When sampling is from **normally distributed population** and **population variance is known.** (Population may not be normally distributed but sample size ≥ 30, replace population variance by sample variance)

In the situation when both the samples follow normal distribution and population variances are known, the distribution of the test statistic under null hypothesis ibution. The test statistic llowing equation

$$z = \frac{(\overline{x_1} - \overline{x_2}) - (\mu_1 - \mu_2)}{\sqrt{\frac{\sigma_1^2}{n_1} + \frac{\sigma_2^2}{n_2}}}$$

.....(4)

In the situation when the samples do not follow normal distribution but if the samples are large enough (≥30) then the distribution of the test statistic under null hypothesis follows a standard normal distribution for assumed α. The test statistic in this case is calculated by the following equation

$$z = \frac{(\overline{x_1} - \overline{x_2}) - (\mu_1 - \mu_2)}{\sqrt{\frac{s_1^2}{n_1} + \frac{s_2^2}{n_2}}}$$

..... (5)

**Situation 2**

When sampling is from **normally distributed population** but with **unknown population variance.**

$$t = \frac{(\overline{x_1} - \overline{x_2}) - (\mu_1 - \mu_2)}{\sqrt{\frac{s_p^2}{n_1} + \frac{s_p^2}{n_2}}}$$

In this situation the test statistic is calculated by first calculating the pooled variance given by $s_p^2$. The test statistic is then calculated by the following equation.

$$s_p^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}$$

..... (6)

Where,

Under the null hypothesis the test statistic follows student's t distribution with $(n_1+n_2-2)$ dfs. Since under null hypotheses there is no difference, $\mu_1$ and $\mu_2$ are assumed to be the same and hence $\mu_1$ minus $\mu_2$ becomes zero.

The following is a hypothetical data set of a research study to answer the question whether the serum cholesterol of healthy adult males, living in hot desert areas is, on an average, different (ie., significantly higher or lower) from the average serum cholesterol of healthy adult males living in temperate climates. The serum cholesterol values of 12 subjects from the deserts and 14 subjects from temperate climate are presented as under :

Serum Cholesterol Values(mg/dl)

Desert group (Total = 12) : 254, 218, 176, 242, 184, 239, 225, 256, 218, 182, 210, 191

Temperate Climate Group (Total = 14) : 210, 176, 194, 250, 219, 207, 162, 154, 258, 166, 219, 200, 176, 182,

Hypotheses

$H_0$: $\mu_1 = \mu_2$ against $H_1$: $\mu_1 \neq \mu_2$ which is equivalent to saying

$H_0$: $\mu_1 - \mu_2 = 0$ against $H_1$: $\mu_1 - \mu_2 \neq 0$

Data

As given above

$$s_p^2 = \frac{(n_1 - 1)s_1^2 + (n_2 - 1)s_2^2}{n_1 + n_2 - 2}$$

$$= \frac{(12-1)(28.2)^2 + (14-1)(31.5)^2}{12+14-2} = 901.95$$

$$t = \frac{(\overline{x_1} - \overline{x_2}) - (\mu_1 - \mu_2)}{\sqrt{\frac{s_p^2}{n_1} + \frac{s_p^2}{n_2}}} = \frac{(216.25 - 198.07) - 0}{\sqrt{\frac{901.95}{12} + \frac{901.95}{14}}} = 1.53$$

Assumptions

Both the populations follow approximate normal distribution with unknown population variances and $\alpha$ = 5%.

Test Statistic

Since population variance is unknown we use equation 6 to calculate the test statistic value.

Distribution of test statistic

If null hypothesis is true then the test statistic will follow student's t distribution with ($n_1$+$n_2$-2). From the t table we get the value against (12+14-2=24) dfs as 2.06.

Statistical Decision

Since the calculated test statistic value lies below the table value we do not reject the null hypothesis (accept $H_0$).

Conclusion

Serum Cholesterol levels of healthy adult males, living in hot desert areas is, on an average, **not different** from the average serum cholesterol of healthy young males living in temperate climates. (p>0.05)

**Paired Comparisons**

The `t' test we have described above deals with situations in which there are two different samples whose means are to be compared. Sometimes, in medical research, we may have either only one sample which gives us two sets of readings (before and after readings) or else, we may have two different samples which are very similar to each other excepting for the factor which is being studied. Let us have a look at the following examples :

(a) To study the efficacy of a drug in reducing the Serum Cholesterol level, we took 10 healthy adult males and measured their Serum Cholesterol levels. These 10 subjects were then given the drug for 1 month and the Serum Cholesterol levels were again measured thereafter.

(b) For evaluating the skin irritant effect of an industrial chemical, we applied the chemical (in paste form, using paraffin jelly as the medium) on the right forearm of 10 subjects, while on the left forearm, only paraffin jelly was applied to serve as control. After 24 hours, we measured the maximum diameter of hyperaemia in millimeters on both the forearms.

(c) For studying the effect of tobacco smoking during pregnancy on the birth weight of the child, we took a sample of 90 pregnant ladies who were tobacco users. For each such lady, we took another pregnant lady of same age, parity, income status and duration of pregnancy but who was a non smoker. In other words, we "pair - matched" each subject (pregnant smoker) with a control (pregnant non-smoker). We then followed up each of the 180 subjects till delivery and recorded the birth weight of the offspring in grams.

All the above three examples have very different objectives and settings; however, they have one thing in common - each data point of the first sample is related to a unique data point of the second sample. These are the situations of "paired samples". Such "paired samples" may represent two sets of measurements on the same subject in a "before and after" fashion (thus, each subject serving as his own control, vide example No. 1 above); or they may be two exactly similar anatomic or physiological points excepting for the factor under study (example No. 2 above); or, measurements on different people who are chosen on an individual basis using "matching criteria", so that they are very similar to each other, except for the factor under study (example No.3 above).

The statistical procedure in such situations is the "paired" `t' test where we first calculate the difference between pairs of observation i.e. difference ($d_i$) between before and after value. The n sample differences then represent a sample from a normally distributed population. The test statistic for testing the hypothesis that the mean difference between the before and after value =0 ($\mu_d$=0) is as follows:

$$t = \frac{\overline{d} - \mu_d}{SD(difference)/\sqrt{n}}$$

.....(7)

Where $\overline{d}$ is the sample mean difference, $\mu_d$ is hypothesized

Table - 9

| Subject No | Serum Cholesterol mg/dl | | Difference (d) (= d1 -d2) |
|---|---|---|---|
| | Before therapy d1 | After therapy d2 | |
| 1 | 306 | 280 | +26 |
| 2 | 254 | 242 | +12 |
| 3 | 198 | 204 | -6 |
| 4 | 242 | 238 | + 4 |
| 5 | 236 | 228 | + 8 |
| 6 | 228 | 202 | +26 |
| 7 | 286 | 264 | +22 |
| 8 | 274 | 258 | +16 |
| 9 | 208 | 209 | -1 |
| 10 | 188 | 198 | -10 |
| | | | |

Hypotheses

$H_0$: $\mu_d = 0$ against $H_1$: $\mu_d \neq 0$

Data

Now, the mean of the differences of the 10 observations (+26, +12, + ----- -1, -10) comes out to + 9.7 and the standard deviation comes out to 12.96 thus.

$\bar{d} = 9.7$, SD(difference) = 12.96, n= 10.

Assumptions

The observed differences constitute a random sample from a normally distributed population and $\alpha = 5\%$.

Test Statistic

Using equation (7) for paired observation we get test statistic value as

Statistical Decision

$$t = \frac{\bar{d} - \mu_d}{SD(difference)/\sqrt{n}} = \frac{9.7 - 0}{12.96/\sqrt{10}} = 2.37$$

df = (n - 1) = (10-1) =9

Now, turning to the t table, we find the t table value at p or $\alpha = 0.05$ and df = 9 is 2.26. Since our calculated `t' value (2.37) is more than the table value (2.26) we conclude that our results are significant i.e. we reject our null hypothesis.

Conclusion

What we are in fact concluding is our sample of 10 subjects shows that there is a reduction on an average by 9.7 mg/dl due to the drug; and the "probability" that in the large reference population (of millions of persons who would be given the drug), the drug will not lead to a reduction in Serum Cholesterol is less than 5 in 100 chances; thus there are 95 in 100 chances that the drug will lead to a reduction in Serum cholesterol in the large reference population ($p<0.05$).

Once again, if we are using "numerical-ordinal" scales then it should not be the "paired t-test" but rather a non parametric test (Wilcoxon's signed rank test) that should be used. For example, if we are comparing the "pain scores" (0,1,2,3 etc) before and after a drug then we should **not** use the paired t test as described above, but the Wilcoxon's signed rank test.

**Which test to use for difference in means of three or more samples?**

If we are comparing the means of 2 samples, then we use the 't' test as described earlier. However if we are testing the difference in means between 3 or more samples then we should not use 't' test. In such situations we should use ANALYSIS OF VARIANCE (ANOVA). For example if we want to see whether the average Hb% level is different among pure vegetarian, ovo-vegetarian and non-vegetarian pregnant women, then we would use ANOVA.

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## Testing for Proportions

In clinical trials one may count the number of times an event occurs. For example number of successful outcomes, number of failures or number of patients recovered after administration of drug etc. This proportion may be compared with a hypothesized value or we may study a two sample problem in which trials are conducted in two independent study groups. Similarly patients in one group may receive new treatment drug and another independent group may receive existing conventional treatment. We may be interested in comparing the proportion of patients attacked by disease after administration of the treatment in the two populations. The population proportion is denoted by 'π'.

The testing of hypothesis about population proportion is carried out in the same way as means.

**Hypothesis Testing: A Single Population Proportion**

In testing a single population proportion denoted by π against a hypothesized value of $\pi_0$ approximate normality assumptions holds true if the sample size is large. The test statistic is given as

$$z = \frac{p - \pi_0}{\sqrt{\frac{\pi_0(1-\pi_0)}{n}}} \quad \text{.....(8)}$$

Which when the null hypothesis is true follows a standard normal distribution. Here p is the sample proportion and $\pi_0$ is the hypothesized population proportion.

Consider a hypothetical example. In clinical studies of an anti-allergy drug, 70 of 781 subjects experienced drowsiness. A competitor claims that 8% of users of his drug experience drowsiness. Use a 0.05 significance level to test this claim.

Hypotheses

Ho: $\pi=\pi_0$ (0.08) against $H_1$: $\pi \neq \pi_0$ (0.08)

Data

The data obtained on drug says 70 out of 781 subjects experienced drowsiness. Hence, p = 70 / 781 = 0.089

Assumptions

The random sample is drawn from a normally distributed population and α = 5%.

Test Statistic

The test statistic is given by equation 8

$$z = \frac{p - \pi_0}{\sqrt{\frac{\pi_0(1-\pi_0)}{n}}} = \frac{0.089 - 0.08}{\sqrt{\frac{0.08(1-0.92)}{781}}} = 0.99$$

Distribution of test statistic

The test statistic, if $H_0$ is true, follows standard normal distribution with mean of 0 and variance of 1.

Decision Rule

For α = 0.05, the standard normal table value is 1.96. So since the test statistic value is less than the table value we fail to reject the null hypothesis.

Conclusion

There is not sufficient evidence to warrant rejection of the claim that drowsiness will be less among users of the competitors drug vis-a-vis the drug used by us (p>0.05)

**Hypothesis Testing: The Difference Between Two Population Proportions**

This is the most common situation in medical research. We test the null hypothesis that the difference between the two proportions is zero or some other value. When the null hypothesis is stated as $\pi_1 = \pi_2$ (two population proportions are same), it means that $\pi_1 - \pi_2 = 0$ we are testing the hypothesis that (difference between two population proportions is zero). The test statistic is given as,

$$z = \frac{(p_1 - p_2) - (\pi_1 - \pi_2)}{SE_{p_1 - p_2}} \quad \text{..... (9)}$$

where,

$p_1$ and $p_2$ are sample proportion values.

$x_1$ & $x_2$ are numbers in the first and second samples possessing the characteristic of interest. The test statistic under null hypothesis follows standard normal distribution.

$$SE_{p_1-p_2} = \sqrt{\frac{\bar{p}(1-\bar{p})}{n_1} + \frac{\bar{p}(1-\bar{p})}{n_2}} \quad \text{and} \quad \bar{p} = \frac{x_1 + x_2}{n_1 + n_2},$$

Consider a hypothetical example where we sampled 55 males in their adolescent ages. 24 of them were obese. Another sample of 149 females had 36 obese ladies. Can we conclude that in the sampled populations the proportion of obese males is higher than that of females ?

Hypotheses

Ho: $\pi_1 \leq \pi_2$ or $\pi_1 - \pi_2 = 0$ against $H_1$: $\pi_1 > \pi_2$ or $\pi_1 - \pi_2 > 0$, $\pi_1$ and $\pi_2$ are proportions of obese in male & female populations respectively.

Data

The data gives the sample proportion values as p1= 24/55 = 0.44 and p2=36/149 = 0.24.$\bar{p}$ = (24+36)/ (55+149) = 0.29

Assumptions

The two independent simple random samples is drawn from a normally distributed population and $\alpha$ = 5%.

Test Statistic

The test statistic is given by equation 9

$$z = \frac{(p_1 - p_2) - (\pi_1 - \pi_2)}{SE_{p_1 - p_2}}$$

$$= \frac{0.44 - 0.24}{\sqrt{\frac{0.29(1-0.29)}{55} + \frac{0.29(1-0.29)}{149}}} = 2.71$$

Distribution of test statistic

The test statistic, if $H_0$ is true, follows standard normal distribution with mean of 0 and variance of 1.

Decision Rule

For $\alpha$ = 0.05, the standard normal table value is 1.645 for one tailed hypothesis. So since the test statistic value is greater than the table value (2.71 > 1.645) we reject the null hypothesis.

Conclusion

There is sufficient evidence that proportion of obese in male population is significantly higher than female population (p<0.05)

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# Hypothesis Test for Counts and Non Parametric Tests

The hypothesis testing procedure discussed earlier, whether z test, unpaired t test or paired t test required the population distribution to be normal or approximately normal. In medical research many times we are not sure about the underlying distribution of the population. In such cases we apply non parametric tests which are not based on the assumption of normality of population especially when the sample size is small (n<30). Since they do not assume any distribution they are also called as distribution free tests. Non parametric tests are weaker than parametric tests. Few of the commonly encountered non parametric tests are discussed below.

### Hypothesis Testing for Categorical Data

The previous section of hypothesis testing dealt with situations when we had discrete or continuous, i.e., "quantitative or numerical variables", which could be measured. Apart from above mentioned situations many times medical research deals with situations involved with comparing two groups with the presence and absence of various diseases. Here the qualitative or categorical variables are measured in terms of "counts". The statistical tests used for such variables which do not assume normality of the variable are specific and called as **nonparametric tests**. These are also called as **distribution free test**. These tests are weaker than parametric test and require fewer assumptions. For categorical data the test used is called as chi-square test ($x^2$ test). Chi-square tests have three applications.

(a) $x^2$ **test for independence** to test whether two or more characteristics are associated (independent) to each other.

(b) $x^2$ **test for goodness of fit** to study whether two or more independent populations are similar with respect to some characteristic.

(c) $x^2$ **test for homogeneity** to study whether two study groups independently drawn from two populations are homogenous with respect to some criteria of classification

In all the three situations the test statistic takes the same formula given as follows :

$$X^2 = \frac{\sum (O_{ij} - E_{ij})^2}{E_{ij}}$$

where $O_{ij}$ and $E_{ij}$ are observed and expected frequencies for $i^{th}$ row and $j^{th}$ column.

When the information is collected in counts it is compiled and presented in a table called as **contingency table**. When both the qualitative variables are dichotomous the tabular presentation takes the form of 2 x 2 contingency table (2 rows and 2 columns). In general we can have r x c contingency table where r is number of rows and c is number of columns. Under the null hypothesis the test statistic follows a chi-square distribution with (r-1)x(c-1) degrees of freedom.

Let us illustrate the procedure of Chi-square test using the hypothetical example on the association between maternal age and congenital malformations. Let us say, we started with the research issue as to whether advanced maternal age (>35 years) is associated with congenital malformations among the children. We took a sample each, say, 500 pregnant ladies aged > 35 years and another 1000 pregnant ladies aged upto 35 years and followed them till delivery. We found that out of the 500 children born to ladies > 35 years, 50 had congenital malformations, while out of 1000 ladies upto 35 years, there were again 50 children born with congenital malformations. We would thus proceed to test the research hypothesis that the age of mother and congenital malformations are associated. This research hypothesis would be tested against the **"Null Hypothesis" which states "There is no association between congenital malformation and age of mother". (Age of mother and congenital malformation are independent to each other).** The outcome variable of interest is dichotomous (either malformed child or normal child)

Table - 10 : $X^2$ test for Independence

| Samples of ladies | Number of Children | | Total |
|---|---|---|---|
| | Having Congenital malformations | Not having Congenital malformations | |
| > 35 years | ($O_{11}$)50 (10%) (a) | ($O_{12}$)450 (90%) (b) | 500 (100%) (a+b) |
| < 35 years | ($O_{21}$)50 (5%) ( c) | ($O_{22}$)950 (95% (d) | 1000 (100%) (c+d) |
| Total | 100 (6.67%) (a+b) | 1400 (93.33%) (b+d) | 1500 (100%) (n) |

$O_{11}$, $O_{12}$, $O_{21}$ and $O_{22}$ (Equivalent to a, b, c and d) are the observed frequencies in our sample. To calculate the chi-square test statistic value we are first required to calculate the expected frequencies. Expected frequencies are the one that we expect if null hypothesis is true and is given by

$$\text{Expected frequency} = \frac{(\text{Marginal row total}) \times (\text{Marginal column total})}{n}$$

Thus for the above example we have expected frequencies for each cell as follows :

$E_{11}$ = (500X100)/1500 = 33.33

$E_{12}$ = (500X1400)/1500 = 466.67

$E_{21}$ = (1000X100)/1500 = 66.67

$E_{22}$ = (1000X1400)/1500 = 933.33

### Test Statistic

Test Statistic for chi-square tests is given by

$$X^2 = \frac{\sum (O_{ij} - E_{ij})^2}{E_{ij}}$$

where $O_{ij}$ and $E_{ij}$ are observed and expected frequencies for $i^{th}$ row and $j^{th}$ column.

Substituting the values from the above example we get

$$X^2 = \frac{(50-33.33)^2}{33.33} + \frac{(450-466.67)^2}{466.67} + \frac{(50-66.67)^2}{66.67} + \frac{(950-933.33)^2}{933.33}$$

$$X^2 = 13.39$$

### Distribution of the Test Statistic

Under null hypothesis the test statistic follows a chi-square distribution with (row-1) X (column-1) degrees of freedom. For the above problem we have (2-1) X (2-1) =1 degree of freedom. For 1 df and assumed á level of significance the chi-square table value is 3.84.

### Statistical Decision

If the calculated test statistic value is greater than table value we reject the null hypothesis otherwise accept it. Since our calculated test statistic value = 13.39 > 3.84 we reject null hypothesis.

### Conclusion

On the clinical front we conclude that there is a definite relationship between advanced maternal age (> 35 years) and congenital malformations in the offspring.

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## Advanced Statistical Techniques

The most commonly used statistical procedures in medical research are the "z" test for comparing two means or two proportions, the unpaired and paired 't' tests and the chi-square test, the details of which have been explained in this section. There are certain situations when different statistical techniques are required. The medical researcher should have an orientation to these procedures so that he/she can decide as to which procedure is most appropriate. As regards actual calculations, the same can be easily undertaken with statistical software EPI-2002, details of which are being described in the next section.

**Which test to use**

As we said earlier, in the previous section on Research Methodology, the prototype scenario is to study an association between a given exposure variable and an "outcome" variable. (Please refer to detailed discussion on 2 x 2 table in that chapter). Now, we must first decide as to which "scale" have we recorded the exposure and the outcome variable. (i.e., Quantitative Continuous, Discrete or Ordinal; or, Qualitative- Dichotomous, polychotomous nominal or polychotomous ordinal) Next, depending on the scale on which the exposure and outcome variables have been recorded, the appropriate test can be used.

1. For testing one to one (Univariate) relationship between exposure and outcome variable (Table - 11).

2. One to One (Univariate) Situation of Paired (dependent) samples or 'Before and After' situations

   (a) For Means : Paired 't' test

   (b) For proportion : McNemar Chi square

   (c) For Medians : Wilcxon Signed Rank test.

3. If the outcome variable is dependent on time (as survival)

Use Survival analysis method as Kaplan Meier method

4. For control of confounding (Bivariate or multivariate analysis)

   (a) For one or two confounding variables and when both the exposure & outcome are recorded on qualitative (usually dichotomous) scale: Mantel-Haenszel's stratified analysis

   (b) For one or two confounding variables and when either exposure or outcome are recorded on quantitative (Continuous, discrete or ordinal) scale : - Two way or Multiple way ANOVA.

   (c) When a large number of confounding variables are to be controlled.

      (i) If outcome variable is recorded on quantitative (Continuous or discrete numerical) scale: Multiple Linear Regression Model.

      (ii) If the outcome variable is recorded on dichotomous scale: Use Multiple Logistic Regression

      (iii) If the outcome variable is a dichotomous variable but dependent on some type of time duration, as survival time : Use Cox

Table - 11

| | | OUTCOME | | | | | |
|---|---|---|---|---|---|---|---|
| | | **Continuous** | **Discrete** | **Numerical Ordinal** | **Dichotomous** | **Polychotomous Nominal** | **Polychotomous Ordinal** |
| EXPOSURE | **Continuous** | Pearson Correlation & Regression | Pearson Correlation & Regression | Spearman Rank correlation | 't' test | ANOVA | ANOVA |
| | **Discrete** | Pearson Correlation & Regression | Pearson Correlation & Regression | Spearman Rank correlation | 't' test | ANOVA | ANOVA |
| | **Numerical Ordinal** | Spearman Rank correlation | Spearman Rank correlation | Spearman Rank correlation | Mann Whitney U test | Kruskal Wallis test | Kruskal Wallis test |
| | **Dichotomous** | 't' test | 't' test | Mann Whitney U test | Chi Square for 2X2 table | Chi Square for rXc table | Chi Square for linear trend in proportions |
| | **Polychotomous Nominal** | ANOVA | ANOVA | Kruskal Wallis test | Chi Square for rXc table | Chi Square for rXc table | Chi Square for rXc table |
| | **Polychotomous Ordinal** | ANOVA | ANOVA | Kruskal Wallis test | Chi Square for linear trend in proportions | Chi Square for rXc table | Chi Square for rXc table |

Proportional Hazards Regression model.

Fisher Exact Test for 2 x 2 table

Many times we face the situation where the variables of classification are qualitative but the sample size is too small. **Chi-square test fails when the sample size is less than 30.** In such situations instead of using chi-square test we should use Fisher Exact Test.

McNemar Test for related data

In the situation of a chi square test, as described earlier, if "paired matching" has been done then McNemar test should be done instead of ordinary Chi square test.

Medain based Non Parametric test:

At times when the scale of measurement has been ordinal numerical (as rank achieved, grade of dyspnoea, economic status and so on) we should compare the medians rather than the means, using certain non parametric tests. The following tests are commonly used:-

(a) Mann-Whitney 'U' test : When medians of the two independent samples are to be compared. It is the counterpart of unpaired 't' test.

(b) Wilcoxon Signed Rank test : When the medians of the paired samples are to be compared. It is the counterpart of "paired t test".

(c) Kruskal Wallis test : When medians of three or more samples are to be compared. It is the counterpart of ANOVA.

Regression Techniques

Often in medical research it is desirable to analyse the relationship or association between two quantitative (i.e., continuous, discrete or numerical ordinal) variables. The nature and strength of relationship that exists is examined by regression and correlation analysis. When the objective is to determine association or the strength of relationship between two such variables we use correlation coefficient (r). If the objective is to quantify and describe the existing relationship with a view of prediction we use regression analysis. Before we develop a mathematical model describing relationship we should first plot the scatter diagram of the variables. A scatter plot is a visual description of the relationship between two continuous variables.

Correlation Coefficient(r)

We have two types of correlation depending on whether the variables are continuous variables and joint distribution is following normal distribution or not.

**Pearson Correlation Coefficient**

This correlation coefficient works when variables are continuous variables and joint distribution is following normal distribution.

The correlation coefficient ranges between -1 to +1. A correlation of zero indicates no association whereas a correlation of 1 indicates perfect association. The sign of correlation coefficient provides information on the type of association between the variables. If it is positive then high values of one variable will be associated with high values of the other variable and if the correlation coefficient is negative then low values of one variable are associated with high values of other variable. The interpretation of r is shown in Table - 12.

**Spearman correlation coefficient**

Sometimes the variables are not normally distributed but are ranked in order then the appropriate correlation measure is Spearman rank correlation coefficient. The Spearman correlation coefficient also ranges from -1 to +1

Table - 12 : Interpretation of r

| Value of r | Relationship |
|---|---|
| If 0< r < ±0.25<br>Between 0 and ±0.25 | Little or no linear relationship. |
| If ±0.25= r < ±0.50<br>Between ±0.25 and ±0.5 | Fair degree of linear relationship |
| If ±0.50 = r < ±0.75<br>Between ±0.5 and ±0.75 | Moderate to good linear relationship. |
| If r = ±0.75 | Very good linear relationship. |

and is interpreted in the same way as the Pearson correlation coefficient.

**Coefficient of determination**

Coefficient of determination is defined as square of correlation coefficient. It is the amount of variation in the dependent variable accounted for by the independent variable. In other words if coefficient of correlation (r) between age and blood pressure is 0.8 then coefficient of determination $r^2$ = 0.64. This is interpreted as 64% of variability in blood pressure is accounted by age whereas the remaining 36% is not by age. Other factors such as weight, diet and exercise may account for the 36% variability in blood pressure.

**Simple Linear Regression**

In simple model we have one outcome or dependent variable associated with only one independent variable. The line describes the linear relationship between the variables. We predict the dependent variable by a straight line equation.

**Multiple Linear Regression**

Multiple regression is the extension of simple linear regression except that in this regression model we have more than one independent or explanatory variables, and the outcome (dependent) variable is continuous or discrete numerical scale.

**Multiple Logistic Regression**

In logistic regression, the outcome variable or dependent variable is dichotomous (Died/Alive, Yes/No, Present/Absent). Logistic regression is widely used in medical science since the medical researcher many a times is interested in presence or absence of a condition or disease and also the coefficients derived from logistic regression can be interpreted as odds ratio.

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# Survival Analysis

The various statistical situations that we have considered till now relate to "risk" or to "prognosis" or treatment related outcomes. However, sometimes the research question may be more interesting and somewhat different from the above mentioned situations. For example, the question could be "what are the chances that a case of HIV infection acquired due to blood transfusion would be surviving at the end of 6 years?"; or, "what are the chances that a lady who has been diagnosed as cervical cancer by early screening and treated would be alive at the end of 5 years?" or **in general how long people with a life threatening disease survive following treatment.** The analytical methods used to draw inferences regarding the chances of surviving / dying / getting cured/getting diseased (in short, the chances of developing the "outcome of interest"), over the various points of time are answered by "survival analysis". Thus survival analysis deals with situations where the outcome is dichotomous and is a **function of time.**

Suppose patients suffering from a life threatening disease 'A' are treated with two treatment modalities and followed over specific time period say 5 years. The study continues during which any of the following three situations may occur.

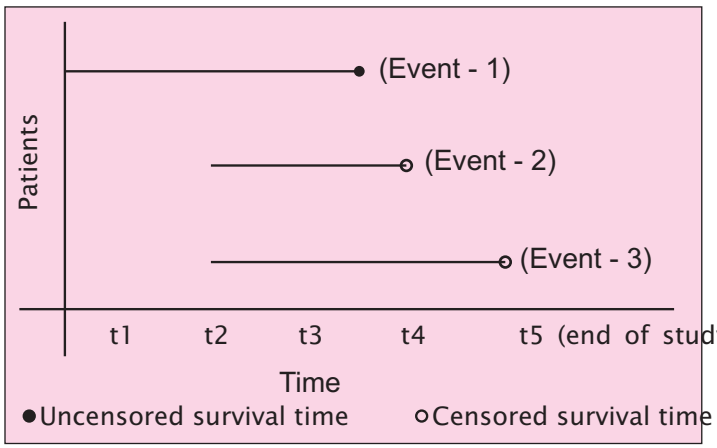
(1) The event of interest (death of patient due to disease 'A') has occurred.

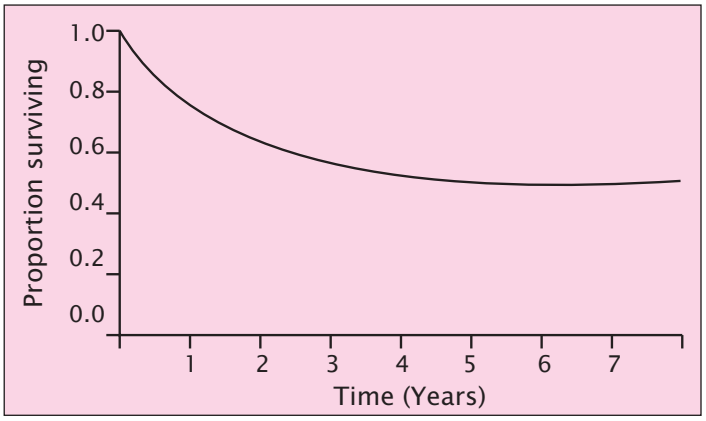
(2) The patient is lost to follow up, from death due to cause other than disease 'A' or has left the study by moving out of area etc.

(3) The event of interest (death of patient) does not occur till the end of study. i.e. the patient is alive when the study is terminated.

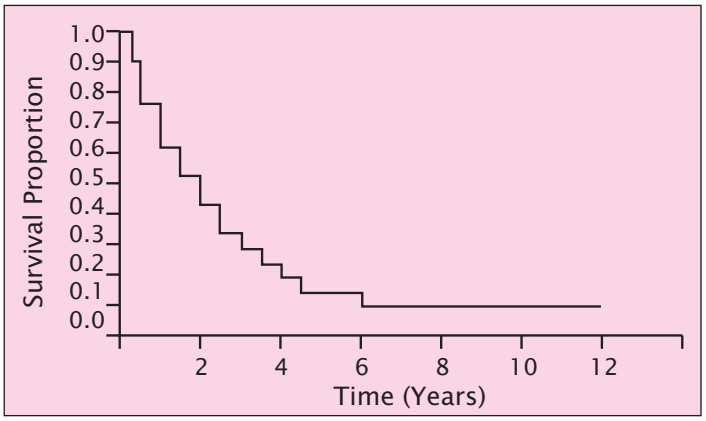
The time from enrollment to experiencing one of the above situations is called survival time. In situations 2 and 3 the survival time of patients is called as **censored survival time**. Thus all those who achieve the outcome of interest are "uncensored" data while those who do not achieve the outcome are "censored" data.

Visual representation of the survival experience of patients against time is represented by survival curves. Thus survival curves show the percentage surviving versus time. The following is a graph depicting survival curve.



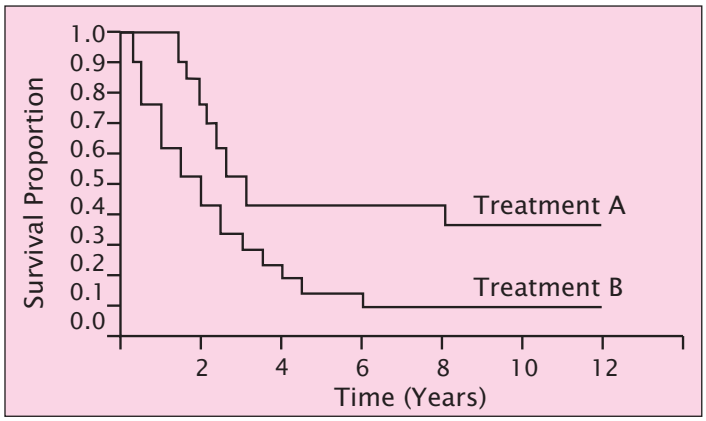

Most real life survival curves are usually shown as staircase curves with a step down each time there is a death. This is because the survival curve represents the actual experience of a particular group of people. At the moment of each death, the proportion of survivor's decreases.




### Comparison between two survival curves

The curves may compare results from different treatments as in the graph shown below. If one curve is continuously "above" the other, as with these curves, the conclusion is that the Treatment "A" associated with the higher curve was more effective for these patients then Treatment "B". The two lines represent the two "survival curves".

The vertical (or Y) axis of the graph is the percentage of patients in the group surviving. The horizontal (or X) axis represents time, starting from the time of diagnosis, or the time that treatment starts. As time goes on, some of the patients die and the curve steps down each time this




happens. Most of the times these curves flatten out at the ends suggesting that some patients in each of the two groups are cured or at least are long term survivors, though the odds of that are obviously much greater for the upper curve.

There are number of methods of analyzing a survival data. Life table method accounts for differences in follow-up time and also account for changes in survival rate over time. It breaks the follow-up period of the study into intervals and then calculates the proportion of people at risk at the start of each interval who survive until the start of the next interval.

There are two methods to calculate life tables.

(a) Actuarial method

(b) Kaplan-Meier method.

The basic difference between the two methods is the interval classification. The actuarial method adopts fixed class intervals which are most often year following the end of treatment given. The Kaplan-Meier method uses the next death, whenever it occurs, to define the end of the last class interval and the start of the new class interval. In both the methods the statistical test applied to test the null hypothesis that there is no difference in survival rates of the patients treated with two different treatment modalities (comparing two survival curves) is the **Log-Rank Test.** Log-Rank test does not control for confounding. To control for confounding we use another test called as **Cox proportional hazards regression.** The mathematical calculation of the two tests is not discussed in detail but we only need to know that in medical research articles when we see Log-Rank test applied, a crude test for difference in survival curves was conducted whereas when we come across Cox proportional hazard model then the comparison in survival curves was conducted

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# Sample Size Determination

In the initial chapters, we have highlighted that the major reason for utilizing statistics is because we study a sample instead of complete population. Research studies (surveys, experiments, observational studies, etc.) are always better when they are carefully planned. Determining sample size is a very important issue and hence must be planned carefully because samples that are too large may waste research time, resources, patient effort and money invested in clinical trial, while samples that are too small may lead to inaccurate results. Also, it may be considered unethical to recruit patients into a study that does not have a large enough sample size for the trial to deliver meaningful information. Thus to ensure that a statistical test will have adequate power, one usually must perform the exercise of calculating how large an 'n' (sample size) is required. It is not possible to compute a sample size for certain types of experiments because prior information is lacking or because the success of the experiment is highly variable. These studies are called as **pilot studies**. Pilot experiments are designed to explore a new research area to determine whether variables are measurable with sufficient precision as well as to check the logistics of a proposed experiment. Usually a pilot study is conducted by taking an approximate sample size of 30 or less. In most of the other research designs (for hypothesis testing) the sample size calculation depends upon the four major components viz the power, the level of significance, the effect size or the expected parameter value in the population and the expected size of the treatment effect sought. We have already discussed that **power of a study** is its ability to detect a true difference in outcome. This is usually chosen to be 80%. If study power is set at 80% it accepts a likelihood of one in five (that is, 20%) of missing such a real difference i.e. the study will have 20% possibility of a "false-negative" result. Level of significance is predefined before we start the experiment. The chosen **level of significance or Type I error** is the probability of detecting a treatment effect when no effect exists (leading to a "false-positive" result) and defines the threshold "p value". Results with a p value above the threshold lead to the conclusion that an observed difference may be due to chance alone, while those with a P value below the threshold lead to rejecting chance and concluding that the intervention has a real effect. The type I error is most commonly set at 5% (or, sometimes at 1%). This means the investigator is prepared to accept a 5% (or 1%) chance of erroneously reporting a significant effect. The **effect size** is the biologically significant difference which is specified from a detailed review of literature, from experts or by conducting a pilot study. This is defined as “minimum detectable RR or OR or Treatment Effect (TE)”. We consider below sample size determination in simple situations of estimation alone and not hypothesis testing. In hypothesis testing along with α, power is also considered.

### Sample Size determination for Estimating a Mean

Sample size 'n' is given by

$$n \geq \frac{z^2_{1-\alpha/2}\sigma^2}{d^2}$$

where,

- d is the precision or margin of error. In other words it is the acceptable deviation between the hypothesized value and the true value of population parameter assuming 95% confidence interval.
- σ is the population standard deviation which is estimated from pilot study or from previous similar study.
- $Z_{1-\alpha/2}$ is the table values for alpha error corresponding to the standard normal distribution. This is 1.96 at 5% (i.e. 0.05) and 2.57 at 1% alpha error (two tailed).

### Sample Size determination for Estimating Proportion

The procedure in estimating sample size for proportion remains same as in case of means. Assuming that

$$n \geq \frac{z^2_{1-\alpha/2}pq}{d^2}$$

population is large we determine the sample size by following equation.

where,

- $p$ is the proportion in population possessing the characteristic of interest and q=1-p. This expected proportion in population is estimated from literature or pilot study. If nothing is known of p then it can be assumed to 0.5.
- $d$ is the acceptable deviation
- $Z_{1-\alpha/2}$ is the value of two tailed alpha error; this is 1.96 at 5% (i.e. 0.05) and 2.57 at 1% alpha error (two tailed). For one tailed alpha error this will be 1.64 at 0.05 and 2.33 at 0.01 levels of alpha error.

### Sample Size determination for Estimating Difference between Means

For comparison of means in two independent samples the sample size calculation remains similar to single

$$n \geq \frac{z^2_{1-\alpha/2}\sigma^2}{d^2}$$

population mean. Here $n_1 = n_2 = n$

where it is assumed that $\sigma_1$ and $\sigma_2$ are same and equal to $\sigma$. If they are not equal their average can be taken as an estimate of the standard deviation.

**Sample Size determination for Estimating Difference between Proportions**

The method of sample size determination for estimating difference between proportions is slightly tedious than for single population proportion. No estimate of standard deviation from previous work or literature is required but the actual proportions in the two populations must be

$$n \geq \frac{z^2_{1-\alpha/2}(p_1q_1 + p_2q_2)}{d^2}$$

specified as well as their difference (d).

where $p_1$ and $p_2$ are proportion in population possessing the characteristic of interest and $q_1=1-p_1$ and $q_2=1-p_2$.

**Sample Size application for hypothesis testing in a case control and a prospective studies**

In a case control study besides giving specifications for acceptable alpha error and acceptable beta error, the proportion of the persons without the outcome who are likely to give a history of the exposure (i.e. proportion of controls who are exposed) and the minimum risk (i.e. the minimum Odds Ratio that our study wants to detect) needs to be specified.

In case of a prospective study besides giving specifications for acceptable alpha error and acceptable beta error, the proportion of subjects those who are not exposed to the exposure but are likely to develop the outcome and the minimum risk (i.e. the minimum Relative Risk that our study wants to detect) needs to be specified.

Once the above specifications have been made, the calculation becomes simple by the following formula :

$$n = \frac{(z_{1-\alpha/2} + z_{1-\beta})^2 * p * q}{(p_1 - p_0)^2}$$

where

n = minimum sample size for each group

$Z_{1-\alpha/2}$= value of alpha error

$Z_{1-\beta}$ =value of beta error;

For the usual situation when

alpha error =0.05 two tailed, the value is 1.96 and for

beta error = 0.20, it is 0.84

$P_0$ =Proportion of those "without the exposure" who are likely to develop the "outcome" (in a prospective study) or Proportion of those without the outcome who are likely to have the exposure (in a case control study).

The value of $P_0$ would have to be specified by us. The methods of obtaining the same are extensive reading into the subject, discussions with experts, or finally, by conducting a pilot study if required. Once $P_0$ is specified $P_1$ is then obtained as follows

In a Prospective study

$$P_1 = \frac{P_0 \text{ X RR}}{(1 + P_0 (\text{RR} - 1)}$$

In a Case-control study

$$P_1 = \frac{P_0 \text{ X OR}}{(1 + P_0 (\text{OR} - 1)}$$

and then calculate $P$ & $q$ as

$$P = \frac{P_0 + P_1}{2}$$

$$q = (1-P)$$

(Please note: Sample size determination is discussed in detail with examples in next section on EPI 2002. Hence it is suggested that the readers also review the details given in that section)

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# Methods of Sampling

To draw conclusions about population from sample, there are two major requirements. Firstly, the sample size should be adequately large, an issue which has been discussed in the previous chapter. Secondly, the sample has to be selected appropriately so that it is representative of the population Sample, should have all the characteristics of the population. In other words a sample is expected to be mirror of the population from which it comes. Sampling techniques is concerned with the selection of representative sample, especially for the purposes of statistical inference. We will discuss few of the important sampling techniques adopted in medical research.

### Simple Random Sampling (SRS)

In this method the individual units constituting the sample are selected at random. Each unit in the population has an equal chance or probability to be selected in the sample. For this reason, it is sometimes referred to as a probability sample. There are two types of random sampling, simple random sampling with replacement and simple random sampling without replacement. In SRS with replacement the selected unit is replaced back to the population and again has the chance of getting selected. In SRS without replacement, which is the usual method in medical research, the selected unit is not put back in the population and hence the population size reduces by one at each selection. Random samples can be drawn by lottery method or by using random number tables. In Lottery method we make small chits of paper for each unit in the population which are folded and then mixed together. From this the required number are picked blindly. For example, if you want to select 10 subjects randomly from a population of 100, you can write their names, fold them up, mix them thoroughly then pick ten. In this case, every name had an equal chance of being picked. The other method of drawing a random sample is by using random number tables. This method is possible only with finite population i.e. when the population size N is known. The technique of selecting random sample with the help of these numbers is very simple. Suppose we have to select a sample (n) of 100 subjects from a population of 500 (N). We first make, a serial list of each and every subject of the 500 subjects in the population. This is called the "sampling frame". Then from the random number table, random numbers are selected row wise or column wise. Since 'N' (500) is of 3 digits, the random numbers selected are also 3 digits. If the selected random number is less than N, then the unit corresponding to that random number from population is selected in the sample. However if the selected random number is greater than N then the remainder after dividing the random number by N is selected in the sample. For example if selected random number is 167 then the unit corresponding to this number in the sampling frame is selected in the sample. But if the random number is 641 then the remainder after dividing 641 by 500 is 141. Thus the unit corresponding to 141 in the sampling frame is taken in the study. Simple random sampling is very scientific but the practical problem is that it may be quite difficult, often impossible to make a complete list of all subjects in the population from which the sample is to be selected.

### Stratified Random Sampling

In this method the complete population is divided into homogenous sub groups called strata and then a stratified sample is obtained by independently selecting a separate simple random sample from each population stratum. This gives equal chance to the units in each stratum to be selected as sample. The total sample is the addition of samples of each stratum. Population can be divided into different groups based on some characteristic or variable like income or education. The advantage of this sampling procedure is that each subgroup, however small, has representation in the total sample. For example, if we draw a simple random sample from armed forces population, a sample of 100 may contain only 7 to 8 officers, 15 to 20 JCOs and 70 to 80 Other ranks (OR). To get adequately large representation for all the three rank structures, we can stratify on rank and select simple random samples from each of the three strata.

### Systematic Random Sampling

A systematic random sample is obtained by selecting one unit on a random basis and then choosing additional units at evenly spaced intervals until the desired number of sample size is obtained. For example, if there are 100 students(N) in a class and we wish to select a sample of 20 students (n) from them by systematic random sampling procedure, than the first step is to write the names of 100 students in alphabetical order or their roll numbers one below the other. In the systematic sampling procedure we divide N by n to get the sampling fraction (k). Thus in the example k=100/20 = 5. Next we randomly select any number between 1 to k i.e., between 1 to 5. Suppose the number we select is 4. Then the student number 4 is selected in the sample. Thereafter every kth student is selected in the sample until we reach the last one. Thus the student's corresponding to numbers 4, 9, 14, 19, .....99 are to be selected in the sample.

### Cluster Sampling

Cluster sampling is used when the population is heterogeneous. Clusters are formed by grouping units on the basis of their geographical locations. A cluster sample is obtained by selecting clusters from the population on the basis of simple random sampling. From the selected clusters each and every unit is included for study. Cluster sampling is very useful method for the field epidemiological research and for health administrators. A special form of cluster sampling called the "30 cluster sampling" has been recommended by the W.H.O. for field studies in assessing vaccination coverage. In this a list of all villages (clusters) for a given geographical area is made. 30 clusters are selected using Probability Proportional to Size (PPS). From each of the selected clusters, 7 subjects are randomly chosen. Thus a total sample of 30 x 7 = 210 subjects is chosen.

**Multistage Sampling**

In this method the whole population is divided in first stage sampling units from which a random sample is selected. The selected first stage is then subdivided into second stage units from which another sample is selected. Third and fourth stage sampling is done in the same manner if necessary. For example in an urban survey in a state, a sample of towns may be taken first and then in each of the selected towns a second stage sample of households may be taken. If needed further from each of the selected household a third stage sample of individuals may be selected. Since the samples are selected at each stage the method is called multi stage sampling.

**Randomization (Random allocation)**

'Randomization' is different from random sampling. Randomization (or, random allocation) is a method used for allocating selected subjects (already selected by random sampling method) into 2 or more than 2 groups with a view to ensure that these groups are similar in all respects excepting for the drug or vaccine etc that we are interested in administrating to them. Randomization ensures that the treatment groups are comparable with respect to other factors (such as age, sex, severity of illness) which might be associated with the outcome. Hence if a difference in response between groups is seen, we can be confident that this is due to the treatment, rather than due to other factors.

Random allocation can be done in many ways from tossing a coin to using random number tables. For example, keep tossing a coin and all patients who get `heads' get drug `X' and all patients who get `tails' get `Y'. If there are 3 groups (drugs X,Y,Z), toss a die and all patients who get 1 and 4 go to X, 2 and 5 go to Y and 3 and 6 go to Z; or, more scientifically, we should use a random table and all subjects getting even numbers go to `X' and all getting odd numbers get Y.

Let us say, we are having an experimental study in which we are studying a new drug 'X' against an existing drug 'Y'. Our sample size calculations indicated that we will need 10 subjects in each of the groups 'X' and 'Y' (total 20 subjects).

Now, the first step is to decide by any "random" (fair play) process as to which all random members so selected will get treatment 'X' and which will get 'Y'. This we can do by keeping two chits, having written 'X' on one and 'Y' on the other. Similarly, place another 2 chits (with "even" written on one and "odd" written on the other) in another box. Now, ask any impartial observer to pick up one chit from each box. Let us say that chits drawn were 'X' from one box and "even" from the other. Thus, we will give treatment "X" to all even random numbers so selected and "Y" to all odd random numbers. Next, make a table, listing all the 20 patients as seen in Table 12.

Now, select any random starting point from the random numbers table by dropping a pencil. Let us say, out of the 35 rows and 36 columns in our random number table, we picked up the intersection of 29th row and 4th column, i.e. number 9. Now note down this number against patient No. 1. From here we proceed down the 4th column, noting the numbers against the patient's serial numbers and ignoring any zero. Once we come to the end of column 4, we continue with column no. 5 Thus, the next number after 9 is zero hence we ignore it; we take the next number i.e. 7, and write it against patient No.2. The next random member is 8 and we write it against patient No. 3. We continue this process till a random number has been allocated to each of the 20 patients. Now, in the next column of our above table we write down whether the random number selected for the particular patient is odd (O) or even (E). Thus, the random number given to the first patient is 9, i.e., odd and we write 'O' opposite it, similarly we write 'O' and 'E' respectively for 2nd and 3rd patient and so on. Now, in the fourth column with the heading "treatment X and Y" write X for all patients getting 'E' and 'Y' for all patients getting 'O'. The final table will look like in

Table - 12

| Patient No. | Random No. | Even or odd | Treatment (X or Y) |
|---|---|---|---|
| 1 | | | |
| 2 | | | |
| 3 | | | |
| 4 | | | |
| ... | | | |
| ... | | | |
| 20 | | | |
| | | | |

Table - 13

| Patient No. | Random No. | Even or odd | Treatment (X or Y) |
|---|---|---|---|
| 1. | 9 | O | Y |
| 2. | 7 | O | Y |
| 3. | 8 | E | X |
| 4. | 4 | E | X |
| 5. | 1 | O | Y |
| 6. | 1 | O | Y |
| 7. | 7 | O | Y |
| 8. | 8 | E | X |
| 9. | 9 | O | Y |
| 10. | 2 | E | X |
| 11. | 8 | E | X |
| 12. | 7 | O | Y |
| 13. | 1 | O | Y |
| 14. | 8 | E | X |
| 15. | 6 | E | X |
| 16. | 8 | E | X |
| 17. | 8 | E | X |
| 18. | 5 | O | Y |
| 19. | 9 | O | Y |
| 20. | 6 | E | X |
| | | | |

Mrs. Seema R Patrikar & Col RajVir Bhalwar

## Miscellaneous Topics

### Qualitative research methods

Till now the research and analysis that we have considered falls into the category of Quantitative Research. Qualitative research in contrast deals with the indepth response of the individual with respect to different issues on which the information is gathered. In other words when it is subjective matter it is best answered by qualitative research techniques rather than quantitative research techniques. Qualitative research gathers information from individuals about the issue of interest. In presence of a particular problem qualitative research explores it in depth understanding the issue with respect to the nature of problem, the reasons of the existence of problem, ways and means of solving it. Qualitative research is more of an answer to "why" as against quantitative research which answers "what". Even if your study isn't perfect in every last detail, you'll still get mostly good results from a qualitative method that relies on understanding users and their observed behavior. The most common methods in qualitative research are personal interviews, Focus Group Discussion (FGDs), case studies and "Observation of Subjects". Although procedures and outcomes of qualitative data analysis differ from that of quantitative techniques, the principles are not so different. In both cases, researchers will have to describe the sample and population, compile and summarize the data. Also the summary data needs to be represented in a way that interpretation becomes easy. At the end we need to draw conclusions.

### Standardization of Mortality Rates

As has been mentioned in the section on Principles of Epidemiology, the crude death rate (CDR) could be different among 2 communities simply because their age structures are different. Hence to scientifically compare the 2 CDRs after removing the confounding effect of age structure on mortality, we use the process called as standardization. Standardization can be done by two methods

(a) Direct method

(b) Indirect method.

Direct Method of Standardization

This is simple and preferred method to calculate the age adjusted mortality rates. To perform a direct standardization, one has to first select a standard population. This population is arbitrary, although conventionally one uses either the World Standard Population produced by the World Health Organization, or a census population for the country in which the work is being conducted. Next, one computes the age-specific rates within the study group. Then, one multiplies these age specific mortality rates by the number of people in that age group in the standard population to get the "expected" number of deaths in each age group in the standard population. These expected counts are summed and divided by the total population size of the standard population to yield the direct standardized rate. In other words the standardized crude death rate in direct method is the crude death rate experienced by standard population if it was exposed to the age specific death rate of the study population.

Indirect Method of Standardization

Indirect standardization uses the standard population to provide age-specific rates i.e. the age specific mortality rates of the standard population are applied to the age structure of the study population. Within each age stratum, one multiplies the age specific mortality rates of the standard population by the number of people in that age group in the study population to determine the "expected" number of deaths that would have been expected in each age group of the study population, had the age specific mortality rates of the standard population been applicable to them. These expected numbers are added up across all age groups. We now divide the observed number of deaths by the expected number of deaths. This ratio is multiplied with the crude death rate of the standard population to yield the Standardized Mortality Rates. In other words in indirect standardization, one computes the number of cases of deaths (or disease) that would have been expected if the death (or disease) rates from the standard population had applied in the study population. This is also known as standardized

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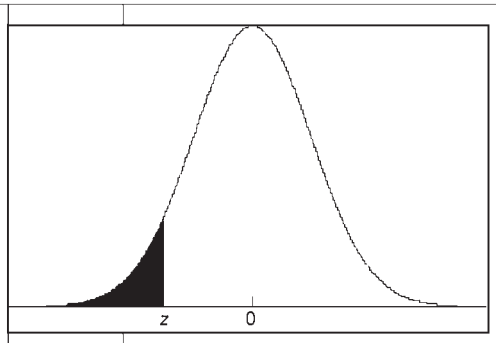
## Statistical Table A

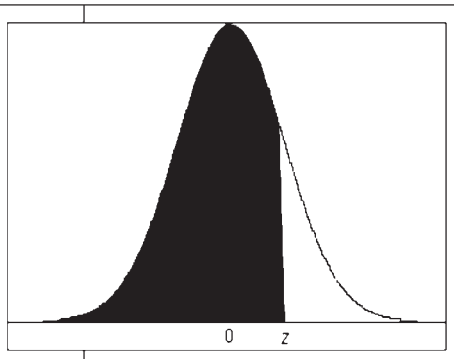
**Cumulative Probabilities for the Standard Normal (Z) Distribution**




Values in the table correspond to the area under the curve of a standard normal random variable for a value at or below *z*.

| z | 0.00 | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
|---|---|---|---|---|---|---|---|---|---|---|
| -5.0 | 0.0000003 | | | | | | | | | |
| -4.5 | 0.000003 | | | | | | | | | |
| -4.0 | 0.00003 | | | | | | | | | |
| -3.5 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 | 0.0002 |
| -3.4 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0003 | 0.0002 |
| -3.3 | 0.0005 | 0.0005 | 0.0005 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0004 | 0.0003 |
| -3.2 | 0.0007 | 0.0007 | 0.0006 | 0.0006 | 0.0006 | 0.0006 | 0.0006 | 0.0005 | 0.0005 | 0.0005 |
| -3.1 | 0.0010 | 0.0009 | 0.0009 | 0.0009 | 0.0008 | 0.0008 | 0.0008 | 0.0008 | 0.0007 | 0.0007 |
| -3.0 | 0.0013 | 0.0013 | 0.0013 | 0.0012 | 0.0012 | 0.0011 | 0.0011 | 0.0011 | 0.0010 | 0.0010 |
| -2.9 | 0.0019 | 0.0018 | 0.0018 | 0.0017 | 0.0016 | 0.0016 | 0.0015 | 0.0015 | 0.0014 | 0.0014 |
| -2.8 | 0.0026 | 0.0025 | 0.0024 | 0.0023 | 0.0023 | 0.0022 | 0.0021 | 0.0021 | 0.0020 | 0.0019 |
| -2.7 | 0.0035 | 0.0034 | 0.0033 | 0.0032 | 0.0031 | 0.0030 | 0.0029 | 0.0028 | 0.0027 | 0.0026 |
| -2.6 | 0.0047 | 0.0045 | 0.0044 | 0.0043 | 0.0041 | 0.0040 | 0.0039 | 0.0038 | 0.0037 | 0.0036 |
| -2.5 | 0.0062 | 0.0060 | 0.0059 | 0.0057 | 0.0055 | 0.0054 | 0.0052 | 0.0051 | 0.0049 | 0.0048 |
| -2.4 | 0.0082 | 0.0080 | 0.0078 | 0.0075 | 0.0073 | 0.0071 | 0.0069 | 0.0068 | 0.0066 | 0.0064 |
| -2.3 | 0.0107 | 0.0104 | 0.0102 | 0.0099 | 0.0096 | 0.0094 | 0.0091 | 0.0089 | 0.0087 | 0.0084 |
| -2.2 | 0.0139 | 0.0136 | 0.0132 | 0.0129 | 0.0125 | 0.0122 | 0.0119 | 0.0116 | 0.0113 | 0.0110 |
| -2.1 | 0.0179 | 0.0174 | 0.0170 | 0.0166 | 0.0162 | 0.0158 | 0.0154 | 0.0150 | 0.0146 | 0.0143 |
| -2.0 | 0.0228 | 0.0222 | 0.0217 | 0.0212 | 0.0207 | 0.0202 | 0.0197 | 0.0192 | 0.0188 | 0.0183 |
| -1.9 | 0.0287 | 0.0281 | 0.0274 | 0.0268 | 0.0262 | 0.0256 | 0.0250 | 0.0244 | 0.0239 | 0.0233 |
| -1.8 | 0.0359 | 0.0351 | 0.0344 | 0.0336 | 0.0329 | 0.0322 | 0.0314 | 0.0307 | 0.0301 | 0.0294 |
| -1.7 | 0.0446 | 0.0436 | 0.0427 | 0.0418 | 0.0409 | 0.0401 | 0.0392 | 0.0384 | 0.0375 | 0.0367 |
| -1.6 | 0.0548 | 0.0537 | 0.0526 | 0.0516 | 0.0505 | 0.0495 | 0.0485 | 0.0475 | 0.0465 | 0.0455 |
| -1.5 | 0.0668 | 0.0655 | 0.0643 | 0.0630 | 0.0618 | 0.0606 | 0.0594 | 0.0582 | 0.0571 | 0.0559 |
| -1.4 | 0.0808 | 0.0793 | 0.0778 | 0.0764 | 0.0749 | 0.0735 | 0.0721 | 0.0708 | 0.0694 | 0.0681 |
| -1.3 | 0.0968 | 0.0951 | 0.0934 | 0.0918 | 0.0901 | 0.0885 | 0.0869 | 0.0853 | 0.0838 | 0.0823 |
| -1.2 | 0.1151 | 0.1131 | 0.1112 | 0.1093 | 0.1075 | 0.1056 | 0.1038 | 0.1020 | 0.1003 | 0.0985 |
| -1.1 | 0.1357 | 0.1335 | 0.1314 | 0.1292 | 0.1271 | 0.1251 | 0.1230 | 0.1210 | 0.1190 | 0.1170 |
| -1.0 | 0.1587 | 0.1562 | 0.1539 | 0.1515 | 0.1492 | 0.1469 | 0.1446 | 0.1423 | 0.1401 | 0.1379 |
| -0.9 | 0.1841 | 0.1814 | 0.1788 | 0.1762 | 0.1736 | 0.1711 | 0.1685 | 0.1660 | 0.1635 | 0.1611 |
| -0.8 | 0.2119 | 0.2090 | 0.2061 | 0.2033 | 0.2005 | 0.1977 | 0.1949 | 0.1922 | 0.1894 | 0.1867 |
| -0.7 | 0.2420 | 0.2389 | 0.2358 | 0.2327 | 0.2296 | 0.2266 | 0.2236 | 0.2206 | 0.2177 | 0.2148 |
| -0.6 | 0.2743 | 0.2709 | 0.2676 | 0.2643 | 0.2611 | 0.2578 | 0.2546 | 0.2514 | 0.2483 | 0.2451 |
| -0.5 | 0.3085 | 0.3050 | 0.3015 | 0.2981 | 0.2946 | 0.2912 | 0.2877 | 0.2843 | 0.2810 | 0.2776 |
| -0.4 | 0.3446 | 0.3409 | 0.3372 | 0.3336 | 0.3300 | 0.3264 | 0.3228 | 0.3192 | 0.3156 | 0.3121 |
| -0.3 | 0.3821 | 0.3783 | 0.3745 | 0.3707 | 0.3669 | 0.3632 | 0.3594 | 0.3557 | 0.3520 | 0.3483 |
| -0.2 | 0.4207 | 0.4168 | 0.4129 | 0.4090 | 0.4052 | 0.4013 | 0.3974 | 0.3936 | 0.3897 | 0.3859 |
| -0.1 | 0.4602 | 0.4562 | 0.4522 | 0.4483 | 0.4443 | 0.4404 | 0.4364 | 0.4325 | 0.4286 | 0.4247 |
| -0.0 | 0.5000 | 0.4960 | 0.4920 | 0.4880 | 0.4840 | 0.4801 | 0.4761 | 0.4721 | 0.4681 | 0.4641 |

**Cumulative Probabilities for the Standard Normal (Z) Distribution**




Values in the table correspond to the area under the curve of a standard normal random variable for a value at or below *z*.

| z | 0.00 | 0.01 | 0.02 | 0.03 | 0.04 | 0.05 | 0.06 | 0.07 | 0.08 | 0.09 |
|---|---|---|---|---|---|---|---|---|---|---|
| 0.0 | 0.5000 | 0.5040 | 0.5080 | 0.5120 | 0.5160 | 0.5199 | 0.5239 | 0.5279 | 0.5319 | 0.5359 |
| 0.1 | 0.5398 | 0.5438 | 0.5478 | 0.5517 | 0.5557 | 0.5596 | 0.5636 | 0.5675 | 0.5714 | 0.5753 |
| 0.2 | 0.5793 | 0.5832 | 0.5871 | 0.5910 | 0.5948 | 0.5987 | 0.6026 | 0.6064 | 0.6103 | 0.6141 |
| 0.3 | 0.6179 | 0.6217 | 0.6255 | 0.6293 | 0.6331 | 0.6368 | 0.6406 | 0.6443 | 0.6480 | 0.6517 |
| 0.4 | 0.6554 | 0.6591 | 0.6628 | 0.6664 | 0.6700 | 0.6736 | 0.6772 | 0.6808 | 0.6844 | 0.6879 |
| 0.5 | 0.6915 | 0.6950 | 0.6985 | 0.7019 | 0.7054 | 0.7088 | 0.7123 | 0.7157 | 0.7190 | 0.7224 |
| 0.6 | 0.7257 | 0.7291 | 0.7324 | 0.7357 | 0.7389 | 0.7422 | 0.7454 | 0.7486 | 0.7517 | 0.7549 |
| 0.7 | 0.7580 | 0.7611 | 0.7642 | 0.7673 | 0.7704 | 0.7734 | 0.7764 | 0.7794 | 0.7823 | 0.7852 |
| 0.8 | 0.7881 | 0.7910 | 0.7939 | 0.7967 | 0.7995 | 0.8023 | 0.8051 | 0.8078 | 0.8106 | 0.8133 |
| 0.9 | 0.8159 | 0.8186 | 0.8212 | 0.8238 | 0.8264 | 0.8289 | 0.8315 | 0.8340 | 0.8365 | 0.8389 |
| 1.0 | 0.8413 | 0.8438 | 0.8461 | 0.8485 | 0.8508 | 0.8531 | 0.8554 | 0.8577 | 0.8599 | 0.8621 |
| 1.1 | 0.8643 | 0.8665 | 0.8686 | 0.8708 | 0.8729 | 0.8749 | 0.8770 | 0.8790 | 0.8810 | 0.8830 |
| 1.2 | 0.8849 | 0.8869 | 0.8888 | 0.8907 | 0.8925 | 0.8944 | 0.8962 | 0.8980 | 0.8997 | 0.9015 |
| 1.3 | 0.9032 | 0.9049 | 0.9066 | 0.9082 | 0.9099 | 0.9115 | 0.9131 | 0.9147 | 0.9162 | 0.9177 |
| 1.4 | 0.9192 | 0.9207 | 0.9222 | 0.9236 | 0.9251 | 0.9265 | 0.9279 | 0.9292 | 0.9306 | 0.9319 |
| 1.5 | 0.9332 | 0.9345 | 0.9357 | 0.9370 | 0.9382 | 0.9394 | 0.9406 | 0.9418 | 0.9429 | 0.9441 |
| 1.6 | 0.9452 | 0.9463 | 0.9474 | 0.9484 | 0.9495 | 0.9505 | 0.9515 | 0.9525 | 0.9535 | 0.9545 |
| 1.7 | 0.9554 | 0.9564 | 0.9573 | 0.9582 | 0.9591 | 0.9599 | 0.9608 | 0.9616 | 0.9625 | 0.9633 |
| 1.8 | 0.9641 | 0.9649 | 0.9656 | 0.9664 | 0.9671 | 0.9678 | 0.9686 | 0.9693 | 0.9699 | 0.9706 |
| 1.9 | 0.9713 | 0.9719 | 0.9726 | 0.9732 | 0.9738 | 0.9744 | 0.9750 | 0.9756 | 0.9761 | 0.9767 |
| 2.0 | 0.9772 | 0.9778 | 0.9783 | 0.9788 | 0.9793 | 0.9798 | 0.9803 | 0.9808 | 0.9812 | 0.9817 |
| 2.1 | 0.9821 | 0.9826 | 0.9830 | 0.9834 | 0.9838 | 0.9842 | 0.9846 | 0.9850 | 0.9854 | 0.9857 |
| 2.2 | 0.9861 | 0.9864 | 0.9868 | 0.9871 | 0.9875 | 0.9878 | 0.9881 | 0.9884 | 0.9887 | 0.9890 |
| 2.3 | 0.9893 | 0.9896 | 0.9898 | 0.9901 | 0.9904 | 0.9906 | 0.9909 | 0.9911 | 0.9913 | 0.9916 |
| 2.4 | 0.9918 | 0.9920 | 0.9922 | 0.9925 | 0.9927 | 0.9929 | 0.9931 | 0.9932 | 0.9934 | 0.9936 |
| 2.5 | 0.9938 | 0.9940 | 0.9941 | 0.9943 | 0.9945 | 0.9946 | 0.9948 | 0.9949 | 0.9951 | 0.9952 |
| 2.6 | 0.9953 | 0.9955 | 0.9956 | 0.9957 | 0.9959 | 0.9960 | 0.9961 | 0.9962 | 0.9963 | 0.9964 |
| 2.7 | 0.9965 | 0.9966 | 0.9967 | 0.9968 | 0.9969 | 0.9970 | 0.9971 | 0.9972 | 0.9973 | 0.9974 |
| 2.8 | 0.9974 | 0.9975 | 0.9976 | 0.9977 | 0.9977 | 0.9978 | 0.9979 | 0.9979 | 0.9980 | 0.9981 |
| 2.9 | 0.9981 | 0.9982 | 0.9982 | 0.9983 | 0.9984 | 0.9984 | 0.9985 | 0.9985 | 0.9986 | 0.9986 |
| 3.0 | 0.9987 | 0.9987 | 0.9987 | 0.9988 | 0.9988 | 0.9989 | 0.9989 | 0.9989 | 0.9990 | 0.9990 |
| 3.1 | 0.9990 | 0.9991 | 0.9991 | 0.9991 | 0.9992 | 0.9992 | 0.9992 | 0.9992 | 0.9993 | 0.9993 |
| 3.2 | 0.9993 | 0.9993 | 0.9994 | 0.9994 | 0.9994 | 0.9994 | 0.9994 | 0.9995 | 0.9995 | 0.9995 |
| 3.3 | 0.9995 | 0.9995 | 0.9995 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 0.9996 | 0.9997 |
| 3.4 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9997 | 0.9998 |
| 3.5 | 0.9998 | | | | | | | | | |
| 4.0 | 0.99997 | | | | | | | | | |
| 4.5 | 0.999997 | | | | | | | | | |
| 5.0 | 0.9999997 | | | | | | | | | |

## Statistical Table B

**t Distributions**

| cum probability | 0.80 | 0.90 | 0.95 | 0.975 | 0.99 | 0.995 | 0.999 | 0.9995 |
|---|---|---|---|---|---|---|---|---|
| right tail | 0.20 | 0.10 | 0.05 | 0.025 | 0.01 | 0.005 | 0.001 | 0.0005 |
| df | | | | | | | | |
| 1 | 1.38 | 3.08 | 6.31 | 12.71 | 31.82 | 63.66 | 318.29 | 636.58 |
| 2 | 1.06 | 1.89 | 2.92 | 4.30 | 6.96 | 9.92 | 22.33 | 31.60 |
| 3 | 0.98 | 1.64 | 2.35 | 3.18 | 4.54 | 5.84 | 10.21 | 12.92 |
| 4 | 0.94 | 1.53 | 2.13 | 2.78 | 3.75 | 4.60 | 7.17 | 8.61 |
| 5 | 0.92 | 1.48 | 2.02 | 2.57 | 3.36 | 4.03 | 5.89 | 6.87 |
| 6 | 0.91 | 1.44 | 1.94 | 2.45 | 3.14 | 3.71 | 5.21 | 5.96 |
| 7 | 0.90 | 1.41 | 1.89 | 2.36 | 3.00 | 3.50 | 4.79 | 5.41 |
| 8 | 0.89 | 1.40 | 1.86 | 2.31 | 2.90 | 3.36 | 4.50 | 5.04 |
| 9 | 0.88 | 1.38 | 1.83 | 2.26 | 2.82 | 3.25 | 4.30 | 4.78 |
| 10 | 0.88 | 1.37 | 1.81 | 2.23 | 2.76 | 3.17 | 4.14 | 4.59 |
| 11 | 0.88 | 1.36 | 1.80 | 2.20 | 2.72 | 3.11 | 4.02 | 4.44 |
| 12 | 0.87 | 1.36 | 1.78 | 2.18 | 2.68 | 3.05 | 3.93 | 4.32 |
| 13 | 0.87 | 1.35 | 1.77 | 2.16 | 2.65 | 3.01 | 3.85 | 4.22 |
| 14 | 0.87 | 1.35 | 1.76 | 2.14 | 2.62 | 2.98 | 3.79 | 4.14 |
| 15 | 0.87 | 1.34 | 1.75 | 2.13 | 2.60 | 2.95 | 3.73 | 4.07 |
| 16 | 0.86 | 1.34 | 1.75 | 2.12 | 2.58 | 2.92 | 3.69 | 4.01 |
| 17 | 0.86 | 1.33 | 1.74 | 2.11 | 2.57 | 2.90 | 3.65 | 3.97 |
| 18 | 0.86 | 1.33 | 1.73 | 2.10 | 2.55 | 2.88 | 3.61 | 3.92 |
| 19 | 0.86 | 1.33 | 1.73 | 2.09 | 2.54 | 2.86 | 3.58 | 3.88 |
| 20 | 0.86 | 1.33 | 1.72 | 2.09 | 2.53 | 2.85 | 3.55 | 3.85 |
| 21 | 0.86 | 1.32 | 1.72 | 2.08 | 2.52 | 2.83 | 3.53 | 3.82 |
| 22 | 0.86 | 1.32 | 1.72 | 2.07 | 2.51 | 2.82 | 3.50 | 3.79 |
| 23 | 0.86 | 1.32 | 1.71 | 2.07 | 2.50 | 2.81 | 3.48 | 3.77 |
| 24 | 0.86 | 1.32 | 1.71 | 2.06 | 2.49 | 2.80 | 3.47 | 3.75 |
| 25 | 0.86 | 1.32 | 1.71 | 2.06 | 2.49 | 2.79 | 3.45 | 3.73 |
| 26 | 0.86 | 1.31 | 1.71 | 2.06 | 2.48 | 2.78 | 3.43 | 3.71 |
| 27 | 0.86 | 1.31 | 1.70 | 2.05 | 2.47 | 2.77 | 3.42 | 3.69 |
| 28 | 0.85 | 1.31 | 1.70 | 2.05 | 2.47 | 2.76 | 3.41 | 3.67 |
| 29 | 0.85 | 1.31 | 1.70 | 2.05 | 2.46 | 2.76 | 3.40 | 3.66 |
| 30 | 0.85 | 1.31 | 1.70 | 2.04 | 2.46 | 2.75 | 3.39 | 3.65 |
| 31 | 0.85 | 1.31 | 1.70 | 2.04 | 2.45 | 2.74 | 3.37 | 3.63 |
| 32 | 0.85 | 1.31 | 1.69 | 2.04 | 2.45 | 2.74 | 3.37 | 3.62 |
| 33 | 0.85 | 1.31 | 1.69 | 2.03 | 2.44 | 2.73 | 3.36 | 3.61 |
| 34 | 0.85 | 1.31 | 1.69 | 2.03 | 2.44 | 2.73 | 3.35 | 3.60 |
| 35 | 0.85 | 1.31 | 1.69 | 2.03 | 2.44 | 2.72 | 3.34 | 3.59 |
| 36 | 0.85 | 1.31 | 1.69 | 2.03 | 2.43 | 2.72 | 3.33 | 3.58 |
| 37 | 0.85 | 1.30 | 1.69 | 2.03 | 2.43 | 2.72 | 3.33 | 3.57 |
| 38 | 0.85 | 1.30 | 1.69 | 2.02 | 2.43 | 2.71 | 3.32 | 3.57 |
| 39 | 0.85 | 1.30 | 1.68 | 2.02 | 2.43 | 2.71 | 3.31 | 3.56 |
| 40 | 0.85 | 1.30 | 1.68 | 2.02 | 2.42 | 2.70 | 3.31 | 3.55 |
| 50 | 0.85 | 1.30 | 1.68 | 2.01 | 2.40 | 2.68 | 3.26 | 3.50 |
| 100 | 0.85 | 1.29 | 1.66 | 1.98 | 2.36 | 2.63 | 3.17 | 3.39 |
| *z* | 0.84 | 1.28 | 1.64 | 1.96 | 2.33 | 2.58 | 3.09 | 3.29 |
| | 60% | 80% | 90% | 95% | 98% | 99% | 99.8% | 99.9% |
| | Confidence Level | | | | | | | |

## Statistical Table C

**Chi - Square Distributions**

| cum probability | 0.025 | 0.80 | 0.90 | 0.95 | 0.975 | 0.99 | 0.995 | 0.999 | 0.9995 |
|---|---|---|---|---|---|---|---|---|---|
| right tail | 0.975 | 0.2 | 0.1 | 0.05 | 0.025 | 0.01 | 0.005 | 0.001 | 0.0005 |
| df | | | | | | | | | |
| 1 | 0.00098 | 1.64 | 2.71 | 3.84 | 5.02 | 6.63 | 7.88 | 10.83 | 12.12 |
| 2 | 0.051 | 3.22 | 4.61 | 5.99 | 7.38 | 9.21 | 10.60 | 13.82 | 15.20 |
| 3 | 0.216 | 4.64 | 6.25 | 7.81 | 9.35 | 11.34 | 12.84 | 16.27 | 17.73 |
| 4 | 0.48 | 5.99 | 7.78 | 9.49 | 11.14 | 13.28 | 14.86 | 18.47 | 20.00 |
| 5 | 0.83 | 7.29 | 9.24 | 11.07 | 12.83 | 15.09 | 16.75 | 20.51 | 22.11 |
| 6 | 1.24 | 8.56 | 10.64 | 12.59 | 14.45 | 16.81 | 18.55 | 22.46 | 24.10 |
| 7 | 1.69 | 9.80 | 12.02 | 14.07 | 16.01 | 18.48 | 20.28 | 24.32 | 26.02 |
| 8 | 2.18 | 11.03 | 13.36 | 15.51 | 17.53 | 20.09 | 21.95 | 26.12 | 27.87 |
| 9 | 2.70 | 12.24 | 14.68 | 16.92 | 19.02 | 21.67 | 23.59 | 27.88 | 29.67 |
| 10 | 3.25 | 13.44 | 15.99 | 18.31 | 20.48 | 23.21 | 25.19 | 29.59 | 31.42 |
| 11 | 3.82 | 14.63 | 17.28 | 19.68 | 21.92 | 24.73 | 26.76 | 31.26 | 33.14 |
| 12 | 4.40 | 15.81 | 18.55 | 21.03 | 23.34 | 26.22 | 28.30 | 32.91 | 34.82 |
| 13 | 5.01 | 16.98 | 19.81 | 22.36 | 24.74 | 27.69 | 29.82 | 34.53 | 36.48 |
| 14 | 5.63 | 18.15 | 21.06 | 23.68 | 26.12 | 29.14 | 31.32 | 36.12 | 38.11 |
| 15 | 6.26 | 19.31 | 22.31 | 25.00 | 27.49 | 30.58 | 32.80 | 37.70 | 39.72 |
| 16 | 6.91 | 20.47 | 23.54 | 26.30 | 28.85 | 32.00 | 34.27 | 39.25 | 41.31 |
| 17 | 7.56 | 21.61 | 24.77 | 27.59 | 30.19 | 33.41 | 35.72 | 40.79 | 42.88 |
| 18 | 8.23 | 22.76 | 25.99 | 28.87 | 31.53 | 34.81 | 37.16 | 42.31 | 44.43 |
| 19 | 8.91 | 23.90 | 27.20 | 30.14 | 32.85 | 36.19 | 38.58 | 43.82 | 45.97 |
| 20 | 9.59 | 25.04 | 28.41 | 31.41 | 34.17 | 37.57 | 40.00 | 45.31 | 47.50 |
| 21 | 10.28 | 26.17 | 29.62 | 32.67 | 35.48 | 38.93 | 41.40 | 46.80 | 49.01 |
| 22 | 10.98 | 27.30 | 30.81 | 33.92 | 36.78 | 40.29 | 42.80 | 48.27 | 50.51 |
| 23 | 11.69 | 28.43 | 32.01 | 35.17 | 38.08 | 41.64 | 44.18 | 49.73 | 52.00 |
| 24 | 12.40 | 29.55 | 33.20 | 36.42 | 39.36 | 42.98 | 45.56 | 51.18 | 53.48 |
| 25 | 13.12 | 30.68 | 34.38 | 37.65 | 40.65 | 44.31 | 46.93 | 52.62 | 54.95 |
| 30 | 16.79 | 36.25 | 40.26 | 43.77 | 46.98 | 50.89 | 53.67 | 59.70 | 62.16 |
| 40 | 24.43 | 47.27 | 51.81 | 55.76 | 59.34 | 63.69 | 66.77 | 73.40 | 76.10 |
| 50 | 32.36 | 58.16 | 63.17 | 67.50 | 71.42 | 76.15 | 79.49 | 86.66 | 89.56 |
| 60 | 40.48 | 68.97 | 74.40 | 79.08 | 83.30 | 88.38 | 91.95 | 99.61 | 102.7 |
| 80 | 57.15 | 90.41 | 96.58 | 101.9 | 106.6 | 112.3 | 116.3 | 124.8 | 128.3 |
| 100 | 74.22 | 111.7 | 118.5 | 124.3 | 129.6 | 135.8 | 140.2 | 149.4 | 153.2 |

## Statistical Table D

**Random Number Table**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 10838 | 39674 | 89911 | 16909 | 83608 | 63979 | 66741 | 42709 | 46563 |
| 76944 | | | | | | | | |
| 64601 | 07625 | 01465 | 64301 | 71790 | 26366 | 62953 | 79705 | 33810 |
| 87546 | | | | | | | | |
| 54643 | 18925 | 93054 | 95890 | 38892 | 62488 | 70789 | 25861 | 03719 |
| 03970 | | | | | | | | |
| 77348 | 16408 | 55270 | 06117 | 61493 | 61510 | 89303 | 51985 | 34871 |
| 76215 | | | | | | | | |
| 40104 | 83291 | 32504 | 42842 | 30286 | 43155 | 95258 | 67060 | 69903 |
| 65423 | | | | | | | | |
| 85216 | 98509 | 78323 | 77764 | 69896 | 95662 | 27286 | 10722 | 36265 |
| 39615 | | | | | | | | |
| 28588 | 29907 | 20466 | 26485 | 14847 | 33531 | 64206 | 93115 | 86752 |
| 82449 | | | | | | | | |
| 33751 | 55762 | 25276 | 54916 | 62443 | 66464 | 92239 | 43236 | 02699 |
| 16769 | | | | | | | | |
| 67723 | 34495 | 98411 | 43515 | 97707 | 42557 | 13714 | 16347 | 50418 |
| 83529 | | | | | | | | |
| 79005 | 11664 | 04796 | 11857 | 40223 | 02676 | 19535 | 59259 | 22257 |
| 20256 | | | | | | | | |
| 56119 | 43690 | 42472 | 64297 | 54310 | 40488 | 35266 | 70226 | 83504 |
| 32941 | | | | | | | | |
| 73588 | 60392 | 18412 | 84417 | 98384 | 35002 | 12488 | 99278 | 91876 |
| 82296 | | | | | | | | |
| 67554 | 64737 | 55638 | 12651 | 23054 | 90869 | 79381 | 46283 | 13366 |
| 90955 | | | | | | | | |
| 11414 | 09278 | 66628 | 69337 | 66686 | 17579 | 43505 | 08991 | 33382 |
| 53675 | | | | | | | | |
| 39323 | 75978 | 63972 | 65640 | 98032 | 83002 | 61684 | 43222 | 11423 |
| 79214 | | | | | | | | |
| 98319 | 50678 | 02023 | 58482 | 24355 | 21029 | 13134 | 03311 | 57265 |
| 41429 | | | | | | | | |
| 54432 | 06585 | 59008 | 84337 | 76569 | 38336 | 38606 | 64179 | 73219 |
| 49716 | | | | | | | | |
| 40763 | 24174 | 33999 | 31368 | 06454 | 83040 | 96709 | 68371 | 16423 |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 96239 | | | | | | | | |
| 72332 | 58963 | 53537 | 11469 | 41213 | 89216 | 44909 | 23066 | 43871 |
| 80858 | | | | | | | | |
| 69761 | 55042 | 14891 | 54426 | 43936 | 27407 | 33293 | 74938 | 17011 |
| 85482 | | | | | | | | |
| 87873 | 72273 | 42944 | 96894 | 80898 | 53445 | 10201 | 45928 | 18629 |
| 48959 | | | | | | | | |
| 42278 | 79931 | 62099 | 60437 | 04587 | 87458 | 36577 | 01702 | 78616 |
| 12841 | | | | | | | | |
| 23165 | 50501 | 89317 | 36867 | 80958 | 53072 | 96652 | 78267 | 73213 |
| 48715 | | | | | | | | |
| 87237 | 95685 | 95952 | 06582 | 27022 | 94823 | 32451 | 91855 | 60943 |
| 70454 | | | | | | | | |
| 82041 | 03514 | 70485 | 37985 | 36667 | 50861 | 25091 | 34252 | 03632 |
| 61015 | | | | | | | | |
| 88355 | 92247 | 97975 | 34543 | 64945 | 19461 | 52918 | 91425 | 99176 |
| 34515 | | | | | | | | |
| 21806 | 74545 | 61188 | 41797 | 70002 | 02872 | 81656 | 48758 | 80149 |
| 91556 | | | | | | | | |
| 20975 | 55582 | 19259 | 81095 | 83846 | 71903 | 41044 | 42770 | 15231 |
| 40263 | | | | | | | | |
| 21954 | 52543 | 38566 | 70988 | 54325 | 50596 | 22218 | 18191 | 45111 |
| 28703 | | | | | | | | |
| 85089 | 51557 | 93609 | 12622 | 77329 | 03640 | 46631 | 31689 | 97070 |
| 97309 | | | | | | | | |
| 54546 | 92819 | 29149 | 83084 | 76654 | 01076 | 16724 | 41000 | 09300 |
| 94014 | | | | | | | | |
| 01754 | 26721 | 35183 | 81988 | 95253 | 66582 | 17299 | 11590 | 63272 |
| 31238 | | | | | | | | |
| 85944 | 94433 | 39537 | 42614 | 92225 | 68449 | 00686 | 93847 | 26511 |
| 83890 | | | | | | | | |
| 65048 | 86902 | 25259 | 31229 | 00884 | 17551 | 14667 | 53141 | 55042 |
| 62400 | | | | | | | | |
| 64566 | 07756 | 37967 | 47665 | 51022 | 75362 | 25983 | 04358 | 51045 |
| 25764 | | | | | | | | |
| 66807 | 39597 | 17885 | 88457 | 99223 | 78718 | 10317 | 92847 | 22848 |
| 57867 | | | | | | | | |

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 74376 97288 | 70644 | 78935 | 71771 | 00968 | 37679 | 28158 | 06380 | 07794 |
| 36289 17457 | 11045 | 19039 | 32468 | 03741 | 89949 | 41237 | 78992 | 99881 |
| 58775 81945 | 96668 | 88083 | 07075 | 97464 | 80930 | 52419 | 88715 | 29610 |
| 61967 79784 | 73958 | 19022 | 23434 | 33644 | 13965 | 29412 | 38380 | 79516 |
| 44599 59515 | 63827 | 49516 | 19684 | 73974 | 61937 | 05509 | 73239 | 41654 |
| 87642 59263 | 46835 | 82761 | 23171 | 58925 | 80287 | 95276 | 12317 | 38956 |
| 20894 54852 | 77185 | 62758 | 53191 | 53308 | 94052 | 25645 | 83344 | 97397 |
| 00063 50012 | 50788 | 27707 | 53380 | 35336 | 78882 | 19694 | 35263 | 76266 |
| 52164 93395 | 03882 | 61518 | 41259 | 04339 | 99445 | 87718 | 88667 | 95976 |
| 50227 57582 | 34832 | 44018 | 65324 | 96496 | 39452 | 34156 | 54608 | 52973 |
| 30791 36857 | 03929 | 11465 | 15231 | 73803 | 36884 | 85922 | 37016 | 35578 |
| 75571 44459 | 05560 | 36721 | 19356 | 95323 | 57307 | 43905 | 14986 | 59411 |
| 98282 97519 | 05260 | 29189 | 17703 | 47898 | 78429 | 61024 | 09437 | 82549 |
| 15226 00274 | 22165 | 94521 | 97756 | 11952 | 51760 | 13639 | 55584 | 45015 |
| 90071 54590 | 96443 | 89545 | 57984 | 23338 | 33513 | 64438 | 59374 | 60922 |
| 35516 72654 | 42718 | 14975 | 99311 | 70361 | 67973 | 70508 | 93881 | 80740 |
| 83534 21042 | 35519 | 13563 | 70391 | 92580 | 43793 | 76317 | 21841 | 92024 |
| 07913 19662 | 32658 | 40684 | 89058 | 30871 | 58201 | 04093 | 94240 | 45802 |
| 53911 | 98376 | 54105 | 61312 | 72897 | 97267 | 19826 | 03550 | 38889 |

34372

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 06611 69745 | 71427 | 86220 | 01651 | 50706 | 03371 | 68021 | 44810 | 55915 |
| 67835 69740 | 15129 | 21479 | 55981 | 33983 | 35052 | 38793 | 89938 | 35127 |
| 17920 00152 | 18189 | 60459 | 21770 | 29817 | 60924 | 12956 | 91157 | 75225 |
| 69140 98890 | 67908 | 16162 | 80889 | 03778 | 49272 | 30940 | 30028 | 02963 |
| 78664 69736 | 22562 | 14009 | 90031 | 84138 | 49871 | 05602 | 00085 | 79120 |
| 36642 43322 | 48525 | 60857 | 42785 | 57213 | 95511 | 53848 | 85046 | 90118 |
| 85767 67097 | 91313 | 66425 | 07807 | 13484 | 08988 | 13442 | 52051 | 60111 |
| 18583 95131 | 99430 | 49043 | 90191 | 17544 | 68245 | 45880 | 51766 | 80235 |
| 44224 59985 | 46949 | 92903 | 39420 | 56241 | 89091 | 59884 | 85652 | 93960 |
| 73416 03972 | 86414 | 52221 | 68380 | 24971 | 12698 | 29227 | 96480 | 56508 |
| 45631 56918 | 39129 | 75122 | 35139 | 48095 | 65345 | 79502 | 42583 | 08254 |
| 71640 53558 | 76478 | 53036 | 03742 | 52239 | 71564 | 87264 | 60563 | 23244 |
| 94477 16941 | 94860 | 45942 | 23401 | 26917 | 80508 | 28066 | 86525 | 20607 |
| 38335 76164 | 19327 | 96470 | 78482 | 71887 | 90036 | 33425 | 23548 | 15009 |
| 24372 68467 | 18391 | 82636 | 45725 | 51053 | 55091 | 27039 | 94408 | 38679 |
| 41130 78543 | 55906 | 76286 | 81601 | 04852 | 27562 | 13751 | 34669 | 48060 |
| 71399 23138 | 76753 | 28345 | 32725 | 23165 | 25332 | 47243 | 43457 | 39200 |

# Quantitative Sciences

## Statistical Software


## Authors

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37 Introduction to Statistical Software for Analysis of Epidemiological & Medical Research : Epi - 2002

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# Introduction to Statistical Software for Analysis of Epidemiological and Medical Research : Epi - 2002

## Overview of Epi Info

Epi Info is a package which is most suitable for doctors and researchers. It is a package which sufficies for nearly all the usual clinical research and epidemiological settings. Epi Info is a public domain database and statistics program for performing statistical applications in clinical research. Statistics, graphs, tables, and maps can be produced with simple commands. **Epi Info is free, downloadable software provided by the CDC** (www.cdc.gov/epiinfo/) and has been developed as a joint collaboration between WHO and CDC, Atlanta. In our experience Epi-Info 2002 is the best for all the statistical requirements of most clinical researchers and epidemiologists and it would be worthwhile that we master the use of this programme.

We are providing a copy of EPI 2002 in a CD alongwith this book. A file (sample.dbf) is also given in the CD for you to practice analysis with EPI.

A word of caution, however, is required. Statistical software are actually "enlarged calculators", which make easy your problems of calculation. However, they can never substitute for the essential knowledge of epidemiology, research methodology and bio-statistics. In fact, inadvertent use of statistical software without adequate background of research methodology and biostatistics may create more problems than do good. Secondly, please do remember that no statistical software can substitute for accurate, valid and reliable data. In the field of Information Technology, there is an old saying "Garbage In, garbage Out" (GIGO) !

## Installing Epi Info 2002

You will need to uninstall any earlier versions of EPI that may already be on your system.

(a) On your desktop, click **Start**, then **Programs**, then **Epi Info 2000**, then **Uninstall Epi Info 2000**.

(b) Continue to follow the instructions on your screen.

(c) When this is complete, install the new Epi Info.

### Installation from the Internet

**Step 1** : Log on to CDC's website at www.cdc.gov/epiinfo/epiinfo.htm

**Step 2** : Click the **Download** button to perform a Web Install of the latest Epi Info.

**Step 3** : Save the file to a temporary folder on your hard drive (anywhere except where Epi Info will be stored).

**Step 4** : Go to this temporary folder and double click the **Setupweb.exe** icon for a complete installation by following the directions on your screen. You must be connected to the Internet while this installation occurs. Web Install will NOT result in a copy of setup files after the installation is complete. This means that you will not be able to install the program onto another system with these files. To do so, you must download the Complete Installation Package, then save onto a CD-ROM.

**Step 5** : Begin using Epi Info

### Installation from a CD-ROM

**Step 1** : Insert disc in CD-ROM drive.

**Step 2** : Open **My Computer**, click on **(E:) (CD Drive)**

**Step 3** : Click on **Epi Info** folder and select **Full Version** folder

**Step 4** : Click on **Setup** icon. The Installation Wizard should begin. Follow the instructions as they appear. Most of your selections should be **OK** and **Next.**

**Step 5** : Click **OK** to put Epi Info icon on your desktop. Make sure icon is on your desktop; double click to make sure it works.

**Step 6** : Begin using Epi Info.

## How to Run Epi Info

Once Epi Info is installed on your computer, the easiest way to "run" the software is clicking the Epi Info icon on


your desktop. The Epi Info main menu should then appear:

### Main Menu

The main programs of Epi Info can be accessed either through the PROGRAMS menu or by clicking on the buttons. The components of the Main Menu of Epi Info 2002 are -

MakeView, Enter Data, Analyze Data, Epi Map, Nutrition, Epi Info Website and Exit

Though all these programs are being mentioned we would concentrate on two major programs- Statcalc (assessed

through Utilities) and Analyze Data because these are the major requirements for epidemiologists and clinical researchers.

**Statcalc**

Statcalc is assessed through the dropdown menu in Utilities on the top of the main menu. Statcalc is an epidemiologic calculator that gives various statistical analysis of the data entered in the table form which appears on the screen. Three types of analysis are offered.

(a) Tables (2 x 2, 2 x n)

(b) Sample size and power

(c) Chi square for trend

Each option can be assessed by pressing <Enter>.


**Tables**

It provides statistical analysis of tables (from 2 x 2 to 2 x 9 tables) along with the exact confidence limits for odds ratios. Stratified analysis of 2-by-2 tables can be carried out to produce odds ratios and risk ratios (relative risks) with confidence limits. Several types of chi-square tests, Fisher exact tests, Mantel Haenszel summary odds ratios and associated p values are provided.

Single 2-by-2 Tables

2-by-2 tables are frequently used in medical research to explore associations between EXPOSURE (to risk factors or the intervention in a clinical trial) and DISEASE (or other outcomes, if the outcome is not a disease but rather improvement from disease as may occur in a clinical trial). The table in STATCALC is set up with EXPOSURE on the left and DISEASE across the top. STATCALC produces results that test for relationships between EXPOSURE and DISEASE. The 2X2 layout is given in Table - 1.

Table - 1 : 2 X 2 Table

| | Disease present (D+) | Disease Absent (D-) | Total |
|---|---|---|---|
| Exposure present(E+) | a | b | a+b |
| Exposure Absent(E-) | c | d | c+d |
| Total | a+c | b+d | a+b+c+d |

The details of 2 X 2 table have already been covered in detail in the sections on Epidemiology and Research Methodology. When a 2 x 2 table appears on the screen we need to enter four numbers in the table. To do this enter the number in the first cell and press <Enter>, the cursor goes in the next cell. Again enter the next cell entry and press <Enter> to go to the next cell. (If any entry is wrongly entered this option does not allow you to edit hence you have to keep on pressing <Enter> till we are back to the empty 2 x 2 table). After the entry in the 4$^{th}$ cell press <Enter> or <F4> to calculate the single table statistics showing associations between EXPOSURE to the risk factor and DISEASE or other outcomes. Generally an association is suggested by an odds ratio or relative risk. The statistical significance is interpreted by 'p' values for chi square tests.

Pressing <Enter> or <F4> displays the statistical result which gives all the summary statistics i.e. Odds ratio along with the 95% confidence interval, Relative Risk along with 95% confidence interval. Remember that only one of these will be appropriate so don't quote both. You will also get some test statistics, such as $X^2$ values. If the computer says that Cornfield not accurate, you can generally ignore this, but take advice from Epidemiologist or Statistician. Depending on the study design (a case-control or a cohort or a cross sectional design) we should select summary statistics (as either OR or RR). Generally, an association is suggested by an odds ratio or relative risk larger or smaller than 1.0. The further the odds ratio or relative risk is from 1.0, the stronger the apparent association. The significance is assessed by the p value. Whenever $p<0.05$ it is considered to be statistically significant; also when the confidence limits for the odds ratio do not include 1.0 it is significant. Whenever the frequencies entered in the table are very small (<5) the program recommends Fisher Exact Test Results and the Exact confidence limits to be used.

Consider an example where we picked up 100 diagnosed patients of IHD from our Cardiology centre and another 100 subjects from the same centre in whom IHD had been excluded (Total = 200). We took the history from each and every one regarding smoking. Suppose we observed from our data that out of the 100 IHD cases, 80 were smokers and 20 non-smokers; while out of 100 healthy (non-IHD) subjects, there were 20 smokers and 80 non smokers. We would then consolidate our data into a '2 X 2' table. Data is given in Table - 2

Table - 2

| | Disease present (D+) | Disease Absent (D-) | Total |
|---|---|---|---|
| Exposure present(E+) | 80 | 20 | 100 |
| Exposure Absent(E-) | 20 | 80 | 100 |
| Total | 100 | 100 | 200 |

Once we enter this data, press <Enter> or <F4> to get the table statistics.

Analysis of Single Table
**Odds ratio = 16.00 (7.60<OR<34.18)**
Cornfield 95% confidence limits for OR
Relative Risk = 4.00 (2.67<RR<5.99)
Taylor Series 95% confidence limits for RR
Ignore relative risk if case control study.

| | Chi-Squares | P-values |
|---|---|---|
| Uncorrected : | 72.00 | 0.0000000 |
| Mantel-Haenszel : | 71.64 | 0.0000000 |
| Yates corrected : | 69.62 | 0.0000000 |

F2 More Strata; <Enter> No more Strata; F10 Quit

On pressing <Enter> or <F4> following analysis is provided

The output given by the software includes the odds ratio as well as the relative risk along with the 95% confidence interval (which is shown in parentheses after the value of OR or RR. Depending on our study design we select between the two estimates. If the study design is a case control study (as was in this example) then select odds ratio (OR) along with 95% confidence limits. If the study design is a cohort study then select RR and if cross sectional then also select the odds ratio which is approximately equal to the prevalence odds ratio. Whether you select the RR or OR, also select the chi square along with the p value for mentioning in your results. To be on the safer side, select Mantel-Haenszel Chi-square along with the p value.

### Stratified Analysis of 2by2 tables

Associations between DISEASE and EXPOSURE can be missed or falsely detected if CONFOUNDING is present. A confounding factor is one that is associated with both the DISEASE and the EXPOSURE. Age is a frequent confounder. Any factor other than the main EXPOSURE being considered can be treated as a confounder. For details on confounding and its control refer to chapter on confounding in Research Methodology section.

Stratification means making a separate table of DISEASE by EXPOSURE for each possible combination of confounders. In the simplest case, this could mean separate tables for males and females, if SEX is the potential confounder. If AGE, SEX, and CITY are confounders, separate tables would be made for each possible combination of age, sex and city. The Mantel-Haenszel weighted odds ratio, relative risk, summary chi square and p value combine results from different strata to remove confounding caused by the variables used for stratification. Thus, if tables are entered for males and females, confounding by SEX will be removed. The degree of confounding can be judged by comparing the crude and weighted odds ratios; if they are identical, there was no confounding by SEX. The approximate and exact confidence limits provide additional measures. If the weighted odds ratio or relative risk has confidence limits that do not include 1.0, then there is a significant statistical association between the DISEASE and the EXPOSURE, after controlling for confounding by the stratifying factor.

Consider following example. A study was done to see whether consumption of alcohol is a risk factor for oral cancer. 100 cases of oral CA and 100 healthy subjects were asked regarding history of alcohol consumption during past 15 years. The results are shown in Table - 3.

Table - 3

| History of Alcohol | Oral cancer | | |
|---|---|---|---|
| | Present | Absent | Total |
| Present | 80 | 20 | 100 |
| Absent | 20 | 80 | 100 |
| Total | 100 | 100 | 200 |

Analysis of Single Table
**Odds ratio = 16.00 (7.60<OR<34.18)**
Cornfield 95% confidence limits for OR
Relative Risk = 4.00 (2.67<RR<5.99)
Taylor Series 95% confidence limits for RR
Ignore relative risk if case control study.

| | Chi-Squares | P-values |
|---|---|---|
| Uncorrected : | 72.00 | 0.0000000 |
| Mantel-Haenszel : | 71.64 | 0.0000000 |
| Yates corrected : | 69.62 | 0.0000000 |

F2 More Strata; <Enter> No more Strata; F10 Quit

(Also see chapter on Confounding in the section on Research Methodology). Enter the four numbers in the 2 X 2 table on the screen.

Press <Enter> or <F4>. On pressing <Enter> or <F4> the following output is given.

Since above is a case control study we select **odds ratio = 16** which concludes that the risk of getting oral cancer is 16 times higher if a person drinks alcohol.

Now we also know that tobacco use is related to oral cancer. Hence stratifying the data by Tobacco status, we have two tables, one for tobacco users and the other for non-users of tobacco. This becomes stratified 2 X 2 tables with 2 stratums. In this case enter the four numbers for the first stratum and press <F4> or <Enter> to calculate the related statistics. Press <F2> to enter another stratum. Enter the four numbers for this second stratum and press <F4> or <Enter>. Repeat the process for all the stratums available. Pressing <Enter> when there are no more stratums will present the stratified analysis summary for all strata entered. Pressing <Enter> again will then offer an opportunity to do exact confidence limits. Stratified

analysis are not done for tables larger than 2-by-2

| History of Alcohol | Oral cancer | | |
|---|---|---|---|
| | Present | Absent | Total |
| Present | 60 | 15 | 75 |
| Absent | 20 | 5 | 25 |
| Total | 80 | 20 | 100 |

Analysis of Single Table
**Odds ratio = 1.00 (0.28<OR<3.46*)**
Cornfield 95% confidence limits for OR
*Cornfield not accurate. Exact limits preffered.
Relative Risk = 1.00 (0.80<RR<1.25)
Taylor Series 95% confidence limits for RR
Ignore relative risk if case control study.

| | Chi-Squares | P-values |
|---|---|---|
| Uncorrected : | 0.00 | 1.0000000 |
| Mantel-Haenszel : | 0.00 | 1.0000000 |
| Yates corrected : | 0.08 | 0.7728300 |

F2 More Strata; <Enter> No more Strata; F10 Quit

In the example considered the stratums for Tobacco users and non-Tobacco users are as follows. Substituting the values for first stratum and pressing <Enter> or <F4>

| History of Alcohol | Oral cancer | | |
|---|---|---|---|
| | Present | Absent | Total |
| Present | 5 | 20 | 25 |
| Absent | 15 | 60 | 75 |
| Total | 20 | 80 | 100 |

yields the following output

**Stratum I : Tobacco users**

Since we have one more stratum of non-Tobacco users we press <F2>.

**Stratum II : Non users of Tobacco**

On pressing <F2> another 2 X 2 table appears on the screen. Enter all the four cell values for non-Tobacco users and press <Enter>. The following output appears on the screen.

Analysis of Single Table
**Odds ratio = 1.00 (0.28<OR<3.46*)**
Cornfield 95% confidence limits for OR
*Cornfield not accurate. Exact limits preferred.
Relative Risk = 1.00 (0.40<RR<2.47)
Taylor Series 95% confidence limits for RR
Ignore relative risk if case control study.

| | Chi-Squares | P-values |
|---|---|---|
| Uncorrected : | 0.00 | 1.0000000 |
| Mantel-Haenszel : | 0.00 | 1.0000000 |
| Yates corrected : | 0.08 | 0.7728300 |

F2 More Strata; <Enter> No more Strata; F10 Quit

Stratified Analysis
**Summary of 2 Tables**
Crude odds ratio for all strata = 3.45
Mantel-Haenszel Weighted Odds Ratio = 1.00
Cornfield 95% Confidence Limits
0.41 < 1.00 < 2.37
Mantel-Haenszel Summary Chi Square = 0.04
P Value = 0.83907676
Crude RR for all strata = 1.86
Mantel-Haenszel Weighted Relative Risk
Of Disease, given Exposure = 1.00
Greenland / Robins Confidence Limits =
0.77 < MHRR < 1.29
<Enter> for more; F10 to quit

Since no more stratum are available press <Enter>. On pressing <Enter> the stratified analysis or the summary of 2 tables appears on the screen as follows:

**The odds ratio for each table is 1.0 and the Mantel-Haenszel summary odds ratio is 1.0.** The crude odds ratio and the Mantel Haenszel summary odds ratio are quite different, leading to the conclusion that use of tobacco was a confounding factor and that there appears to be no risk of cancer due to alcohol after considering the effect of tobacco.

### Sample Size & power

Determining sample size is a very important issue, as already emphasized in the section of biostatistics. In the sample size calculations, an initial screen explains the data items and allows input of a single set of values.


Pressing <F4> then shows the results on the second screen. On pressing Sample size & power three options are

made available

(a) Population Survey

(b) Cohort or cross-sectional

(c) Unmatched case-control

**The screen is as follows**

Sample size calculations are possible by both **Statcalc** as well as **EpiTable**. However if you are calculating the sample size for population survey, we recommend that you use EpiTable programme that is separately given for sample size calculations, and not Statcalc. For cohort, cross sectional and unmatched case-control design you can calculate by either EpiTable or Statcalc. For matched pair case-control design calculate sample size using Epi Table.

Population Survey

We recommend the use of EpiTable, described later.

Cohort or cross-sectional studies

For this type of study the proportion of disease in the unexposed group and the relative risk that the study anticipates to detect needs to be specified. Also the confidence interval along with desired power of the study requires to be specified. Once all the specifications are filled up, pressing <F4> calculates the minimum required sample size for our study.

Consider following study. We want to try acetazolamide as a prophylactic therapy against the development of High Altitude Pulmonary Oedema (HAPO). Our background information based on available data tells us that till now people have not been taking Diamox (i.e., are `not exposed' to Diamox) and 10 out of every thousand such persons develop HAPO; thus proportion of `outcome' (HAPO) among those who are `not exposed' (i.e., not taking Diamox) is 10/1000 = 0.01 or 1%.

Considering the cost and problems of logistics, we would say that putting this prophylactic therapy into routine preventive use will be worthwhile only if Diamox reduces the load of HAPO by at least 50%; thus the minimum detectable RR = 0.5. We specify an alpha error of 0.05 (two tailed) (i.e., confidence level of 95%) and beta error of 0.20 i.e. power of 80%.

Substituting the required values as above the required minimum sample size is obtained by pressing <F4>. The result screen is as follows.

Thus we would require a total of 10130 subjects to be studied, 5065 subjects who would get Diamox and another 5065 subjects who would not get any drug.

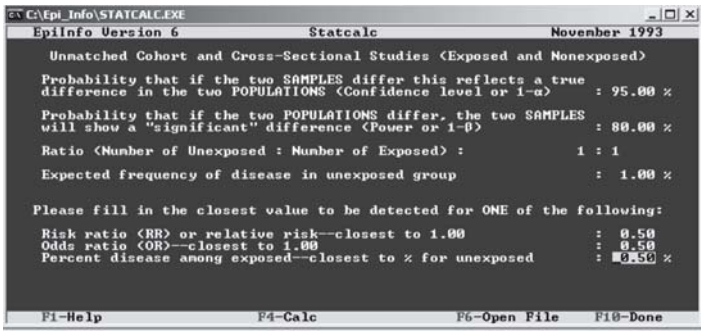
Case-control study

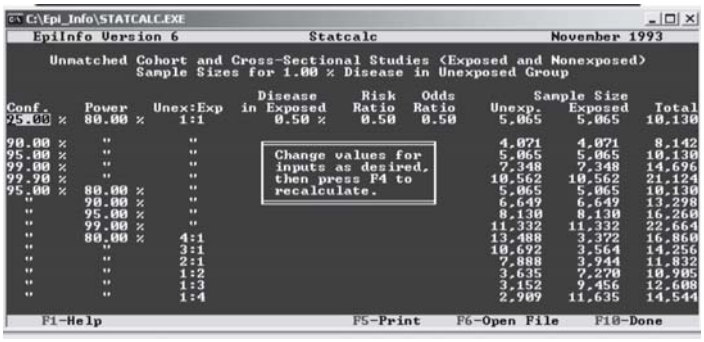
This option deals with the sample size determination when the study design is case control study. For this type of study the proportion of exposure in the not ill group (control) and the odds ratio that the study anticipates to detect needs to be specified. Also the confidence interval along with desired power of the study requires to be specified. Once all the specification is filled up pressing <F4> calculates the minimum required sample size for our study.

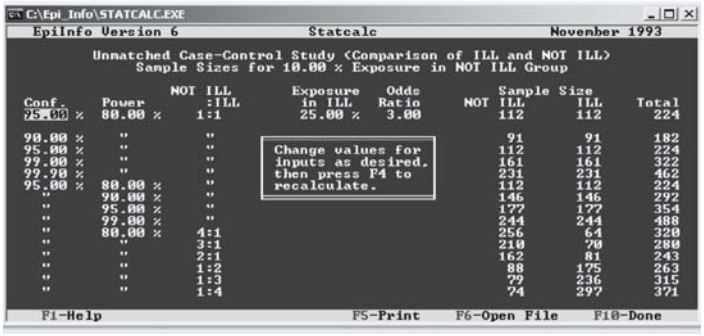
Continuing the same situation of HAPO, a research study wanted to find out whether even a slight physical exertion during first 24 hours of entry into high attitude may be associated with the development of HAPO. To proceed with this question as a case-control study, we want to take up cases of HAPO admitted to the hospital and healthy subjects who did not develop HAPO as a control group. Our background information from pilot study gives an indication that out of the healthy persons who did not develop HAPO (i.e., in whom outcome is absent), about 10% did engage in physical exertion within 24 hours after entry into high altitude (i.e., had the `exposure' to physical exertion); thus percentage of exposure among controls is 10% or 0.1. We think that physical exertion during first 24 hours should carry at least 3 times higher risk for developing HAPO; a risk less than this may not have public health significance since the administrators may not agree to “waste” so many man-days in rest if the risk is not really high (3 times). Thus, the minimum detectable OR that we choose is 3.

Once all the required information is substituted in the Case-control study screen and press <F4> the required minimum sample size is displayed on the screen as under.

Thus a total of 224 subjects are needed. In other words we



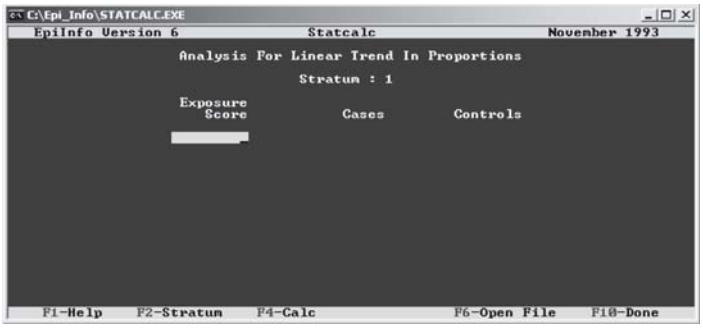



will we will need 112 cases OF HAPO and another 112 healthy controls to do this study.

**Chi Square for Trend**

Many times the variables of interest are measured on qualitative polychotomous ordinal scale, i.e., there are more than two exposure categories and these multiple




categories have a definite common-sense ordering . In such situations, it is advisable to do the chi-square test for linear trend in proportions and not a simple chi-square test for rXc contingencey table. The Chi Square for trend tests whether the odds (risk) increase or decrease in each group with respect to the first group, which is taken as the baseline for comparison. Epi calculates the chi-square for trend there are at least three or more exposure levels and which have a sensible ordering of categories. For this we have to choose Chi square for trend and press return (<enter>). The screen looks as under

You have to choose an exposure score. The first category should be your unexposed (or least exposed) group. Choose 1 as their exposure score, then go on to fill in the cases and controls columns, which refer to the outcome. Fill in your next group as the next least exposed. Typically their exposure score would be 2 and the next group's 3 and so on. When you have entered all your data, press F4 which will calculate the $X^2_{trend}$

This statistic always has 1 degree of freedom. Also the p value is given to you. When finished press F10 to exit.

Consider an example to understand this concept in detail. Suppose we have a hypothetical cohort study, which was undertaken to assess whether smoking by mothers during pregnancy is a possible determinant of congenital malformations in the foetus. Let us assume that a total of

| Exposure Category (Exposure | Smoking habits during pregnancy (Exposure score) | Status of delivered child | |
|---|---|---|---|
| | | Congenital Malformation (cases) | Normal (controls) |
| 1 | Non-smokers | 81 | 1995 |
| 2 | 1 to 10 cigg/day | 10 | 162 |
| 3 | 11 20 cigg/day | 28 | 115 |
| 4 | > 20 cigg/day | 21 | 50 |
| | Total | 140 | 2322 |

2462 pregnant ladies were taken up and their average daily cigarette consumption was assessed. 2076 ladies

**Analysis for Linear Trend In Proportions**

Chi Square for linear trend : 128.167
p value : 0.00000

| Exposure Score | Odds Ratio |
|---|---|
| 1.00 | 1.00 |
| 2.00 | 1.52 |
| 3.00 | 6.00 |
| 4.00 | 10.34 |

were non smokers, while 172, 143 and 71 were smoking upto 10 cigarettes, 11 to 20 and more than 20 cigarettes per day respectively. It was observed that 81 (i.e. 3.09%) of the non-smoker mothers delivered congenitally malformed children. The proportion of such malformed children increased progressively. It was 10, 28and 21 as the smoking category increased respectively. Putting the following information in a table form we have the following, which is clearly an qualitative, ordinal, polychotomous data :

After entering all the numbers in the table, pressing <F4> gives the following output

Interpretation

There exist highly significant linear trend in the odds of successive levels of the smoking and congenital malformation. The odds of congenital malformation in ladies who are smoking 11-20 cigg/day increases by 6 times and in ladies who smoke > 20 cigg/day the odds increases by more than 10 times as compared to non


smokers. In addition with a p value of < 0.0001, this overall 'trend' (of increasing risk of congenital malformation with increasing smoking) is statistically very highly significant.

## Epitable

EPITABLE is statistical calculator with many statistical functions and graphs which you should become acquainted with to carry out various research analysis. EPITABLE is separately given in the CD with this book. This programme can be accessed by first pressing on the EPI6 icon and then subsequently pressing EPITABLE calculator through Programs. The EPITABLE appears as below.

The components of Epitable are:

(a) Describe
(b) Compare
(c) Study
(d) Sample
(e) Probability
(f) Setup

**Describe**

This option calculates confidence intervals around an estimate of a proportion, a mean, or a median.

Proportion

| **Simple random sampling** | |
|---|---|
| Numerator | : 12 |
| Total observations | : 997 |
| Proportion | : 1.2036% |
| Fleiss quadratic 95% CI | [0.6534 2.1552] |
| Exact binomial 95% CI | [0.6234 2.0930] |
| Mid-p 95% CI | [0.6538 2.0372] |
| **Select the Exact binomial 95% CI** | |

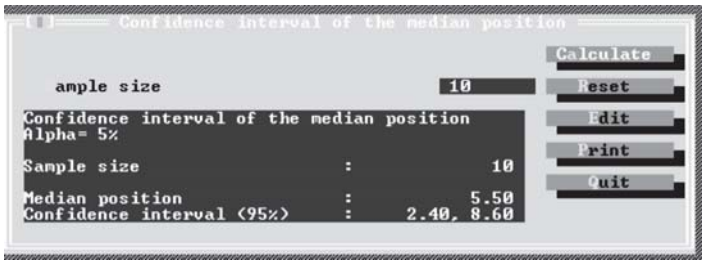
Confidence interval is calculated for proportions estimated from simple random samples or cluster samples. Three methods for calculating confidence intervals of a proportion are presented. These are Fleiss quadratic, exact binomial and mid-p.

**Example :** Suppose in a survey we wish to detect the seropositivity for HIV in blood donors. Total of 997 cases are considered. Out of these 12 are found to be positive. In the describe dropdown menu select the proportion option and then select Simple random sampling. Substitute 12 in the numerator and 997 in the denominator. On pressing calculate, the following output is given.

Mean

This command provides the confidence interval of a mean using the alpha risk specified in the setup option. The inputs required are the mean and the standard deviation values for the given data. If the size of the population from which the sample is taken is not known, we should use the default maximum value of 999999999.

Let us consider an hypothetical example where 10 volunteers are weighed in a consistent manner before they start consuming an experimental diet. Weights in kg for these 10 volunteers are as follows, 81, 79, 92, 112, 76, 126, 80, 75, 68, 78. We calculate the mean in the usual manner by adding all the observations (weights) and then dividing by 10 to give us the mean weight as 86.7. Similarly we calculate the standard deviation which is equal to 18.33. Now if we wish to calculate the 95% confidence interval for mean we select 'Mean' and substitute the requisite information, i.e. value of mean as 86.7, Sample standard deviation as 18.33 along with the sample size as 10. On pressing calculate following output

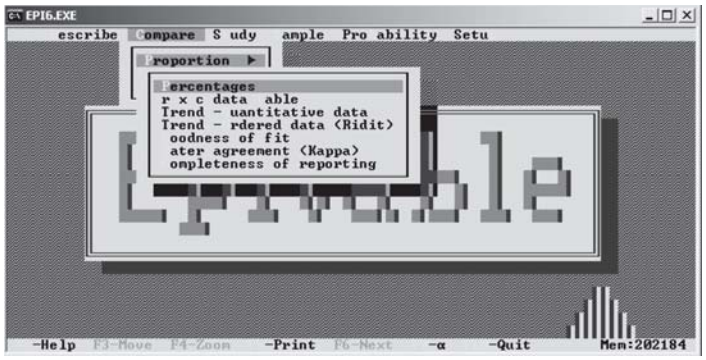



renders the 95% confidence interval.

Median

This option gives the confidence interval of a median using the alpha risk specified in the setup option. The inputs required are the median and the sample size for the given data. For example we ask the 10 patients attending OPD to evaluate his pain on a scale of 0 (no pain) to 10 (the worst pain). The scores given by the patients are 3,4,2,6,1,8,1,9,3,6.

**Note that the package gives the median position along with 95% confidence interval for median position and not the median value.**




The median score of pain after arranging the patients in ascending order is 3.5 which is the middle most position i.e. 5.5.

**Compare**

This menu compares the **proportions**, **means** and **variances** using various statistical methods. Under proportion menu following components are available:

Proportion

This option compares several proportion expressed either as percentages, rows or columns, quantitative or qualitative manner using the chi square test. The various

| | | |
|---|---|---|
| $Chi^2$ | : | 7.34 |
| Degrees of freedom | : | 1 |
| p value | : | 0.006748 |

options available are as follows.

**Percentages**

When we have the percentages in the two groups which we

are interested to compare we use this option. The program requires the percentage values along with the sample sizes for each group. On analyzing it gives the chi-square statistics along with the significance value i.e. p-value. Consider an hypothetical example where we sampled 55 males in their adolescent ages. 44% of them were obese. Another sample of 149 females had 24% obese ladies. To test whether from the sampled populations the proportion of obese males was comparatively higher than that of females, we use the Percentage option of Proportion in Epitable.

**Since p<0.05 we reject the hypothesis i.e.** we can conclude that there is significant difference in proportion of obese. In other words we say that the percentage of obese males is greater than percentage of obese females in the sampled population.

**Chi square for r x c data table**

This is applicable when we have qualitative data in terms of counts which can be compiled in terms of rows and columns. The procedure is as follows. First indicate the number of rows and the number of columns. Then enter the data for each cell. Chi square calculation will be performed when the calculate button is selected. The percentage of cells with an expected value <5 is returned if any such cells are found. When more than 10% of the cells have expected values <5, chi square calculation is no longer recommended. The chi square calculation is not

| Mothers | Status of delivered child | |
|---|---|---|
| | Congenital Malformation | Normal |
| Upto 35 years of age | 50 | 950 |
| > 35 years | 50 | 450 |

valid if there are expected cells with values <1. In this case, an error message is displayed.

| Chi square calculation | | |
|---|---|---|
| $Chi^2$ | : | 13.39 |
| Degrees of freedom | : | 1 |
| p value | : | 0.000253 |

Let us illustrate the procedure of Chi-square for r x c table using the hypothetical example on the association between maternal age and congenital malformations. Let us say, we started with the research issue by taking two groups of mothers, one group upto 35 years of age and other above 35 years of age. We took a sample each, 500 pregnant ladies aged > 35 years and another 1000 pregnant ladies aged upto 35 years and followed them till delivery. We found that out of the 500 children born to ladies > 35 years, 50 had congenital malformations, while out of 1000 ladies upto 35 years, there were again 50 children born with congenital malformations. Converting it into a 2 x 2 table.

Substitute all the observed frequencies and press calculate. The following output is displayed.

Since p<0.05 we can conclude that there is statistically significant association or that there is a definite relationship between advanced maternal age (>35 years) and congenital malformations in the offspring.

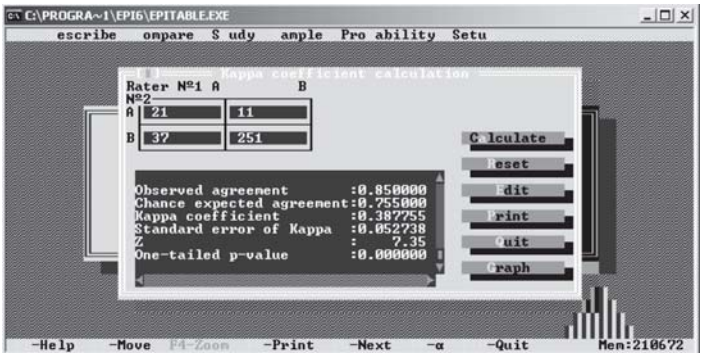
**Trend Quantitative data**

This is same as discussed under chi square for trend in 'Statcalc' and hence is not repeated here.

| Lab Technician's Diagnosis | Microbiologist's Diagnosis | | |
|---|---|---|---|
| | Positive | Negative | Total |
| Positive | 21 | 11 | 32 |
| Negative | 37 | 251 | 288 |
| Total | 58 | 262 | 320 |

**Two rater agreement (Kappa)**

This allows us to measure the inter observer reliability. The consistency of measurement by different observers is




assessed by kappa coefficient. This measure is carried out only for categorical data upto 6 categories. Each cell of the table corresponds to the count of observation classified by rater 1 and rater 2. For example we may be desirous of undertaking a study on Pulmonary TB, with AFB on sputum smear as the method of measurement. Let us say we are using Laboratory technicians to examine the sputum slides after training given to them by microbiologist. For doing an inter observer reliability assessment (between the microbiologist and Lab technician) we took 320 stained slides and eah slide was examined by both of them. The results are as follows:

On pressing Rater Agreement (Kappa) and substituting the values as given above the following output is rendered.

The Kappa coefficient of 0.38 is interpreted as moderate agreement.

**Means**

This option performs a test (F test), which is equivalent to a student's t test for 2 samples. This test is not valid if all samples come from

| | |
|---|---|
| Variance between samples : | 2135.62 |
| Residual variance | : 901.95 |
| F Statistic | : 2.37 |

normally distributed populations with variances not statistically different.

Consider a hypothetical data of a research study to answer the question whether the serum cholesterol of healthy adult males, living in hot desert areas is, on an average, different (ie., significantly higher or lower) from the average serum cholesterol of healthy young males living in temperate climates. The serum cholesterol values of 12 subjects from the deserts yielded a mean value of 216.25 mg/dl with variance of 795.24 mg/dl. Similarly 14 subjects from temperate climate yielded a mean value of 198.07 mg/dl with variance of 992.25 mg/dl.

The details of the two population means along with variance ($SD^2$) and sample size are substituted to give us following output.

Since p>0.05 we accept the null hypothesis i.e. we can conclude that Serum Cholesterol levels of healthy adult males, living in hot desert areas is, on an average, **not different** from the average serum cholesterol of healthy young males living in temperate climates.


**Study**

This option gives methods of measuring association for cohort and case control studies. Different methods for measuring vaccine efficacy are also presented. There are various methods available. The control method uses the proportion of population vaccinated and the proportion of cases vaccinated. Methods based on the estimation of attack rates in cohort study, estimation of odds ratio in case control and matched case-control study is given. Also measures of parameters in screening studies are performed using this module. Examples are not carried out for each.

It is expected that students solve few modules on their own with real life data set.

The screen appears as given below.

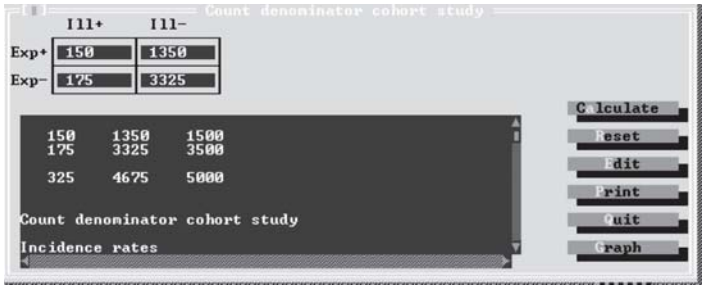
Cohort / cross sectional

Cohort/cross sectional (In cohort study, associations are measured for data tables with cumulative incidence and incidence density). In stratified cohort studies, after specifying the number of strata, associations are measured on cumulative incidence and incidence density

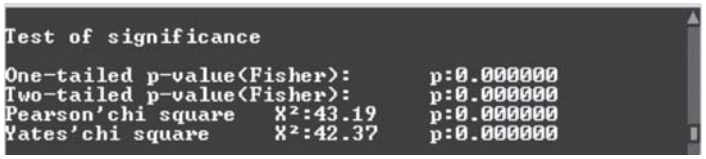
(a) Cumulative incidence

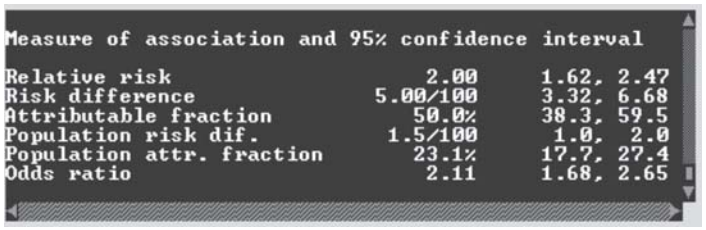
(b) Incidence density

| | III+ | III- |
|---|---|---|
| Exp+ | 150 | 1350 |
| Exp- | 175 | 3325 |








(c) Stratified, cumulative

(d) Stratified, density

Please compare the results as they are shown in the above screen with the calculations of RR, AR and PAR% which were calculated for the same example in the chapter on "Measurement of Risk" in the section on epidemiology.

Case-control

(a) Unmatched

(b) Matched 1:1

(c) Matched 1:2

(d) Stratified

For example, if we take 5000 healthy adult males in whom IHD was excluded based on history of smoking and resting/exercise ECG. Then, on asking them about history of smoking we found that 1500 were smokers and 3500 non-smokers. We followed up these 2 groups (1500 smokers and 3500 non-smokers) for 20 years and observed that during this period there were 150 cases of IHD among smokers and 175 cases of IHD among non-smokers.

Thus substituting the values of this 2 x 2 table on the screen as

Depending whether the cases and controls are unmatched or matched in the ratio of 1:1 or 1:2 (1:2 means number of controls will be twice the number of cases) we select that particular option

On pressing Calculate following output is given. Again depending on the type of study carried out the correct statistics is selected.

Please refer to our example on odds ratio in the chapter on "Measurement of Risk". We observed from our data that out of the 100 IHD cases, 80 were smokers and 20 non-smokers; while out of 100 healthy (non-IHD) subjects; there were 20 smokers and 80 non smokers. Substituting the values in a 2 x 2 table and pressing calculate gives the following output on the screen.

Vaccine efficacy

| Output | | |
|---|---|---|
| **Measures of association and 95% confidence interval** | | |
| Odds ratio: | 16.00 | 8.00, 31.99 |
| Attributable fraction | 93.8% | 87.5, 96.9 |
| **Exact confidence limits of the odds ratio** | | |
| Fisher: | 7.6013 | 34.0195 |
| Mid-p: | 7.9638 | 32.1333 |

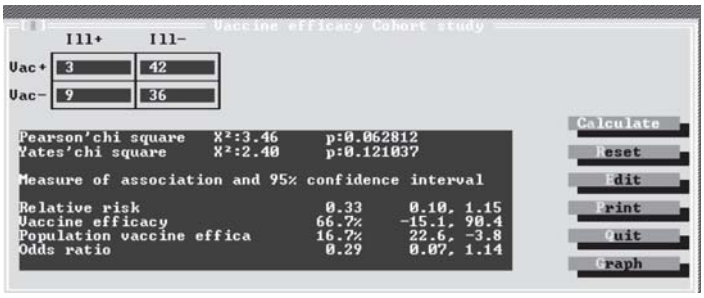
(a) Control method
(b) Cohort study
(c) Case-control study
(d) Matched case control study 1:1
(e) Matched case control study 1:2

Vaccine efficacy is measured by comparing Attack Rates among Vaccinated and Attack Rate among Non vaccinated people. There are four different methods presented which corresponds to different approaches for measuring or estimating Attack Rates among Vaccinated and Attack Rate among Non vaccinated people. The first method i.e. control method is not very precise method. Also confidence interval cannot be calculated unless denominators are known for calculation of various proportions. Other methods are used depending on the study design.

Let us take an hypothetical example where isoniazid chemoprophylaxis and development of tuberculosis is studied. The information gathered is set in the form of a 2 x 2 table.

| Exposure | Outcome | | |
|---|---|---|---|
| | Developed TB | Did not develop TB | Total |
| Given isoniazid (intervention group) | 3 | 42 | 45 |
| Not given isoniazid (Control group) | 9 | 36 | 45 |
| Total | 12 | 78 | 90 |

Substituting all the four cell values of the cohort study with the aim to find beneficial effect of the drug or vaccine we press Calculate.




This yields us the efficacy of 66.7% and hence we conclude that insoniazid chemoprophylaxis reduces the occurrence of TB in close contacts by 66.7%.

Screening

This option is used to evaluate the performance of a diagnostic test. On substituting the true+ and true- values (Gold standard + and - values) and the test+ and test- values the option gives the sensitivity, specificity along with the Predictive value positive and predictive value negative.

Consider an example on evaluating the performance of ELISA as a diagnostic test for HIV infection as compared to the gold standard as PCR. We took 1,00,000 subjects and subjected each and every one of them to both, the ELISA as well as the PCR tests. After substituting the values of a=990, b=9900, c=10 and d=89100 in the table the following output is given.

| Screening | | |
|---|---|---|
| **Measures of association and 95% confidence interval** | | |
| Sensitivity | 99.0% | 98.1, 99.5 |
| Specificity | 90.0% | 89.8, 90.2 |
| Predictive Value Positive | 9.1% | 8.6, 9.7 |
| Predictive Value Negative | 00% | 100.0, 100.0 |

The interpretation of each of the parameters listed above is explained in detail in the section on Research Methodology.

**Sample**

On pressing sample following options are made available.

(a) Sample size
(b) Power Calculation
(c) Random number table
(d) Random number list

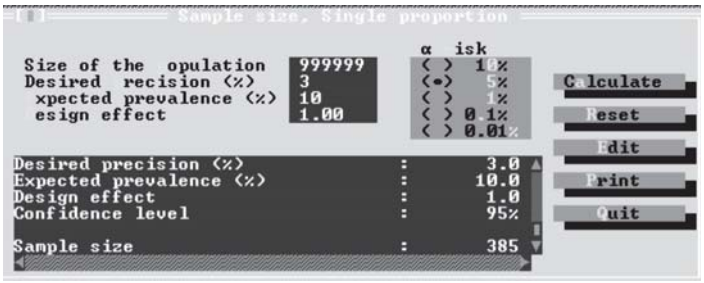
Sample size

The first option gives the desired number of minimum sample size required for the various studies. The parameter under consideration can be single proportion or two proportions. Also sample size can be calculated for cohort and case-control studies.

**Single proportion**

Let us understand this with an example. Suppose a study on gestational diabetes is undertaken. The expected proportion is p=10% with the desired precision or acceptable deviation as 7% to 13% i.e. 3% on either side.(d=0.03). We specify the alpha error as 5%. To estimate the minimum sample size for the above proposed study we first have to press sample and then select the first option single proportion which displays the screen requesting the information on the size of the population, desired precision (%), expected prevalence (%) and design effect. Design effect is a bias introduced in the sampling design and is taken as 1 which means that there is no design effect. (Note: In case of cluster sampling the

design effect is taken as 2). After substituting the required

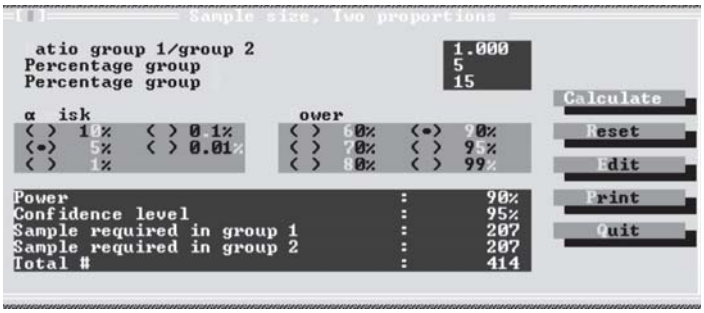



information press calculate.

The required minimum sample size is calculated as 385.

**Two proportions**

This option is used when we are interested in comparing two groups with respect to variable of interest. The specifications required are the anticipated or expected proportions in both the groups along with the alpha error and power of the test. Let us calculate the sample size for the following situation. Suppose the proportions of patients who develop complications after a particular type of surgery is 5% while the proportion of patients who develop complications after another type of surgery is 15%. We wish to test whether the second surgery has more complication rate than the first type of surgery with a power of 90%. The level of significance or type I error is assumed to be 5%. In this given situation to arrive at the number of patients that would be required in each group we first press sample size from the menu sample. From the sample size select Two Proportions. After specifying the requirements as given above and then pressing




Calculate the results on the screen appear as follows:

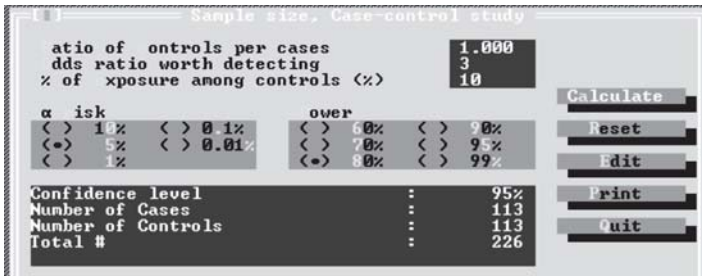
Thus a total of 414 i.e. 207 patients in each group are required to study.

**Cohort study**

Refer back to the example on HAPO which was considered for sample size determination using Statcalc. Substitute the required values of attack rate among non exposed as 1% and the detectable RR as 0.5. Also substitute the alpha error and power as 5% and 80% respectively. After pressing Calculate the minimum required sample size is 10134. In other words we would require to study 5067 subjects who would get Diamox and another 5067 subjects who would not get any drug.

**Case control study**

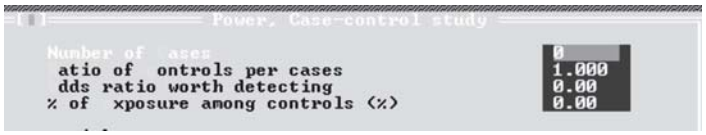
Refer back to the example on HAPO which was considered for sample size determination using Statcalc. Substitute the required values of percentage of exposure among controls as 10% the OR worth detectable as 3. Also substitute the alpha error and power as 5% and 80% respectively. After pressing Calculate the minimum required sample size rendered is 226. In other words we will we will need 113 cases OF HAPO and another 113




healthy controls to do this study. (Note that the sample size determined are almost same when calculated by sample size option of Statcalc)

Power calculation

The power calculation option calculates the power of the study. It is the complement of the beta error. In other


words it is the probability of making the correct decision. It can be calculated in both the cohort studies and case-control studies. The specifications required in both the situations are as under.

Substitute the sample size along with alpha error and other information of the study. Pressing Calculate reveals the power of the study.

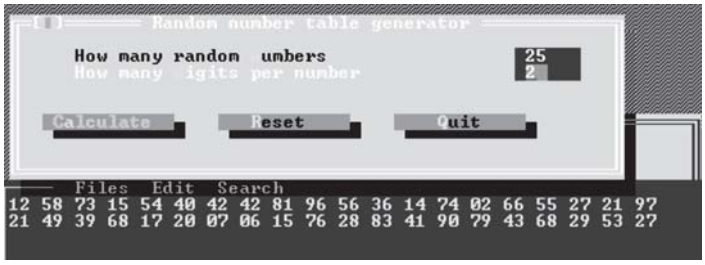
Consider the two examples that we have discussed above in the sample size determination option for cohort and case-control study. If we substitute retrospectively all the specification (except power) taken into consideration including sample size which was calculated. On pressing Calculate the power of the study is detected as 80% for cohort study and 84% for case-control study.

Please note that the calculations for sample size and power by the package differ from the manual way of calculations by slight margin. Hence it is recommended that for calculation of sample size and power the reader preferably uses the ready tables from WHO manual.

Random number table

This option generates a table of random numbers with a specified number of digits. Available options include the number of digits of generated numbers, as well as the total number of random numbers generated.

**Example :** Let us consider a hypothetical study where we require selecting 25 subjects by simple random sampling technique using random number method. Thus we want to generate 25 random numbers. On the screen we specify



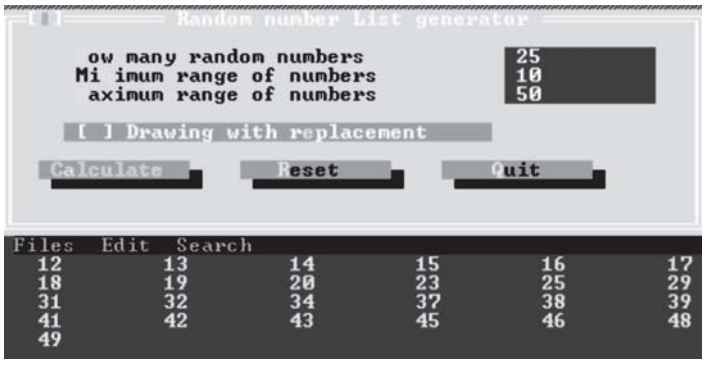

the number of random numbers as 25 and the digits per number as 2 (Since we have population which consists of subjects numbered in two digits). Pressing calculate gives a list of 25 two digit random numbers as follows.

Thus from the population we will choose the subjects with numbers 12, 58, 73 and so on, to form our study sample.

Random number list

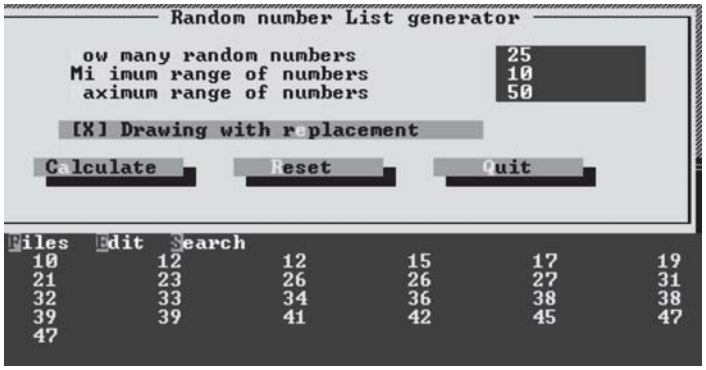
This option generates a list of random numbers ranging from a minimum to a maximum value. These random numbers can be drawn with or without replacement. In without replacement duplicate are not allowed whereas in with replacement duplicates are allowed. The random numbers generated are presented in sorted order.

The difference between random number table and random number list is that the random number table generates the specified number of random numbers from all the available digit number that we have specified. For example in the above example the 25 random numbers




are generated from 01 to 99. Whereas the random number list gives us a list of numbers where the range can be specified by us. For example if we want a list of 25 random numbers from 10 to 50 without replacement then the output is as follows

**Note that none of the random number repeats itself in the list.**




Let us draw the same number of random numbers (25) but now if we specify with replacement then the output is as follows.

**Note that the random number 12, 26 38 and 47 are repeated in the study**

## Analysis of data

Let us once again revert back to the main menu of Epi 2002. One of the most important component of Epi 2002 is Analyze Data. This program allows access to data entered in 20 data formats (e.g. Epi Info data files, Foxpro data base files, Excel files, Access data base files, etc) to perform statistical analysis. Though you can directly enter data in the EPI INFO we strongly recommend that the data be first entered in Excel, Foxpro or Access and then imported to EPI. To understand this option in detail a practice data file named "SAMPLE.dbf" is provided to the readers in a CD, alongwith this book. It is suggested that the readers use this file and try out all the options available in the Analyze Data menu of Epi 2002. The description of the data set in "SAMPLE.dbf " is given at the end of the Epi section.

Using this menu following statistical analysis can be carried out.

(a) It produces tables, epidemiologic statistics & graphs.

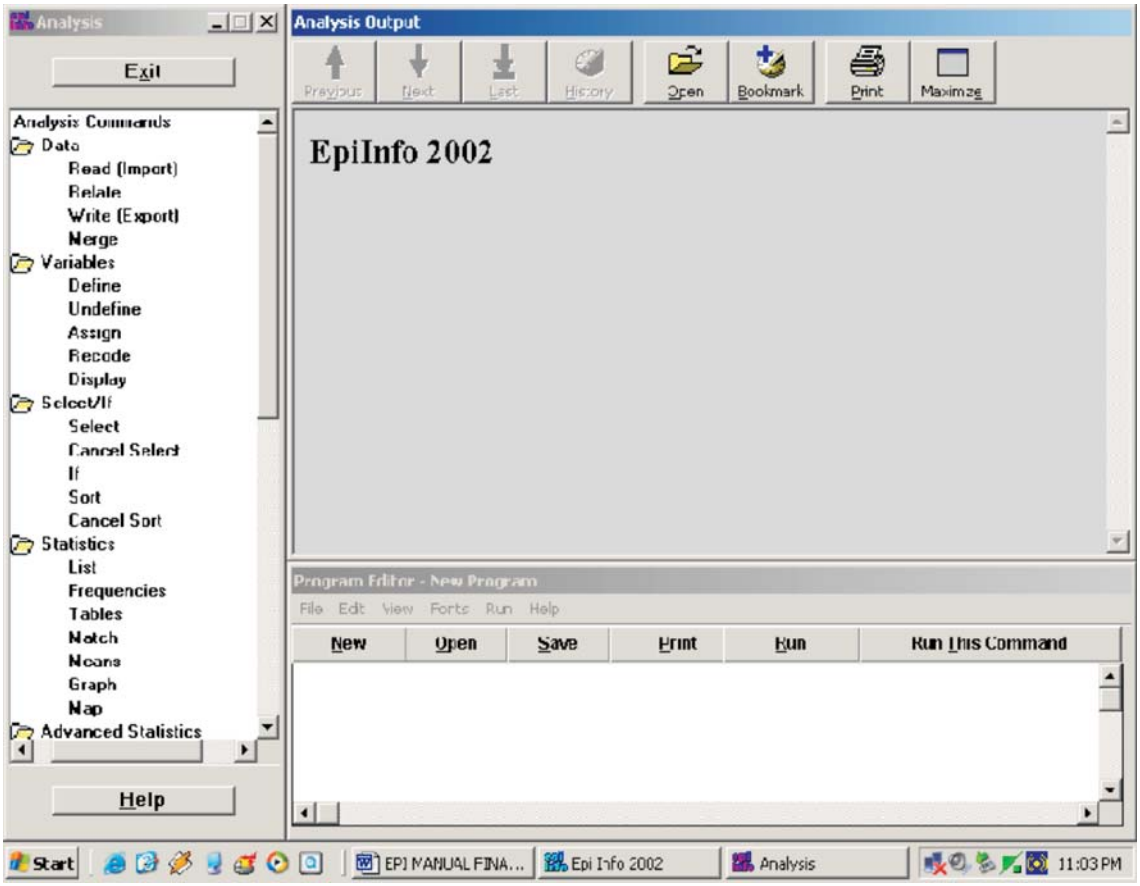
(b) It can also produce lists, frequencies, cross tabulations, and other epidemiologic statistics, such as odds ratios, relative risks and p-values.

(c) Graphing and mapping are also available using this component

First, to activate the analysis screen, click on the "Analyze Data" button on the main screen of EPI - 2002. The menu appears on the screen as shown on next page.

**Read**

By using READ command, located in the left hand column we can tell EPIINFO which file or table to analyze. The Data Formats requires the format in which the data is entered. In our case the data set enclosed in the CD is of type "foxpro" named "SAMPLE.dbf". Hence to read this particular file we should type dBASE IV in Data format. The Data Source requires the source destination of this file from where it can be extracted to read.




**List**

List does a line listing of the current dataset. If variable names are given, List option will list only these variables whereas List * will list all variables of all active records, using several pages across to accommodate all the variables, if necessary. The simplest and sometimes the best way to analyze data are to produce a line listing, using the List command.

**Frequencies**

The Freq command is used to determine the frequency of values for numeric character. The output shows a table of the values for a variable, the number and percent of records having each value, and the confidence intervals for each value as a proportion of the total. For numeric data only, descriptive statistics such as mean and standard deviation are also shown. On selecting the variables and clicking OK the results appear in the browser window. The yellow bars accompany each table to the right which indicates the frequencies. Statistics will be displayed below the table if the value of the variable is numeric.

Example

Suppose in the example "SAMPLE.dbf" we want to find the frequencies of the personnel of different rank structure. The variable we have used for rank is RANK. Click frequencies and specify RANK in the drop down menu of Frequency. Pressing OK yields the Frequencies, Percent, cumulative percent along with 95% confidence intervals

| RANK | Frequency | Percent | Cum Percent |
|---|---|---|---|
| JCO | 105 | 17.1% | 17.1% |
| OFFICER | 25 | 4.1% | 21.2% |
| OTHER_RANK | 484 | 78.8% | 100.0% |
| Total | 614 | 100.0% | 100.0% |

**95% Conf Limits**

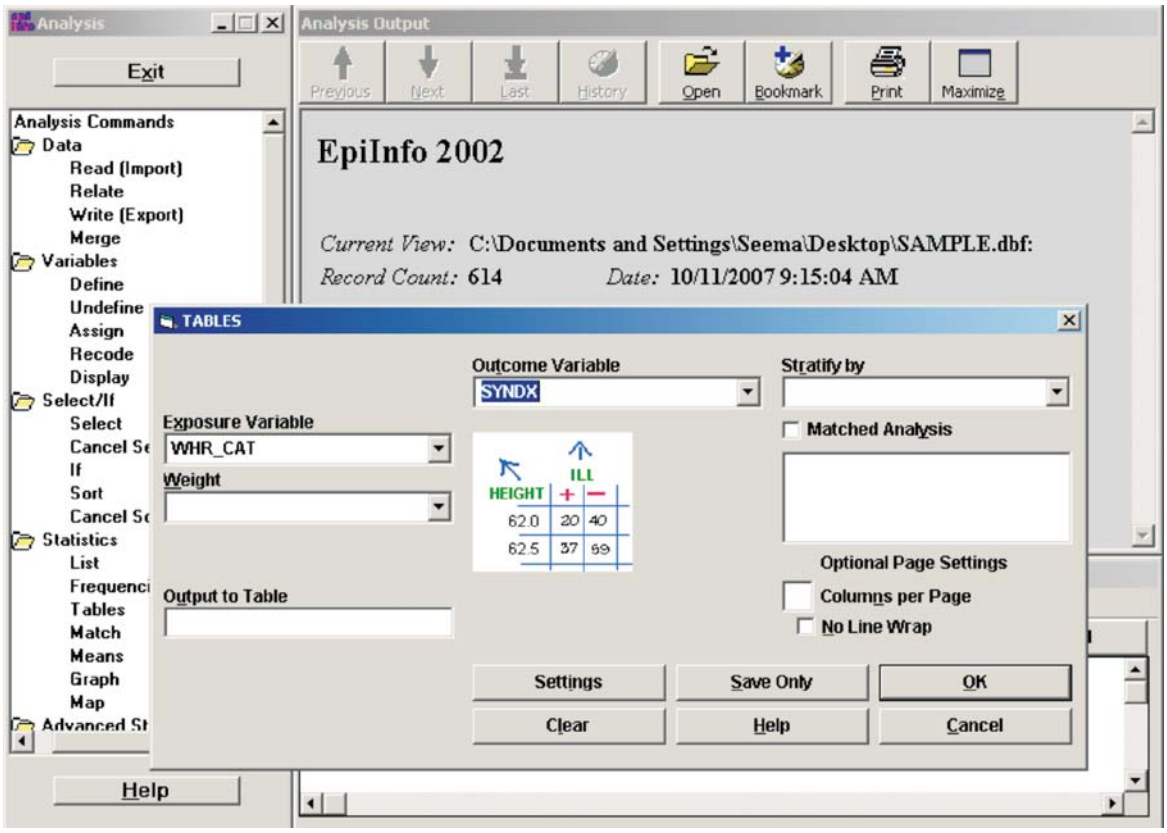
| | | |
|---|---|---|
| JCO | 14.3% | 20.4% |
| OFFICER | 2.7% | 6.0% |
| OTHER_RANK | 75.3% | 82.0% |

for the frequencies in the following manner. The yellow bars also indicate the frequencies for each category.

Tables

The Tables command is used to create a table of categorical data, often called as cross-tabulation. Two variables can be compared using Tables. This is similar to the 'Tables (2 x 2, 2 x n)' option of "Statcalc". In Statcalc when 'Tables' option is used either for analyzing a single table or carrying out stratification analysis for confounding effect, we make use of the readymade 2 x 2 tables. The disease status as well as the exposure status cross classification cell values are directly entered by

counting them separately from raw data. In the "Tables" option of "Analyze Data" the difference is that we do not count the frequencies manually but the raw data file is accessed through the 'Read' (Import) command in "Analyze Data". The computer counts the cell frequencies.




On clicking the command Tables, we select the Exposure (Independent variable) and the Outcome (Dependent variable) variables. Exposure variable is that variable in the database which is to be considered as the risk factor. Outcome variable is the variable in the database considered as the Disease of consequence. Click on OK when done. A single table of 2 or more rows and 2 or more columns can be provided, which is called as an R x C table (Row by Column). In addition to the row and column variables, the user can stratify on additional variables, which is then called as an R x C x S table (Row by Column by Strata). This is used for control of confounding and is equivalent to stratification in Statcalc. The output gives frequency tables accompanied by confidence limits on the proportions and 2x2 tables by odds ratios, risk ratios, and several types of confidence limits on these ratios, as well as chi square and Fisher exact tests. Stratified analyses result in Mantel-Haenszel summary odds ratios and confidence limits.

We will understand the usage of this command by considering our hypothetical data set of "SAMPLE.dbf". Let us say that we are interested in exploring association between SyndromeX and central obesity. Central Obesity (WHR_CAT) is considered to be a risk factor for development of SyndromeX and hence is selected as exposure factor and SyndromeX as our variable of interest as Outcome. We select these variables and then press <OK>.

| | SYNDX | | |
|---|---|---|---|
| WHR_CAT | 0 | 1 | Total |
| **0** | 233 | 7 | 240 |
| Row % | 97.1 | 2.9 | 100.0 |
| Col % | 41.5 | 13.5 | 39.1 |
| 1 | 329 | 45 | 374 |
| Row % | 88.0 | 12.0 | 100.0 |
| Col % | 58.5 | 86.5 | 60.9 |
| Total | 562 | 52 | 614 |
| Row % | 91.5 | 8.5 | 100.0 |
| Col % | 100.0 | 100.0 | 100.0 |

## Single Table Analysis

| | Point Estimate | 95% confidence interval | |
|---|---|---|---|
| | | Lower | Upper |
| **PARAMETERS: Odds-based** | | | |
| Odds Ratio (cross product) | 4.5528 | 2.0176 | 10.2735 (T) |
| Odds Ratio (MLE) | 4.5438 | 2.0979 | 11.0869 (M) |
| | | 1.9874 | 12.1557 (F) |
| **PARAMETERS: Risk-based** | | | |
| Risk ratio (RR) | 1.1036 | 1.0567 | 1.1526 (T) |
| Risk difference (RD%) | 9.1154 | 5.1906 | 13.0403 (T) |
| (T=Taylor series; C=Cornfield; M=Mid-P; F=Fisher Exact) | | | |
| **STATISTICAL TESTS** | Chi-square | | 1-tailed p 2-tailed p |
| Chi square - uncorrected | 15.6 | | 6 9 8 0.0000765860 |
| Chi square - Mantel-Haenszel | 15.6443 | | 0.0000776106 |
| Chi square - corrected (Yates) | 14.5160 | | 0.0001401431 |

Let us now consider another variable BMI. We now wish to explore whether BMI is a confounding variable in the observed association between central obesity and syndromeX. Hence along with exposure and outcome variable we also give the variable BMI in the Stratify By on the screen.

The procedure is to click on Tables in Analyze Data after the data file is imported through 'Read' command. In the exposure dropdown we select the exposure variable as WHR_CAT and the outcome variable as SYNDX. Along with these we also select the confounding variable (BMICAT_01) from the dropdown list of "Stratify By". This is equivalent to stratification in Statcalc. On pressing <OK> the output is rendered as a single 2 x 2 analysis of WHRCAT and SYNDX but taking into consideration BMICAT_01 as 0 and 1. In other words the cross tabulated frequencies are only for the group having BMICAT as 0 (<25) and another single 2 x 2 analysis for the group having BMICAT_01 as 1 (=25). A SUMMARY TABLE provides the summary statistics after removing the effect of confounder. The output is given as under.

WHR_CAT : SYNDX, BMICAT_01 = 0

| | SYNDX | | |
|---|---|---|---|
| WHR_CAT | 0 | 1 | Total |
| **0** | 213 | 5 | 218 |
| Row % | 97.7 | 2.3 | 100.0 |
| Col % | 49.9 | 23.8 | 48.7 |
| 1 | 214 | 16 | 230 |
| Row % | 93.0 | 7.0 | 100.0 |
| Col % | 50.1 | 76.2 | 51.3 |
| Total | 427 | 21 | 448 |
| Row % | 95.3 | 4.7 | 100.0 |
| Col % | 100.0 | 100.0 | 100.0 |

Single Table Analysis

| | Point Estimate | 95% confidence interval | |
|---|---|---|---|
| | | Lower | Upper |
| **PARAMETERS: Odds-based** | | | |
| Odds Ratio (cross product) | 3.1850 | 1.1463 | 8.8501 (T) |
| Odds Ratio (MLE) | 3.1775 | 1.1831 | 9.8531 (M) |
| | | 1.0873 | 11.2925 (F) |
| **PARAMETERS: Risk-based** | | | |
| Risk ratio (RR) | 1.0501 | 1.0082 | 1.0938(T) |
| Risk difference (RD%) | 4.6629 | 0.8211 | 8.5048 (T) |
| (T=Taylor series; C=Cornfield; M=Mid-P; F=Fisher Exact) | | | |
| **STATISTICAL TESTS** | Chi-square | | 1-tailed p 2-tailed p |
| Chi square - uncorrected | 5.44 | | 0.0196061809 |
| Chi square - Mantel-Haenszel | 5.43 | | 0.0197431181 |
| Chi square - corrected (Yates) | 4.45 | | 0.0348403277 |

WHR_CAT : SYNDX, BMICAT_01 = 1

| | SYNDX | | |
|---|---|---|---|
| WHR_CAT | 0 | 1 | Total |
| **0** | 20 | 2 | 22 |
| Row % | 90.9 | 9.1 | 100.0 |
| Col % | 14.8 | 6.5 | 13.3 |
| 1 | 115 | 29 | 144 |
| Row % | 79.9 | 20.1 | 100.0 |
| Col % | 85.2 | 93.5 | 86.7 |
| Total | 135 | 31 | 166 |
| Row % | 81.3 | 18.7 | 100.0 |
| Col % | 100.0 | 100.0 | 100 |

Single Table Analysis

| | Point Estimate | 95% confidence interval | |
|---|---|---|---|
| | | Lower | Upper |
| **PARAMETERS: Odds-based** | | | |
| Odds Ratio (cross product) | 2.5217 | 0.5573 | 11.4101 (T) |
| Odds Ratio (MLE) (M) | 2.5106 | 0.6309 | 16.720105 |
| | | 0.5560 | 23.3880 (F) |
| **PARAMETERS: Risk-based** | | | |
| Risk ratio (RR) | 1.1383 | 0.9744 | 1.3299(T) |
| Risk difference (RD%) | 11.0480 | -2.6348 | 24.7308 (T) |
| (T=Taylor series; C=Cornfield; M=Mid-P; F=Fisher Exact) | | | |
| | | | |
| tailed p | | | |
| Chi square - uncorrected 0.2155466879 | 1.53 | | 38 |
| Chi square - Mantel-Haenszel 0.2169343585 | | 1.52 | 245 |
| Chi square - corrected (Yates) | | 0.89 | 26 |

Warning : The expected value of a cell is <5. Fisher Exact Test should be used.

Summary

Summary information

| Parameters | Point Estimate | 95%Confidence Interval | |
|---|---|---|---|
| | | Lower | Upper |
| Odds Ratio Estimates | | | |
| Crude OR (cross product) | 4.5528 | 2.0176, | 10.2735 (T) |
| Crude OR (MLE) | 4.5438 | 2.0979, | 11.0869 (M) |
| | | 1.9874, | 12.1557 (F) |
| Adjusted OR (MH) | 2.9415 | 1.2562, | 6.8881 (R) |
| Adjusted OR (MLE) | 2.9617 | 1.3062, | 7.4701 (M) |
| | | 1.2285, | 8.2237 (F) |
| Risk Ratios (RR) | | | |
| Crude Risk Ratio (RR) | 1.1036 | 1.0567, | 1.1526 |
| Adjusted RR (MH) | 1.0614 | 1.0188, | 1.1057 |
| (T=Taylor series; R=RGB; M=Exact mid-P; F=Fisher exact) | | | |

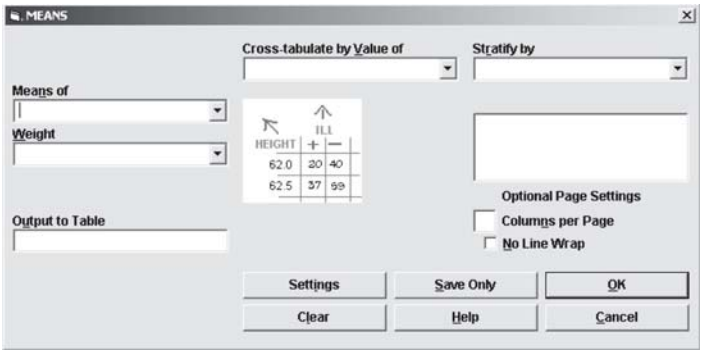
| STATISTICAL TESTS (overall assoc) | Chi-square | 1-tailed p | 2-tailed p |
|---|---|---|---|
| MH Chi square - uncorrected | 6.7724 | | 0.0093 |
| MH Chi square - corrected | 5.8796 | | 0.0153 |
| Mid-p exact | | 0.0039 | |
| Fisher exact | | 0.0060 | |
| In the following two tests, low p values suggest that ratios differ by stratum | | | |
| Chi-square for differing Odds Ratios by stratum (interaction) | 0.0630 | | 0.8018 |
| Chi-square for differing Risk Ratios by stratum | 0.9671 | | 0.3254 |

Since Chi-square for differing Odds Ratios by stratum (interaction) is not significant. We conclude that BMI_CAT_01 is a confounder variable as the crude odds ratio and adjusted odds ratio differ. Based on Adjusted OR(MH) of 2.94, we conclude that the risk of syndromeX due to high WHR, after controlling (adjusting) for the confounding effect of raised BMI, increase the risk by almost 3 times.

**Means**

The Means command can compare mean values of a variable between the groups. The Means command can also compare mean group values before and after the event. This method, however, ignores the matching that occurs from using the same student or subject for both tests. A better method is to subtract the before score from the after score to find the difference for each student, and then to see if the average difference is significantly different from zero, using Students t-test. Epi Info performs the t-test every time the Means command is given with a single variable, just in case the variable represents a difference and you would like to know if it differs, on the average, from zero. If there are only two groups, the equivalent of an independent t-test is performed. If there are more than two groups, then a one-way analysis of variance (ANOVA) is computed. Thus Means provides the equivalent of ANOVA for two or more samples. "One way" means that there is only one grouping variable. If there were two grouping variables, then that would be a two-way ANOVA, which Epi Info does not perform. The one-way ANOVA can be thought of as an extension of the independent t-test to more than two groups. Because the ANOVA test requires certain assumptions about the data and the underlying population, another test (Kruskal-Wallis, also known as the Mann Whitney/Wilcoxon test if there are only two groups) is also provided. This is a non-parametric test, meaning that it does not require assumptions about the underlying population. We will discuss in detail each of the output section separately.

Consider again the example of "SAMPLE.dbf". One of the numeric variables considered is age of the person. If we wish to test whether there is any significant difference between the three ranks of the personnel as regards to the age parameter, we use one way ANOVA. For carrying out this analysis we first click on Means. The following screen




will appear.

In the **Means of** we substitute the continuous numeric age variable and in the **Cross Tabulate by values of** substitute groups which is given in the column of Rank i.e. press Rank and then Press OK. The output is provided in 5 different sections:

(a) A table of the two variables with the continuous variable forming the rows and the grouping variable forming the columns.

(b) Descriptive information of the continuous variable by each group such as number of observations, mean, variance, and standard deviation; minimum and maximum values; the 25th, 50th (median), and 75th percentiles; and the mode values are described.

(c) An Analysis of Variance (ANOVA) table and a p-value for whether or not the means are equal.

(d) A test to determine whether the variances in each group are similar (Bartlett's test for homogeneity of variance).

(e) A non-parametric equivalent, Kruskal-Wallis test instead of the independent t-test and one-way ANOVA is also provided.

For the example considered from SAMPLE.dbf following

**Descriptive Statistics for Each Value of Crosstab Variable**

| | Obs | Total | Mean | Variance | Std Dev |
|---|---|---|---|---|---|
| JCO | 105 | 4652.0000 | 44.3048 | 18.6947 | 4.3237 |
| OFFICER | 25 | 1133.0000 | 45.3200 | 45.4767 | 6.7436 |
| OTHER_RANK | 484 | 18191.0000 | 37.5847 | 8.9804 | 2.9967 |

| | Minimum | 25% | Median | 75% | Maximum | Mode |
|---|---|---|---|---|---|---|
| JCO | 36.0000 | 41.0000 | 45.0000 | 48.0000 | 53.0000 | 46.0000 |
| OFFICER | 35.0000 | 40.0000 | 46.0000 | 51.0000 | 55.0000 | 36.0000 |
| OTHER_RANK | 35.0000 | 36.0000 | 37.0000 | 38.0000 | 55.0000 | 35.0000 |

output is given on the screen.

**ANOVA, a Parametric Test for Inequality of Population Means** (For normally distributed data only)

| Variation | SS | df | MS | F statistic |
|---|---|---|---|---|
| Between | 4921.3197 | 2 | 2460.6599 | 203.9088 |
| Within | 7373.2145 | 611 | 12.0675 | |
| Total | 12294.5342 | 613 | | |

P-value = 0.0000

**Bartlett's Test for Inequality of Population Variances**

Bartlett's chi square= 64.7890 df=2 P value=0.0000

**Mann-Whitney/Wilcoxon Two-Sample Test (Kruskal-Wallis test for two groups)**

Kruskal-Wallis H (equivalent to Chi square) = 183.0437

Degrees of freedom = 2

P value = 0.0000

A small p-value (e.g., less than 0.05) suggests that the variances are not homogeneous and that the ANOVA may not be appropriate.

The overall one-way ANOVA results are said to be significant (p= 0.0000) so we conclude that the mean age in the three ranks (groups) are not same.

Note that All statistical methods require assumptions

(a) ANOVA requires distributional assumptions of

(i) Independence

(ii) Normality

(iii) Equal variance

**(b) Bartlett's Test for Inequality of Population Variances** test for the assumption of equal variances. It also advices you as to whether ANOVA results are appropriate or Non-parametric test are more appropriate.

**(c) Kruskal-Wallis Test**

The Kruskal-Wallis test is the nonparametric analogue to one-way ANOVA. It can be viewed as ANOVA based on **rank-transformed data**. The initial data are transformed to their ranks before submitted to ANOVA. The p-value suggests the significance. The null and alternative hypotheses for the K-W test may be stated in several different ways. We choose to state:

$H_0$: the population medians are equal

$H_1$: the population medians differ

(d) In case when the ANOVA results are significant ($p<0.05$), multiple comparisons between two groups at a time should be carried out. Since in our case results are significant ($p<0.05$) we now compare two means at a time. This is a **post hoc (after-the-fact) comparison**. In other words it means that after rejecting $H_0$ we conduct the following three tests:

Test 1: $H_0$: Group1 = Group 2 vs. $H_1$ Group 1 ≠ Group 2

Test 2: $H_0$: Group1 = Group 3 vs. $H_1$ Group 1 ≠ Group 3

Test 3: $H_0$: Group2 = Group 3 vs. $H_1$ Group 2 ≠ Group 3

This is carried out by the procedure explained in **EPITABLE section of COMPARE.**

### Match

MATCH performs a matched analysis of the specified exposure and outcome variables, which are assumed to be yes/no variables. One table is produced for each number of cases in a match group. The first variable will appear on the left margin and will contain values from zero to the number of cases in the match group. The second variable will appear on the top margin and will contain values from zero to the number of cases in the match group. The cells contain the number of match groups showing the combination of positive exposures and positive outcomes shown in the margins. The output table produced by the command is similar to that produced by TABLES.

### Graph

The GRAPH command in Analysis offers many types of charts for displaying the values of one or more fields in a data table. A toolbar within the graphing module can be activated to allow customization of the resulting graphs. Settings can be saved as templates and used again from Analysis.

### Advanced Statistics

Linear regression

Regression analysis deals with developing a mathematical relationship between two variables of interest. Regression is used when the primary interest is to predict one dependent variable (y) from one or more independent variables (x1, ... xk). When only one independent variable is used to predict the dependent variable then it is termed as simple linear regression. When multiple independent variables are used to predict the dependent variable it is defined as multiple linear regression and for quantifying the relationship between two variables we calculate correlation. To analyse the relationship between the independent and dependent variables we click on Linear Regression. From the dropdown menu in Outcome Variable select the outcome or dependent variable. In the Other Variables select the multiple independent variables and press OK. On pressing OK the output is visible on the screen.

Consider the example SAMPLE.dbf given separately in the CD. Suppose the outcome variable is diastolic blood pressure (DIA_BP). Let the independent variables or predictors be BMI (BMICAT_01), Waist-hip ratio (WAIST_HIP), serum cholestrol level (S_CHOL) and heart rate (HR_CAT_0_1). Follow the instructions given above

and arrive at the solution.

[Hint: In the above example, the regression line is:

$DIA\_BP = a + b_1x_1 + b_2x_2 + b_3x_3 + b_4x_4$

DIA_BP = 58.892 + 6.216(BMICAT_01) + 2.141(HR_CAT_0_1) + 0.047(S_CHOL)+ +18.3(WAIST_HIP)

For any given value of independent variables, diastolic blood pressure (DIA_BP) value can be predicted.]

### Logistic Regression

Logistic regression shows the relationship between an outcome variable with two values (i.e. dichotomous) and explanatory variables that can be categorical or continuous. In Epi Info 2002, either the TABLES command or logistic regression (LOGISTIC command) can be used when the outcome variable is dichotomous (for example, disease/no disease). Analysis with the TABLES command in Epi Info is possible if there is only one "risk factor." Logistic regression is needed when the number of explanatory variables ("risk factors") is more than one. The method is often called "multivariate logistic regression." A model might predict the probability of occurrence of a myocardial infarction (MI) over a 5-year period, given a patient's age, sex, race, blood pressure, cholesterol level, and smoking status. Please note that the outcome variable has to be of YES/NO type or logical (TRUE/FALSE). The latest version of EPI 2002 can take the outcome variable in logical form as 0 & 1. Epi Info 2002 uses a process called "maximum likelihood estimation" to arrive at the best estimate of the relationships based (usually) on a follow-up study. The results include values for the beta coefficients 'ß' but more important for epidemiologists, can produce an odds ratio (OR) for each value of a risk factor compared with its baseline ("absent" or "normal") state.

Consider in SAMPLE.dbf the dependent outcome variable as having IHD(which is coded separately as FINAL_IHD and is logical type) given the different risk factors as BMICAT_01(categorized 0 for BMI<25 and 1 for BMI = 25), weekly exercise (WK_EX_CAT categorized 0 for no exercise and 1 for exercise), waist-hip ratio, (WHR_CAT categorized 0 for having normal waist i.e. = 0.90 and 1 for having central obesity i.e. >0.90), heart rate (HR_CAT_01 categorized 0 for heart rate =72 beats/min and 1 for >72 beats/min) and SyndromeX (categorized 0 for all those who did not qualify as having syndrome X and 1 for all those who qualified as having or presence of syndrome X). Follow the instructions given above and arrive at the solution.

### Survival Analysis

Survival Analysis deals with situations where the outcome variable is dichotomous and is a function of time. The analytical methods used to draw inferences regarding the chances of surviving / dying / getting cured / getting diseased (in short, the chances of developing the "outcome of interest"), over the various points of time are answered by "survival analysis". The accompanying CD gives data set for survival analysis named as "SURVIVAL.dbf". This is a HYPOTHETICAL data of a new drug which was being tried out for treatment of Leukemia. 100 patients of confirmed leukemia was randomized into two groups. One group of 50 subjects which continued with the existing standard therapy (Group1) and another 50 subjects (Group2) were given the trial modality. All subjects were followed up for maximum period of 7 years (84 months) from the point of starting treatment or else till they died due to leukemia or lost to follow up or died due to some other disease. If subject died because of leukemia they are called as uncensored data (0) whereas subjects who died of some other cause and not leukemia or were lost to follow up or were still alive by the end of 7 years are called as censored data (1). The defined outcome of interest was the subject who was living at the end of followup. (This includes those who were loss to followup assuming that they would have lived).

There are three columns. The first column named "Time_since" represents the time in months of the event (death) taking place. The second column, named "Outcome" represents the status of the patient, whether the patient is alive or has died, and the third column, named "Group" represents the group to which the patient belongs, with 1 = existing treatment given and 2 = new trial treatment given. Press Kaplan-Meier Survival from Advanced Statistics and give input of all the required variables. The Censored Variable is the Outcome variable, Time Variable is Time_Since and Group Variable is Group respectively in our example. Value of uncensored is 0 whereas Time Unit is taken as months. Once you press OK the survival curve along with statistical difference between the two survival curves are provided. (The details on Survival Analysis are given in the section of Biostatistics). Follow the instructions given above and arrive at the solution.

#### Description of the data set : SAMPLE.dbf

SAMPLE.dbf file is a HYPOTHETICAL data meant for practicing only. It was a cross sectional study in which 614 healthy army subjects aged more than equal to 35 years were randomly selected from various army units in a very large cantonment. General particulars included age, rank, native state. History was recorded of details of physical exercise, alcohol consumption and tobacco use. Clinical measurements included measurement of height, weight, waist circumference, hip circumference and systolic & diastolic blood pressure. Biochemical measurements included fasting and 2 hour PP blood sugar, lipid profile and fasting insulin levels. Resting ECG was recorded and assessed for evidence of coronary insufficiency (CI) as per the standard Minessota code criteria. Syndrome X was defined as per standard international code criteria. A total of 52 persons out of 614 studied were found to have syndrome X as per defined criteria.

The description of various variables coded in the data sheet is as follows

| | |
|---|---|
| AGE | : Actual age in completed years. |
| RANK | : Self explanatory - Officers/ JCO/Other ranks |
| STATE | : The state of native residence of the subject. |
| WK_ALC | : Average amount of alcohol (in terms of |

gms
of ethanol) consumed in one week as a routine

TOBACCO : Coded as 1 for Users of Tobacco: 0 for non users

WK_EX_CAL : The number of K-calories spent on an average in one week in structured physical exercise (as PT, Games, Walking or sports under own arrangements)

EXCAT : NIL-undertaking no exercise; Similarly MILD,
MODERATE & HEAVY INTENSITY EXERCISE.

WEIGHT : Weight in kgs to the nearest whole number.

HEIGHT : Height in cms to the nearest whole number.

BMICAT_01 : 0 means < 25 and 1 ≥ 25

WAIST : Waist circumference in cms.

HIP : Hip circumference in cms.

WAIST_HIP : Waist-Hip ratio (WHR)

WHR_CAT : 0 = Having normal waist, normal WHR ≤ 0.90; 1= Having central obesity i.e. WHR>0.90

SYS_BP : Systolic Blood pressure in ml/mercury

DIA_BP : Diastolic Blood pressure in ml/mercury

BL_SUG_F : Fasting Blood sugar mg/dl

BL_SUG_PP : 2 hours post prandial blood in mg/dl

S_CHOL : Serum total; cholesterol mg/dl.

INSULIN_F : level of fasting insulin in mIU/ml

HYPERINSUL : 1 = Having hyperinsuliniea as per defined criteria of fasting insulin in uppermost quintile; 0 for Normoinsuliniea

HR : Heart Rate in beats/min

HR_CAT_01 : 0 Heart Rate =72 beats/min, 1 for Heart Rate>72 beats/min

IHD_EVI : Evidence of coronary insufficiency (CI) on resting ECG; 1=CI present; 0=normal

SYNDX : 1= SyndX present as per defined criteria; 0= SyndX absent

FINAL_IHD : TRUE=evidence of CI present; FALSE=No evidence (Normal)

**Using SAMPLE.dbf answer the following questions:**

Q1: Write the scales of measurement for all the variables considered in the SAMPLE.dbf

Q2: If the investigator is interested in assessing whether there exist any association between the occurrence of IHD and systolic blood pressure as risk factor. How will the investigator proceed to test this association?

Q3: In the above situation how will the investigator check whether age is a confounder variable or not?

Q4: Describe the following variables along with the 95% confidence interval.

a) Heart Rate
b) Serum Cholesterol Level
c) Tobacco consumption.
d) Age

Q5: Test whether there is any difference in the proportion of subjects consuming tobacco in the two groups with presence of IHD and absence of IHD.

Q6: To test whether there is any correlation between Waist Hip Ratio and BMI (taking both as dichotomous variables) what type of statistical analysis will be carried out?

Q7: Taking Fasting Insulin as a continuous variable and age as dichotomous variable (0 for = 35 years of age and 1 as > 35 years of age) test whether there is any difference between the insulin levels in the two age groups.

Q8 Carry out analysis to find out whether there is any association between the exposure variables WK_EX_CAL and the outcome variable FINAL_IHD with and without considering the confounder variable BMI

Q9: If we wish to test whether there is any significant difference in the proportion of people of different ranks (RANK) with outcome of "SyndromeX" using EPITABLE and ANALYZE DATA, what would be the difference?

Q10: Which statistics will be used to predict the outcome of SyndromeX in subjects, considering the risk factors as Age, Exercise (WKEXCAT01), TOBACCO consumption (categorized as 0 and 1)?

Q11: Correlate Fasting Insulin and Fasting Sugar using 'Graph' from "Analyze Data"

## References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# Environmental Health Sciences


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# Effects of Hot Environment

The term "heat stress" is applied to any degree of environmental heat that causes physiological thermoregulatory mechanisms to get activated. Human beings are homoeothermic creatures whose physiology attempts to maintain a constant core body temperature of 37°C (range 36 to 38°C). Obviously, this requires balancing of the body heat production with heat loss which is achieved by a combination of physiological mechanisms (as peripheral vasodilatation or vasoconstriction, changes in heart rate, sweating or shivering) and behavioural mechanisms (increase or decrease in voluntary physical activity, seeking appropriate shelter etc). In addition, environmental conditions viz., temperature, humidity and speed of air also greatly determine whether a person will be subjected to thermal stress. Prevention and management of thermal stress disorders therefore requires an understanding of these physiological, behavioural and environmental mechanisms and manipulating them appropriately. For the purpose of thermoregulation, the human body can be conceived of having two "layers" - an outer periphery or "shell" consisting of skin, subcutaneous tissue and muscles, and an inner "core" consisting of brain, heart and viscera.

## Magnitude of the Problem

Epidemiological descriptions provide evidence of diseases and deaths due to hot environment since Biblical and Alexandrian times (1-4). Medical descriptions of heat related Illnesses have been made in relation to various human activities, ranging from adventure and sports to industries, occupation, pilgrimages and, of course, military operations (5-9).

In terms of the burden of mortality, hyperthermic brain injury is the third largest cause of brain-injury related deaths, next to Cardiovascular and traumatic diseases (10, 11). Scientific published data on the magnitude has described the death of almost eleven thousand people in the month of July, in China, during the eighteenth century due to hot weather conditions. The adversities faced by Napoleon's army in 1798, during his Egyptian campaign, were poignantly summarized by Larry. Another description by Marshall enumerates the death of thousands of soldiers due to physical exertion in hot environment, during the Arab-Israeli war of 1956 (12). Again, very high incidence of heat illnesses has been reported from the Middle East, among the Haj pilgrims (13). It has been estimated that the massive heat wave that swept over Europe in 2003, claimed more than 35,000 lives, with France accounting for 14,000 deaths (14). Even in developed countries like United States, heat illness is a major public health issue (15). Data from Centers for Disease Control and Prevention (CDC) indicates that during the period 1979 to 1997, as many as 7000 deaths in the USA were attributable to excessive heat (16). Reports of high incidence of heat illnesses from various other developed countries have appeared recently (17-20).

In India, more than 1600 heat related deaths were reported during the year 2003 (14). A report by Larsen, on behalf of Earth Polity Institute, as quoted by Sri Ramachari (14) makes a pointed reference to India, as "where heat related fatalities in thousands are no longer uncommon", thus exhorting all professionals concerned with human development towards addressing this problem. More recently, apprehensions have also been raised regarding the world wide climatic changes and global warming, which may increase the incidence of heat related illnesses in the human populations (21-23). In India, 3,194 deaths due to heat-stroke have been recorded over the 5-year period 1999 to 2003; the actual magnitude may be much more. The central and northern plains, western deserts and tropical forest areas of North - East have environmental conditions causing heat stress during the months of April to September.

## Epidemiological triad in heat illnesses

In the conventional "Epidemiological triad" of agent, host and environmental factors, the "agent" is "heat". However, who would get adversely affected by this agent is determined by a complex interplay of various factors in the human host or the environment.

Human (Host) Factors

A wide array of host factors have been implicated in increasing the risk of heat illnesses, as summarized in Box 1.

**Box - 1 : Persons at high risk of heat stress**

- Extremes of age (<5 years or >65 years)
- Pregnancy
- Occupation: Workers in military, agricultural, construction & industrial settings, labourers, sports-persons and miners.
- Low level of physical fitness
- Lack of acclimatization to environmental heat
- Obesity
- Alcohol use (acute and chronic)
- Skin diseases: Extensive prickly heat, psoriasis, pyoderma
- Sleep deprivation
- Co-existing febrile illness, renal, thyroid, cardio-vascular and metabolic diseases.
- Previous history of heat-illness

### a) Age

Children upto five years of age and the elderly (aged more than 65 yrs) are at a higher risk and need special

preventive efforts. A considerable portion of such decline in heat tolerance with increasing age may be actually due to reduction in physical fitness, increase in body weight and chronic diseases, which all accompany advancing age (24).

**(b) Gender**

Earlier workers had been of the general opinion that females are less able to work in hot environment and hence more susceptible to heat illnesses. However, more recent evidence suggests that if women are fully acclimatized and physically conditioned, the differences between males and females as regards susceptibility may not be significant. On the other hand, hospitalization data may show a preponderance of males since, in most parts of the world, males are more employed in hazardous heat-illness-prone jobs (25). There is indication that women may be less tolerant to exercise in hot environment during the luteal phase of menstrual cycle as compared to follicular phase (26). There is an indication that pregnant women may be at higher risk of heat illness.

**(c) Racial and genetic factors**

Morbidity and mortality data from the US, British and British- Indian Army, during the world wars, tends to indicate a paradoxical situation that while the overall incidence of heat related illnesses were higher among the whites as compared to soldiers with black colored skin the incidence of severe forms of the disease and death was higher among the latter. More recent evidence, however, indicates that race, per se, may not be an important determinant and any observed differences between racial/ethnic groups may be actually due to socio-cultural reasons. Further studies are required in this field (14). It is also being increasingly realized that certain genetic factors may determine the susceptibility to heat stroke, as those which encode cytokines coagulation proteins and heat shock proteins (HSPs) involved in the process of adaptation to heat stress (27-33).

**(d) Level of physical fitness**

Low level of physical fitness (as indicated by lower levels of $VO_2$ max), in relation to the occupational or recreational requirements, reduce the heat tolerance (25, 34). Similarly, hot environment also has an effect on physical performance in that maximal exercise capacity, as measured by $VO_2$ max, is reduced in hot environment, as compared to temperate environment (35-37).

**(e) Overweight and obesity**

Overweight/obesity (body mass index >25) is also a well accepted risk factor, predisposing to heat illness (38-42). From ergonomics point of view, obesity translates into "additional load" being placed on the body, and hence increases the heat production in a geometrical manner, especially when moderate or heavy exertion is being undertaken. In addition, obesity is often associated with reduced physical fitness which, in turn, is a risk factor for heat illness (43). In fact, there seems to be an interactive effect between obesity and poor physical fitness, with the risk of heat illness multiplying if both are present (38).

**(f) Occupation**

There are certain groups who are well documented to be at high risk by virtue of their occupation or indulgence in certain recreational habits. These include military personnel, mine workers, industrial workers especially those employed around furnaces and foundries, farmers and labourers, especially in tropical countries, fire fighters, sports persons, hazardous waste site workers (particularly due to their impervious clothing ) and adventurers especially when carrying load. Not only sports persons, even spectators may be often at risk (44)

**(g) Physical activity**

Physical activity in a hot /humid environment is a major determinant of heat illness. Within the broad group of "physical activity", certain variables determine the occurrence and severity as follows:

(i) Nature of physical activity

The nature of physical activity and its strenuousness, at a given time is one of the most important determinants since it directly determines the metabolic heat being produced by the body which, in turn, reflects the intrinsic heat load of the body. It also needs to be noted that running or jogging at fast pace leads to very high metabolic heat production and may be particularly hazardous during hot weather.

(ii) The amount of load being carried

For every additional kilogram of "load", an additional 2 kcal / hour of additional heat will be produced, when walking at ordinary pace. This would further increase as the pace increases.

(iii) The type of terrain

As compared to walking on an ordinary black topped road, the metabolic heat production will progressively increase when walking (at the same speed), on a cross country track, on recently ploughed fields, on snow or over heavy sand. In the last case the heat production may be almost two times when compared to walking on road.

(iv) The Inclination (Gradient)

Heat production increases, at a given pace, as the gradient increases. Even a 10% increase in the gradient may substantially increase metabolic heat production.

(v) The duration of physical activity

In harsh, hot & humid environment even well trained persons may suffer from adverse effect of hard physical activity if continued for more than half an hour unless adequate rest pauses are interspersed.

**(h) The type of clothing being worn**

There are 3 aspects, in relation to clothing, which determine the dissipation of metabolic heat, being produced in the body.

(i) The insulation, measured in Clo units (45). The insulation should be, ideally, as low as possible in a hot environment.

(ii) The permeability to moisture, which should be as high as possible.

(iii) Absorption of "radiant energy" which is quite high for dark clothing.

Synthetic material has poor permeability and should be avoided. Similarly multilayered clothing, which 'trap' layers of still air between them tend to increase the insulation even if they have good permeability. Thus the correct approach would be to use light colored loose fitting clothing, in one or two layers, and made of 'breathable' material as cotton.

**(j) Acclimatization to hot environment**

Acclimatization implies physiological adaptation so as to be able to work in the given hot environment without being adversely affected by hot weather. The details of acclimatization are discussed subsequently. Lack of acclimatization is a risk factor for being affected by adverse affects of heat, particularly for exertional heat illness (EHI) which is more common in certain occupational groups as described earlier.

**(k) Lack of concurrent hydration**

It needs to be noted that adequate water has to be replenished, hour by hour, when working in hot environment. The concept of "hardening" the persons to hot environment so that they drink less water on exposure to hot environment (known as "water discipline" or hard scale water rationing") is scientifically incorrect and is likely to do more harm. In fact, dehydration reverses the advantage which is conferred by physical fitness and heat acclimatization (46-48). As would be appreciated subsequently, one of the major pathways through which acclimatization itself works is by increase in sweating. Dehydration will therefore negate the very physiological basis on which acclimatization works. Similar to inadequate replenishment of water, diuretics which are often used by sports persons to reduce their weight before competitions, can have the same adverse effects on heat tolerance, as is caused by dehydration due to drinking less water (49). There is also some evidence that drinking some water, say half to one liter, before physical exercise (pre hydration) may provide some additional advantage as compared to normal (euhydrated) state (50,51).

**(l) Alcohol intake**

It is generally agreed that alcohol intake, in acute or chronic forms, is a definite risk factor for developing adverse effects of hot environment. Kilbourne et al (52), in a case control study, observed that history of alcoholism was associated with a very strong (OR=15.02) and statistically significant risk of fatal form of heat stroke. It is quite likely that the dehydration caused by even moderate amounts of alcohol, as well as the inhibition of secretion of anti-diuretic hormone (thus leading to diuresis and further dehydration) may be the main reasons. The adverse effect of alcohol on heat tolerance may continue for many hours, even for a day, after consumption.

**(m)Skin diseases**

Any impairment of the functioning of sweat glands due to unclean skin, exposure to chemical agents, absence of sweat glands or skin diseases involving a large area, will reduce heat tolerance. The commonest skin disease which interferes with sweat function, thereby reducing heat tolerance, is prickly heat (milaria rubra) (53), which, interestingly, is itself a heat related illness. Similarly, Psoriatic lesions also increase the risk of heat illness (54). Even sunshine may adversely affect tolerance to exercise in a hot environment. The adverse effects of rashes may persist for almost a week after resolution of rash (55, 56).

**(n) Sleep Deprivation**

Sleep deprivation leads to impairment of heat tolerance and also reduces the tolerance built up by acclimatization. The possible mechanism are alteration of thermoregulatory responses during exercise, as also disruption of the cyclical mechanism by which minimum body temperature is achieved as a part of normal circadian pattern (57-60). Available evidence strongly suggests that peaceful sleep of at least 7 to 8 hours in the night and cooler hours of early morning is a good adjunct for preventing heat illness.

**(o) Febrile illness**

Febrile illness, as a consequence of infection or following immunization, increases the "heat load "of the body, as well as the heart rate. It is always a good practice not to exert in hot climate, till 48 hours have elapsed since full recovery from short term febrile illness. For long term febrile illness, re-acclimatization after full recovery should be undertaken. Similarly, gastroenteritis increases the vulnerability by causing dehydration.

**(p) Other illnesses**

Chronic diseases which affect the haemodynamics of circulation, particularly cardio vascular, renal and thyroid diseases or diabetes mellitus will affect heat tolerance mechanism and such persons should be careful when exposed to hot environment (61). In this regard, care should be exercised for providing cool environment in hospitals and nursing homes since it has been shown by Machenbach et al (62) that patients admitted to nursing homes (for different diseases ) are at a higher risk of mortality during hot months vis-à-vis general population.

**(q) Medications (Drugs):**

A number of pharmacological substances reduce tolerance to heat. These include substances often present in "over-the-counter" (OTC) drugs. The important pharmacological agents include tranquilizers of phenothiazine group, anti-cholinergics, anti-histaminics, anti-depressants, beta blockers, ACE inhibitors, diuretics, MAO inhibitors and thyroid hormone preparations (63-66). Kilbourne et al also observed that taking major tranquilizers and anti-cholinergics was an important risk factor for fatal heat stroke (52). Besides pharmacological agents in medications, as above, use of additictive drugs/substances as cocaine, cannabis and amphetamines is also an important risk factor for increased susceptibility to heat illness.

**(r) Previous history of heat illness:**

For reasons which are not still clearly understood, persons who have suffered from heat injury previously are at an increased risk of recurrence (67-69). Moreover, another interesting finding is that there is approximately 40% increased risk of overall (all cause) mortality (mainly due to IHD and cerebrovascular disease), among those who have history of prior hospitalization for heat illness. Thus, being affected by heat illness may also serve as a marker for increased susceptibility to death from others causes. (70).

**(s) Resumption of physical activity without adequate recovery**

Bout of physical activity, followed by another bout, which is likely to be more strenuous than the previous one and undertaken before proper recovery (in terms of stabilization of heart rate), is likely to increase the risk of heat-related illness (71). Similarly, the "last minute dash" in sports events indulged in by sportsperson / military personnel, wherein all available physical energy is used during the last few minutes of a strenuous event may be particularly hazardous (72).

**(t) Type of residential building**

In an earlier study by Parries et al (73) it was observed that a disproportionately large number of heatstroke victims lived on the top floors of buildings. Similarly, in a case control study, Kilbourne et al (52) found out that people staying on floors above the second floor were at 60% increased risk. The same results were observed by Semenza et al (74) who found more than four fold risk for people staying on top floor. It is plausible that heat illness would be greater on the higher floors of building because hot air rises within a building, or else, because of close proximity to a roof heated by the sun. In general, it seems that the higher one stays from the ground or if one stays in the top floor house, the chances of being affected by heat illness are higher, and hence such persons should be more careful regarding prevention.

**(u) Cool environment at home / work place**

Earlier workers had felt that air conditioning at home might actually increase the chances of heat illness, by inhibiting proper acclimatization to hot weather (75). However, Kilbourne et al (52) found quite different results, in that they observed that absence of air conditioning had significant, independent and strong risk for both fatal as well as non fatal heatstroke as compared to persons who had 24 hours air conditioning at home. The workers also observed that spending increased time in air conditioned places (out side the place of residence) also reduced the risk of fatal as well as non fatal heatstroke by one fourth. Similarly Semenza et al (74) have also reported a significant protective effect of residential air conditioning during condition of heat wave.

**(v) Rural-Urban Differences**

It has been observed in western countries that, during heat -wave conditions, the morbidity and mortality in urban areas tends to be higher as compared to rural areas. In fact, urban areas tend to have a 'heat island effect'. The higher effect of heat in urban areas may be due to the higher temperature in cities as a result of increased retention of solar heat by concrete buildings and pavements, increased heat production by motor vehicles, factories and increased concentration of human beings, and, decreased heat loss due to lower wind velocity. In addition, other as yet undefined economic and social differences between city and rural residents may contribute to the higher adversity of heat in cities (76-78).

**(w) Vegetation around places of residence.**

Kilbourne et al (52), in their case- control study, observed that presence of trees and shrub growth around the residence was a strong and significant protective factor, reducing the risk of non-fatal heat stroke by almost half. It is quite logical, since trees and shrubs may shield a residence from direct sunlight.

**(x) Social and religious conglomerations**

A simple epidemiological reason for the observed increase in the incidence of heat illnesses during social and religious conglomerations could be because the "affected" people are much more, hence more cases. However, even when the numbers of the cases are converted to rates by relating them to the population size, it is seen that during such collections in hot / humid weather, the risk of heat illnesses increases. Public Health authorities should therefore keep this aspect as a priority while planning preventive activities during such gatherings (79-81).

**(y) Other social factors**

It has been observed that persons who are living and being cared for, in organized family groups, those who have social contacts and support and who have access to transportation are relatively protected against adverse effects of heat (74).

Environmental Factors

While various attributes of the human host, as described earlier, play an important role in determining who will ultimately get affected by heat illness, a major role in these health issues is played by the physical environment.

From the physical environment point of view, the major factors which emerge as determinants of heat illness are, the temperature of ambient air (usually determined by dry bulb thermometer, DBT), the relative humidity (usually determined by using psychrometric charts and the reading of both the DBT and the wet bulb thermometer, WBT), the Mean Radiant Temperature (MRT) whose main source is either solar radiation or radiations from hot objects as furnaces, and which is usually determined by the globe thermometer (GT), and the speed of the air (usually determined by anemometers or specialized thermometers). Based on the permutation and combination of these parameters, certain indices of environmental heat illness have been developed. A brief description of these indices is as follows:-

**(a) Effective Temperature**

ET is defined as the subjective feeling of warmth (or cold) at a given temperature of air (DBT), when RH is 100%, the air is almost still (minimal air movement) and the subject

is ordinarily clothed. In general, when a person is at rest with a body metabolic heat production of 100 kcal/ hour, in an environment of 100% RH and minimal air movements, an air temperature (DBT) of 36$^0$C marks the upper limit of heat tolerance. If heat productions increases, by strenuous activity to about 425 kcal/hour, under the same environmental conditions, a DBT of 31$^0$C is the upper limit of ET for 4 hourly tolerance (82). For the outdoor setting, the preferred index is Corrected Effective Temperature (CET), where Globe thermometer temperature (GT) is used in place of DBT.

**(b) Oxford (syn: Wet-Dry: WD) Index:**

The Oxford Index is a simple and quite effective Index, based on DBT and WBT

WD Index = 0.85 WBT + 0.15 DBT.

**(c) Wet bulb globe temperature (WBGT)**

WBGT index is most commonly used index of thermal stress. It takes into account the effect of MRT (as measured through globe thermometer (GT) in addition to WBT and DBT as follows:

Outdoor WBGT = 0.7 WBT + 0.2 GT + 0.1 DBT

Indoor WBGT = 0.7 WBT + 0.3 GT

WBGT levels of 30$^0$ C and above indicate definite thermal stress and care needs to be exercised (83). From May to August, most of the Indian subcontinent (except the northern hilly areas) tends to have WBGT values of more than 30$^0$C.

## Prevention of Heat Related Illness

No country, particularly the armed forces and industries, can ignore the potential dangers of sustained heat wave. Every community should assess its resources and develop a contingency plan. Although heat stroke is amenable to medical treatment, control can best be achieved by applying the principles of public health. Sentinel Surveillance, public education, outreach to vulnerable persons and enlistment of the help of the entire community can save lives (81).

A structured approach towards prevention and control of Heat illnesses in communities consist of

(a) Health measures directed towards communities and large populations groups

(b) Specific preventive measures directed towards individuals/small groups identified to be at high risk of heat illnesses due to certain occupational characteristics

(c) Early detection and first aid.

**Public health measures directed towards communities and large populations groups:-**

In tropical countries like India, millions of people among the general population are at risk during the hot/humid months, especially when spells of heat wave strike. In such settings, heat related casualties may occur in large numbers in short duration (84-86) creating almost a disaster like situation and hence the need for public education, provision of evacuation and treatment facilities, and quick first aid. From the public health point of view, the following aspects need to be addressed:

(a) Public education on various preventive measures

Creating public awareness should be high on the list for the public health administrators. Studies have revealed that subjects who listen to media messages through radio or television are less prone to developing heat illness, hence full use of audio-visual and print mass media must be made during the onset of hot weather and also well before the expected heat wave. In Armed Forces settings,

Box - 2 : Education for prevention

- Do not venture out in the sun, especially between 10 am to 4 pm unless the same is necessary
- Avoid strenuous physical exertion between 10 am to 4 pm during the hot weather unless the same is necessary for reasons of occupation.
- Drink at least 4 to 5 liters of cool water in a day even if not feeling thirsty. If undertaking strenuous physical activities, drink a quarter to half liter of water after every half hour, as long as strenuous activity continues.
- Do not wait for 'thirst' to develop. Keep drinking water regularly even if not thirsty.
- If exposure to sun is necessary, place a wet hand towel around your neck.
- Put on a wide brimmed hat of light colour when going out. Simple caps as golf cap may not give enough protection.
- Put on sunglasses when going out in the sun.
- Apply a sun screen ointment with a sun-protection-factor (SPF) of at least 15, which should be able to protect against both UVA and UVB rays , when going out in the sun,.
- Avoid alcohol consumption during hot humid months. If consumption becomes necessary, keep the same within limits of less than 2 small drinks of hard liquor or one bottle of light beer.
- Keep children less than 5 years and elderly (aged 65 years and above) away from sun as far as possible.
- Never leave children (or pets) in a closed, parked car. Try and park your car in cool, shaded place
- Use a car-sun visor to minimize the effect of direct radiant heat produced by the sun.
- Dress for hot, humid weather should be 'breathable' i.e. Loose fitting, light weight, light colored, preferably of cotton material and in one or two layers only.
- Carry a water bottle with cool drinking water whenever you go out in summer months.

all Medical Officers, especially RMOs should endeavour to educate the troops and families regarding these points, as shown in Box - 2.

In addition to providing the messages for simple Dos and Don'ts, the general public should also be made aware of whom to contact during an emergency (telephone numbers and addresses). In addition, messages should also tackle certain myths which need to be busted (Box - 3).

**Box 3 : Myths that need to be removed**

- Alcohol especially if chilled is good (or harmless) during hot weather.
- Track suits or windcheaters should be worn while doing sports or physical training.
- Tough people do not need to drink water.
- After acclimatization (getting used to) to heat, one can do well with only limited amounts of water.
- Drink water only when you are thirsty.
- Sports drinks are better than water.
- Salt tablets are good for preventing dehydration.

(b) Provision of basic preventive amenities at vantage points on a large scale basis, during high risk periods:-

There are four basic amenities which all public health managers must strive to provide to the general public during the hot weather or else, if some high risk activity as sports events or religious/social gatherings are likely. They are:-

(a) Cool drinking water at vantage points.

(b) Covered/shaded areas for taking rest pauses.

(c) Facilities for first aid in a way that they are early accessible to all, particularly the high risk groups.

(d) Public information system to make all aware about the facilities and the telephone numbers/addresses of persons / first aid facilities who may be contacted during need.

(c) Identification of high risk groups and enlistment of community support

Studies have revealed, there are certain high risk groups like agricultural workers, manual laborers, young children, old people, those who are unable to care for themselves or do not have a family to care for them, those staying on higher floors of high rise buildings, people staying in "concrete jungles" of urban areas without much vegetation around, and those using major tranquilizers, anti-cholinergic, alcohol, cocaine or cannabis, and those who form part of large social or religious gatherings/festivals, are more vulnerable to the effects of heat. Enlistment of community support as part of voluntary services with outreach efforts towards these high groups can be of much utility in minimizing the public health impact of heat.

(d) Public Health Surveillance, Early Warning Systems and Disaster Plan

The need to have a good epidemiological surveillance system for heat illnesses as well as various environment conditions that determine those illnesses, need not be over emphasized. This should be established not only for specialized groups like armed forces or industries, but also for the general community as well. It is only through ongoing collection of data and monitoring of trends of occurrence of illness and environmental factors, that proper policy decisions on public health aspects of heat illnesses can be taken (44,87, 88). An effective heat illness surveillance system must include reporting of all heat illness cases according to diagnostic categories, both for inpatient and OPD cases separately. It should include the time and place of exposure, basic clinical data, the antecedent / precipitating factors, personal risk factors and the essential meteorological data (WBT, DBT, GT) according to time and for various locations. The data should be analyzed in an ongoing manner and a "Heat and health early warning system" should be developed to issue early warnings to the physician as well as to the general community. Simple warning criteria for outdoor exercises or events as running, cycling, for general public can be that if the WBGT is >28°C or else if the oxford (WD) index is >26.5°C than the event should be preferably cancelled (87). It should be noted that the Dry bulb / wet bulb / Globe temperature should be recorded as near the place of event and at about the same time when the event is scheduled. More detailed guidelines for use by medical officers in Armed forces are given in Table -1. For combination of DBT and RH which fall in moderate risk category, medical officer should advise the commander to be extra cautious. If the combination fall in high risk zone medical officer should advise the commander to consider canceling the event unless operationally required.

Table - 1 : Rough Guide For Outdoor Physical Exercise based on DBT and RH

| Dry bulbs temp (DBT) °C | Moderate risk of heat effects | High risk of heat effects |
|---|---|---|
| | Relative Humidity | (RH) levels (%) |
| 29.5°C | 100% | - |
| 32.2°C | 70-99% | - |
| 35.0°C | 50-70% | >80% |
| 37.8°C | 40-50% | 60-80% |
| 40.6°C | 20-40% | 50-60% |
| 43.3°C | 10-30% | 40-50% |
| 46.1°C | 10-20% | 30-40% |
| 48.9°C | 1-10% | 20-30% |

**Note**

(a) These meteorological parameters should be recorded as near the place of outdoor exercise as possible and around the same time.

(b) Calculation of RH based on DBT and WBT readings is described subsequently in the chapter on

meteorology in this section.

**Specific Preventive Measures Directed Towards Individuals and Small Groups**

Specific preventive measures directed to individuals or specific high risk groups as industrial workers, military personnel, sports persons etc, are set out to achieve the following objectives :-

(a) To reduce the "heat load":-This is achieved by

(i) Proper protective measures in the industries as isolation of furnaces, air conditioning of works areas, and spray with cold aerosols.

(ii) Seeking shade and wind to the extent possible.

(iii) Frequent rest pauses interspersed between phases of physical activity.

(iii) Putting on proper clothing of low insulation, low energy absorption and high permeability.

(iv) Reducing the amount of exercise in terms of duration or intensity or both especially during hot part of the day.

(v) Avoiding carrying of load or reducing the load.

(b) Improving and maintaining the individual capacity to dissipate heat

This is achieved through acclimatization to heat and proper hydration, as described later.

(c) Avoiding antecedent factors which increases the risk : These include

(i) Avoidance of obesity.

(ii) Avoidance of alcohol and other habit forming agents as cocaine, cannabis and caffeine.

(iii) Avoidance of self medication.

(iv) Avoiding physical activity and exposure to hot environment during febrile illness, until fully recovered.

(v) Ensuring proper sleep of 7 to 8 hours in the night and cooler parts of early morning. An afternoon rest in a shaded place may be of further protective value.

(vi) Avoiding exposure to heat for extremes of age (less than 5 years or more than 65 years) and during pregnancy.

(vii) Maintenance of general hygiene and sanitation, regular bath and care of skin, proper immunization and food/water hygiene to avoid GIT infections.

(viii) Nutritious and palatable meals with plenty of drinking water.

(ix) Treatment of skin conditions as prickly heat, psoriasis, sun burns etc.

(d) Acclimatization to heat

Acclimatization to heat is a process of undertaking gradually increasing physical exercise in gradually increasing hot environment with a view to develop physiological changes, so that the individual, so acclimatized, is able to perform physical activities in the hot environment for which he/she has been acclimatized, with much less risk of suffering adverse effects of heat (88, 89).

The individuals to be acclimatized are subjected to physical exercise in a hot environment in which they are ultimately required to work. The schedule should be in a graded manner, starting with lower intensity of physical exercise for lesser duration (about an hour) in less hot environment. This is gradually increased, both in intensity and duration (to about 90 -120 minutes) and to the required hot environment, by the $6^{th}$ or $7^{th}$ day and continuing thereafter for another 7 days. It takes about 10 to 14 days for status of acclimatization to be achieved.

During the process of acclimatization, individuals should be encouraged to drink plenty of water/oral fluids and additional salt may be given with meals (not as salt tablets). The dictum should be to replace water loss hour by hour and salt loss day by day.

The physiological changes consequent to acclimatization are increased sweating in response to exercise, lowered threshold for exercise induced sweating, lesser rise in heart rate and lesser rise of skin and rectal temperature in response to exercise. In addition, the amount of salt excreted in sweat decreases with acclimatization; there is increased ability to sustain sweat production during prolonged exercise and redistribution of sweating from truncal region to the extremities. Use of heavy or impervious clothing will negate the advantage achieved by acclimatization. It is important to ensure proper hydration to compensate for the water loss.

Secondly, it must be noted that acclimatized people are rendered "heat-fit" only for the particular level of hot environment for which they have been acclimatized; sudden requirement to work in a harsher environment will need further acclimatization.

There is some evidence that physical exercise programme of 2 months, undertaken in temperate environment may lead to improvement in exercise heat tolerance. However, for achieving the ideal state of exercise heat tolerance, acclimatization should ideally be undertaken in hot environment (89). It has also been reported that while acclimatization in a hot and dry (desert like) environment also provides adequate protection in hot and humid (jungle like) environment the reverse may not be completely true, since acclimatization in humid heat produces physiological changes which are more specific for hot and humid conditions (90, 91). Hence, personnel moving to hot and humid areas, even from hot & dry areas, need to be additionally acclimatized.

The tolerance which results from acclimatization may be reversed by use of alcohol, dehydration, sleep deprivation, infections and by salt depletion and hence these aspects must be taken care of, even after individuals have been fully acclimatized (92-94). Moreover, without ongoing heat exposure, it is likely that nearly all the beneficial changes of acclimatization may be lost in about two-and-a-half to three weeks time, although partial losses due to non-exposure for few days can be made up by the body on re-exposure to hot environment. Hence,

acclimatized subjects should continue to exert ohysically in the hot environment once thay have been acclimatized, to retain the acclimatized state. Physically fit subjects are likely to retain the beneficial effects of acclimatization for a longer time (90, 91, 95, 96).

As regards the role of supplemental salt, for a fully acclimatized person, the same may not be required. This is because, with acclimatization, the secretion of sodium in the sweat is greatly reduced so that healthy, acclimatized persons can secrete up to 9 liters of sweat in a day and live in perfectly well salt balance, with 5 to 6 grams of dietary salt per day. However, subjects who are not acclimatized or are in the process of acclimatization in unusually hot environment or else are not consuming normal diet, an additional 10 grams salt may be given in the diet (not as salt tablets) till they are fully acclimatized, taking care that adequate hydration is maintained. Corticoids (Aldosterone, deoxycorticosterone) sometimes administered during or before the process of acclimatization do not seem to be having any useful role. The role of heat shock proteins (HSPs) which are released as a result of exposure to heat, in assisting during acclimatization is still in the preliminary studies (97).

(e) Maintenance of Hydration

During the process of acclimatization and also after acclimatization it is imperative that adequate hydration be maintained, other wise the entire process of acclimatization will be negated. In certain settings particularly in military and industries, there is a general feeling that once fully acclimatized; persons can do with greatly reduced amount of water (the so called water rationing or hard-scale of water or water discipline). Medical persons must explain to commanders that this feeling is scientifically unfounded and can, in fact, lead to disastrous results. It needs to be noted, and explained, that there is no substitute to adequate hydration even after full acclimatization since acclimatization itself works on the principle of increasing the sweating. One can acclimatize to physical work in heat but there is nothing like acclimatization to dehydration.

Persons should be encouraged (even, at times, forced or ordered) to drink water regularly, while working in hot environment, even when not thirsty. It must be explained clearly that thirst is quite a poor index of dehydration and should not be relied upon (98-100). Drinking only when thirsty will result in inadequate replacement of water losses and result in dehydration of more than 2% of body weight, which may be dangerous. A very rough but useful guide for the RMO / MO functioning at isolated areas is to notice the colour of urine of the subject; increasingly yellow shades of urine colour indicate increasing dehydration.

The best fluid for drinking is cool, hygienic water. There does not seem to be any scientific rationale for the so called 'Sports Beverages' which contains large amounts of electrolytes and glucose. Of course, the only advantage of sports beverages seems to be their greater palatability, so that subjects drink more as compared to plain water (101-104). Glucose and electrolytes in such drinks do not increase the intestinal absorption of water, compared to plain water as often claimed (103). There is no place for supplemental salt tablets as has already been emphasized earlier. There is, however, some evidence that providing carbohydrates, in the forms of oral 5% or 10% glucose or sucrose solutions or oral "glucose polymer solutions" (available commercially) can improve the exercise performance and can be used in sustained sports activities (soccer, hockey and tennis) or sustained military operations (105,106).

It would be worthwhile to drink half a litre of water, about an hour before starting physical activities in hot weather, as a 'prehydration' method and to correct any pre-existing water deficit (107). Thereafter, every person should drink 300 to 350 ml water (equal to the usual steel tumbler) every half hourly, during the exercise, without waiting for thirst. In fact, more frequent intakes of smaller amounts (250 ml i.e., one ordinary size glass tumbler every 20 minutes) may be even better. At the same time, care should be taken not to drink so much that it leads to abdominal distension (108-109). A safe upper limit can be a maximum of 500 to 600 ml at a sitting. There is no harm in drinking cold water; there is no evidence that it causes cramps. In-fact, cold water increases the motility of gastric smooth muscle leading to rapid empting and hence faster absorption of water from proximal intestine (110).

**First Aid**

This is described subsequently under management of heat effects

## Clinical features of effects of heat & their management

**Pathophysiology**

As a part of thermoregulatory process, even an increase of 1˚C in the temperature of blood generates signals to the hypothalamic thermoregulatory center leading to increase in heart rate and cardiac output, which, coupled with the sympathetic cutaneous vasodilatation, greatly increases the skin blood flow. Sweating is activated and its evaporation cools the body surface, unless the air surrounding the body is fully saturated with water, i.e., having relative humidity (RH) of 100%.

Increasing the movement of air in contact with the body also increases cooling by promoting evaporation of sweat. Sweating, however, leads to loss of water and salt, which may be as high as 2 liters per hour under conditions of high humidity and physical exertion. If the water and salt are not replaced adequately and concurrently, the fluid reserves would be depleted, even though the body core temperature may not be very high. This condition is called "Heat Exhaustion" (HE).

However, at times, the thermoregulatory response may be overwhelmed by the hot environment, even though the fluid and salt reserves of the body may be adequate. Such thermoregulatory failure, coupled with exaggerated acute phase response (increased production of inflammatory cytokines & endothelium derived vasoactive factors and activation of coagulation process) and alterations in the expression of Heat Shock Proteins (HSPs), leads to "Heat

Stroke" (HS). For these reasons, a number of cases of HE, if not properly managed, would also pass on to HS. Following HS, a Multi-Organ- System-Damage (MOSD) results from a complex interplay between the cytotoxic effects of heat and the inflammatory and coagulation responses of the host.

**The Clinical Syndromes Of Adverse Environmental Heat**

Heat Stroke (HS) :-

The classical clinical description of HS is the triad of hyperpyrexia (rectal temperature > 40°C), CNS dysfunction and anhidrosis. Anhidrosis, however, is not a diagnostic requirement since it may appear later when volume depletion is severe. Moreover, in cases which initially start as HE or cases of HS which occur among young people who have been exerting physically, the skin may be moist. Brain dysfunction is usually severe (coma, stupor or delirium), but may sometimes be subtle, manifesting as inappropriate behaviour or impaired judgment. In fact, any person who develops irrational or confused behavior following exposure to heat stress either with or without a history of physical exertion, should be treated as a potential HS patient. Other clinical features include evidence of dehydration, shock, convulsions and, sometimes, mild icterus. Two forms of HS are recognized, viz. the classical (CHS) and the

Table - 2

| | CHS | EHS |
|---|---|---|
| Age group | Elderly | 15 to 45 years |
| Previous health status | Usually compromised | Healthy |
| Concurrent activity activity | Sedentary | Strenuous |
| H/O drug use | Often present | Usually present |
| Sweating | Often absent | May be present |
| Skin | Dry | Frequently moist |

exertional (EHS) form. The clinical differences between the two forms are shown in Table - 2.

**Differential Diagnosis**

Heat stroke should be considered as a possibility in any patient who presents with elevated body temperature and altered mental functions. Important and common diseases which need to be excluded are tropical infectious diseases like cerebral malaria, encephalitis and meningitis. Other diseases which need to be considered are thyroid storm, pheochromocytoma, status epilepticus, cocaine and amphetamine abuse, delirium tremens and CVA especially pontine hemorrhage. The diagnosis of HS is usually one of exclusion and the typical history of exposure to hot environment during the immediate past is a strong indication towards heat stress hyperthermia.

**Laboratory Investigations**

Blood should always be drawn for a peripheral blood smear for malarial parasite as well as for other infectious causes of hyperpyrexia with CNS dysfunction. Laboratory findings of HS include haemoconcentration, mild leukocytosis, elevation of blood urea and, in some patients of EHS, hypoglycemia. Impaired blood coagulation with lowered prothrombin, low platelet counts, hypofibrinogenaemia and features of DIC may be seen. Serum electrolytes studies generally show normal or high chlorides, hypokalaemia, hypocalcaemia, and hypophosphataemia. Enzyme studies show increase in CPK, SGOT and SGPT levels. If rhabdomyolysis or acute renal failure (secondary to acute tubular necrosis) has set in, urine will show myoglobinuria, proteinuria, and hyaline and granular casts, and there will be increase in BUN levels.

**Complications**

The most serious complication of HS is Multi-Organ-Systems-Damage (MOSD), manifesting as hepatic failure, renal failure, cerebellar damage, cerebral oedema and

Box - 4 : Heat Stroke : Management at First Aid Level

- Record rectal temperature. If it is not possible to record rectal temperature, record oral temperature and add 0.5°C.
- Try and move patient to a cooler, shaded place.
- Remove the clothes.
- Spray skin with water at 25 to 30°C or wrap the patient with a sheet soaked in water at 25-30°C.
- Continue fanning manually or with an electrical fan.
- Keep vigorously massaging the skin to prevent cutaneous vasoconstriction during cooling.
- If available, place ice packs or towel soaked in cold water around the neck, axillae and groin.
- Nurse in the comatose position; clear oral secretions.
- Transport to the medical facility as an emergency.

Box - 5 : Heat Stroke Management at the Level of Solo-Physician or at Primary Health Care Level

- Initiate measures outlined under first aid if not already initiated
- Establish Intravenous line; take blood sample for investigations.
- Continue cooling measures as outlined in first aid.
- In case temperature is not reducing, immerse the patient in tub containing cold or iced water, keeping the head and neck outside the water surface.
- Start normal saline (or Ringer lactate) drip at 20-25°C. Give a challenge of 1 litre fluid in 15 to 30 minutes. Add other electrolytes such as $K^+$, as guided by subsequent investigations.
- If any evidence of seizures, give IV Diazepam 5-10mg over 10 minutes
- If facilities are available, intubate the patient and initiate ventilatory support.
- If rectal temperature is not coming down or there is evidence of cerebral, hepatic or renal complications transfer the patient to a hospital with adequate facilities.

arrhythmias. Rhabdomyolysis and DIC are other serious complications.

**Prognosis**

HS must be treated as an emergency. Mortality may be as high as 30% to 50% among cases in which treatment is delayed. Mortality is directly proportional to the level of core temperature and its duration. Prolonged coma of more than 2 hours is a poor prognostic indicator. Among survivors, neurological recovery generally occurs but some deficit may persist in upto 20% of the cases.

**Treatment**

HS must be treated as a serious medical emergency. Delay in institution of appropriate therapy by even few minutes may make all the difference between life and death. The treatment objectives are, firstly, rapid cooling to bring down the core temperature to below 39°C, reducing it by approximately 0.2°C per minute; secondly, rehydration and care of comatose patient; and, thirdly to support the organ system function. Cooling measures should be stopped once core temp falls below 39°C. The steps in management at the first aid level, and primary care / solo physician level (RMO / OC ADS / MO at peripheral hospital in context of armed forces) are shown in Box 4 & 5 respectively.

**Heat Exhaustion (HE)**

The features which differentiate HE from HS are that core temp is less than 40°C and there is no evidence of CNS dysfunction, though some patients may be anxious or irritable. The main features are feeling of exhaustion, nausea, headache or light headedness, features of dehydration, hypovolaemia (tachycardia, loss of skin turgor, dry mucous membranes and thirst) and syncope. Sweating is usually profuse and skin is moist. Rectal temperature is usually between 39°C to 40°C, though some patients may have a normal temperature. In fact, HE may actually be a point along the continuum which, if not managed energetically, may move on to HS. Urinary output is reduced and urine may be light to dark yellow in colour. Depending on how energetically the patient has been replacing either water or salt, two subtypes, viz. Water Depletion HE and Salt Depletion HE may occur. In water Depletion HE, as compared to Salt Depletion HE, vomiting and muscle cramps are not a prominent feature, while thirst is prominent, and serum $Na^+$ is normal or raised. However, mostly a mixed picture, as described earlier is seen.

Treatment consists of shifting the patient to a cool, shaded and ventilated place. The clothing should be loosened, patient placed in recumbent position and feet should be elevated. If patient can drink, give one liter of water (or, preferably, "Oral Rehydration Solution" 1 packet dissolved in one litre water or else a solution of 2.5g common salt and 2.5g baking soda in 1 liter water) orally in about 30 minutes Give a total of 2 liters in about one to one-and-a-half hours. Simultaneously, measures for cooling, as described under heat stroke, should be initiated. Keep monitoring rectal temp; if rectal temp goes beyond 39°C, the patient may be passing on to heat stroke and should be shifted to a medical facility for appropriate management.

**Other Adverse Effects Of Hot Environment**

Heat Cramps

These manifest as spasms of muscles, especially lower extremity and shoulder, following heavy muscular exertion in hot environment, with associated intake of hypotonic oral fluids. Treatment consists of oral administration of 0.1% to 0.2% salt solution. Severe cases or those with vomiting should be given IV normal saline.

Heat Tetany

Symptoms include carpopedal spasms and paraesthesiae following short exposures to excessively hot environment, leading to hyperventilation and respiratory alkalosis. Treatment consists of removing the patient to a cool environment and asking him to slow down the respiration.

Heat Syncope

This manifests as syncope following exposure to heat stress as a result of peripheral vasodilatation. One should exclude other serious causes of syncope. Treatment consists of removal of patient to cool environment and oral rehydration.

Heat Oedema

This presents with pitting oedema of hands and feet, usually in the elderly, following exposure to heat stress. Other causes of oedema should be excluded. Treatment consists of reassurance, elevation of affected limbs and, if required, compression bandage.

Prickly Heat (Lichen Tropicus, Milaria Rubra)

It manifests as erythematous, pruritic, maculopapular rash. If the condition is allowed to progress, extensive prickly heat that can progress to chronic dermatitis and superinfection can occur. Prevention consists of regular baths with cool water after gently scrubbing the skin, and wearing loose, light weight clothing. Local application of calamine lotion or chlorhexidine lotion alongwith oral antihistamines is helpful. In case of severe forms, local application of 1% salicylic acid cream and antibiotics for superinfection (usually S. aureus) should be given.

## Global warming & ozone attenuation

Increased human activity inclusive of rapid industrialisation, urbanisation and increased burning of fossil fuels coupled with deforestation has lead to Global warming affecting the earth's ecosystem through the changing climatic & environmental conditions.

The earth's mantle of atmosphere, consisting of various gases, acts like a Green House allowing the passage of short wavelength solar radiations in to the biosphere, trapping longer wave length infrared radiations. Presence of these atmospheric gases acts like an insulator for the earth and prevents excess of heating and cooling during the day and night respectively. Otherwise the mean temperature of the earth would have varied from 49°C to (-) 40°C during the day & night as compared to the existing global mean temperature variation of 14°C to 15°C. This phenomenon is known as Green House Effect. Increased

combustion of petroleum fuels through ever increasing automobiles, accelerated by global industrial and commercial development are adding many pollutant gases in to the atmosphere in large quantities. About 6 billion metric tonnes of carbon dioxide are being added to the troposphere annually which is ever increasing. Tropical rain forests, an important carbon sink, are being rapidly depleted & unicellular phytoplankton present in sea, another carbon sink, is damaged by increased ultra violet radiation flux due to depletion of stratospheric ozone resulting in increased concentration of carbon dioxide in the green house which would trap more solar radiation in the biosphere leading to Global Warming. The annual average global temperature has risen gradually from 14.5°C in 1886 to 15.4°C in 1995 which closely relates to the increase in atmospheric heat trapping green house gases. It is predicted that the mean temperature of the globe might increase by 1°C to 3.5°C in the twenty first century with all its adverse effects.

Ozone ($O_3$) is formed by combining of an $O_2$ molecule with oxygen atom under the influence of solar radiations. The average concentration of ozone is about 300 parts per billion by volume in the atmosphere of which 90% is present in stratosphere. Ozone even in such quantities plays a vital role in supporting life on earth. The conversion of Ozone into oxygen molecules and reforming into ozone under the influence of solar radiations helps in conversion of solar energy to heat. Ozone exerts its protective effect by absorbing ultra violet radiations of wave lengths from 290 to 315 nm . Ultra violet radiations are partially shielded by clouds, dust and other air pollutants. Reduction in ozone concentration with clear sky will have adverse effects.

The chlorofluorocarbons (CFCs) are used in refrigeration industry, as propellants in aerosol sprays, as blowing agents for plastic foam and as cleansers in electronic industry. Over 7 lakh metric tonnes of CFCs are not removed by rainfall as they are not soluble in water and further their half lives are over 100 years and thus can exert their influence for a long time. Chlorofluorocarbons like each carbon monoxide molecule can destroy 10,000 ozone molecules other compounds like halocarbons, oxides of nitrogen can also destroy ozone.

**Effects**

The effects of global warming on human health are both direct and indirect which include the following :-

(a) Heat Stress

An increase in average global temperature will result in experiencing of irregular heat waves in mid latitude levels. Minimum temperatures in night and winters would increase more rapidly than average temperatures. A warmed atmosphere holds more water vapour (6% more for each degree celsius) resulting in increased humidity in heat waves.

(b) Weather Disasters

Global warming would result in frequent and more severe storms with heavy precipitation and flooding. The increased temperature of air and oceans result in more evaporation , clouds and rains mainly in coastal areas.

(c) Rising Sea Levels

In the preceding 100 years, sea levels have risen by 10 to 25 cm. Even the expected rise of sea levels sea level by 50 to 100 cm due to thermal expansion of the oceans, melting of glaciers and ice caps will inundate large population centres and much fertile land, resulting in 50 million environmental refugees world wide. Mainland coastal regions and low islands will be in danger. In addition, adjacent land would be rendered unfit for agriculture by the rising salinity of water table. In India 5.7 Lakh hectares and 7 million peoples are at the risk of inundation.

(d) Climate change & Infectious Diseases

Outbreaks of vector borne diseases which are dependent on climatological factors would be common as temperatures coupled with increased humidity would help the vector to develop early and live longer and thus could transmit the disease for longer duration.

Ozone attenuation would adversely affect the life on earth by allowing the ultra violet radiations in the biosphere and their consequent ill effects are as skin diseases, varying from simple sunburn like lesions to cancers (squamous cell & basal cell carcinomas and other malignancies); Keratitis, cortical / subcapsular cataracts and lowering of general immune response.

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# Adverse Effects of Cold Environment : Epidemiology and Prevention

Annals of warfare history have recorded cold injuries as a major problem in military operations. Descriptions of Xenophon's march of Ten Thousand in 400 BC in Armenian region, and Hannibal's loss of large numbers of his Army of half a lakh, while crossing the Alps in 218 BC, are quite vivid (1,2). Deleterious effects of extreme cold are inherent in the atmospheric environment at high altitude, but they also occur at low altitudes as in the Polar Regions. Even sub tropical areas like the plains of Northern India experience severe winters, where such illnesses do occur.

Human exposure to extreme cold produces significant physiologic and psychological challenges. Cold is considered as an important environmental stressor, in view of its potential lethal / serious consequences (3). The human body becomes even more susceptible to the adverse effects of cold when chronic exertional fatigue, sleep loss, and inadequate nutrition are also co-existent (4). Initially, the relevance of cold was limited to the militaries with operational deployment of troops at high altitude and extreme cold areas; the effects of cold climate get further complicated and aggravated due to hypoxia. Thereafter, the medical fraternity got further interested in this field, following the expeditions to the Polar Regions. As of now, cold injuries have become a matter of study, not only in context of military or polar expeditions, but because of increased participation by the general population in such outdoor activities as mountaineering, ice skating, ice fishing, cross country skiing, snow-games, etc.

Extreme cold conditions occur in India in the Himalayan, Sub - Himalayan and the northern Indian plains with cold waves and deaths being recorded every year. Over the 5-year period of 1999 to 2003, a total of 3,524 deaths due to cold exposure have been reported; the actual magnitude may be higher. Groups at particularly high risk include military personnel, agriculturists, mountaineers and persons engaging in adventure or winter sports. From socio - economic aspect, persons with low income, poor housing and inadequate clothing are at particularly high risk especially during the cold wave conditions. Extremes of age (<5yrs or >65yrs), physical exhaustion, pre - existent malnutrition or starvation, use of alcohol and underlying diseases (hypothyroidism, hypoadrenalism, diabetes and CV Disease) increase the risk.

## Adverse Health Effects of Cold

Adverse effects of cold environment can manifest as either generalized effects (hypothermia) or local "tissue-freezing" effects as frost bite, or non-freezing cold injuries (NFCI) as trench foot and chilblains. Besides, local effects due to UV rays predispose to solar keratitis (snow blindness) and sunburns, while exposure to cold, dry air predisposes to rhinitis. Local effects on dental fillings due to cold lead to bacterial invasions and dental problems.

## Pathophysiology

The physiological protective responses to generalized cold involve, firstly, peripheral vasoconstriction, which tends to act as an "insulator" for the inner body core, in an effort not to lose the core heat, and, secondly, increased thermogenesis by shivering. Coupled with behavioural factors as seeking shelter, putting on clothes and increased muscular activity, the body physiology tries to normalise the core temperature. In the initial stages, there is increase in metabolism, heart rate and cardiac output. However, as exposure to cold increases, the overall metabolism slows down and there is reduction in heart rate, cardiac output and respiratory rate.

Local cold induced injuries are due to formation of "Ice - crystals" within the cells followed by rupture of cells due to endosmosis or due to tearing by ice crystals. Distal areas of the body and areas with high surface-to-volume ratio (ears, fingers, toes, nails and cheeks) are more susceptible.

## Generalisied Hypothermia

### Clinical Features

Early symptoms of generalised adverse effects of cold become apparent as the "core" (rectal) temp. drops below 36˚C and are clearly evident once it is below 35˚C. Depending on the core temp, hypothermia may be classified as borderline (36 to 35˚C), mild (35 to 32˚C), moderate (32 to 28˚C) and severe (<28˚C). One of the earliest symptoms of hypothermia is change in behaviour but, unfortunately, the victim is the last person to notice such changes himself. There are mild mood changes, lack of affect, apathy, uncoordinated movements, ataxia, confusion and decreased ability to sense cold. Initially, there is tachycardia, tachypnoea & shivering which can be voluntarily controlled. However, as hypothermia becomes more severe, (32 to 35˚C) there is bradycardia and decrease in respiratory rate. Higher reasoning becomes impaired (e.g., the person may not be able to count backwards from 100, subtracting 9 every time). Shivering becomes violent and cannot be stopped voluntarily. Lack of appreciation of cold may lead to "paradoxical undressing" (the person starts removing the clothes rather than putting on more clothes). Gait becomes stuporous. As the core temp falls below 32˚C, shivering stops. Skin becomes blue and puffy. Patient becomes semiconscious and muscles start becoming rigid. Trismus is often present. There is marked bradycardia and lowering of respiratory rate. ECG shows the 'J' (Osborn) wave at the junction of QRS complex with ST segment in about 80% cases and this may be confused with myocardial ischaemia. Cardiac dysrythmias are very common, especially atrial / ventricular fibrillation. Once the core temp drops to 28˚C or less, the patient is completely unconscious with severe bradycardia. Radial

pulse may not be palpable and carotid pulse may reveal as low as 2 to 3 beats per min. Respiratory rate is also reduced to 1 to 2 per min. Muscles become rigid and pupils dilated. At this stage the patient may appear dead but may not be so. Carotid pulse must be carefully palpated in all such cases.

### Investigations

The most important investigation in a patient of hypothermia is to accurately monitor the core temperature. If possible, an X-ray of the chest or other regions may be taken, primarily to rule out other traumatic injuries since coexisting trauma, haemorrhage and shock may worsen the manifestations of hypothermia. Blood biochemistry usually shows metabolic acidosis, azotaemia and haemoconcentration. ECG may show the 'J' wave as described above, bradycardia and dysrhythmias.

### Treatment

Hypothermia should be treated as a medical emergency. Early recognition and institution of therapy may make all the difference between life and death. The basic principle of management is quick warming of the "core" without causing simultaneous vasodilation of the periphery, from the level of first aid till the most elaborately equipped critical care facility. The steps in management at the first aid level, and at the primary care/ solo physician level are shown in Box - 1 & 2, respectively.

During the process of rewarming, one should be very careful as regards the phenomena of "after-drop". This happens if the extremities are also rewarmed or else the patient starts exerting again, leading to vasodilation of peripheral vessels in arms and legs, thus releasing extremely cold blood as well as acidic metabolites (which were trapped in this part of the vasculature). Once this cold blood and metabolites are shunted back, it further cools the brain, heart and viscera as well as making the myocardium more susceptible to dysrhythmias. Hence, during rewarming, do not warm the extremities and do not let the patient exert even if consciousness has been regained.

One also needs to be careful while instituting cardiopulmonary resuscitation (CPR) in a patient of hypothermia, who may appear dead with dilated, fixed pupils and no discernible pulse or respiration. Such patient may be still alive, in a "metabolic icebox". Instituting CPR in such a patient may precipitate an "after drop" and dangerous dysrhythmias. Hence, in such a patient, one should carefully check the carotid pulsation and respiration to detect very low heart rate (2 to 4 min) and low respiratory rate (2-3/min). If there is evidence of life, one should start rewarming and not institute CPR. CPR should be started only if it is confirmed that pulse is absent. Once started, CPR should be continued as the patient is being rewarmed. There have been cases when patients with severe hypothermia have been given CPR for as long as 3 hours and finally revived. The patient should be declared dead only after he has been rewarmed to core

**Box - 1 : Management at First Aid Level (Nur Asstt. / RMO)**

- Remove wet clothing only when patient has reached a warm, dry and sheltered environment and not in the open.
- Immediately wrap the patient all around, including head, with warm clothes, blankets, quilts, sleeping bags - whatever insulatory material is available, even news papers or rags. Make an "insulatory wrap" of about 4 inches thickness all around the patient. Provide a wind and water proof outer most layer, as polythene sheets.
- Make hot packs with warm water bottles covered with a cloth, or warm pads, at 42°C to 45°C, and apply them to axillae , groin and neck.
- Do not warm the extremities at this juncture. Place arms and hands on the sides and not on the abdomen or in axillae.
- Do not let patient do any physical activity. Treat as a "stretcher case".
- If patient can take orally give warm, sweetend tea or milk to provide "fuel".
- Do not massage the limbs.
- Do not give alcohol or tobacco
- Evacuate to a sheltered place preferably to a medical facility at the earliest.

**Box – 2 : Management At Solo Physician / Primary Care Level (RMO / OC ADS/ MO Peripheral Hospital)**

- Check rectal temp and other vital parameters.
- Quickly open up the insulatory layer, remove wet clothing (if not already removed at first aid level). Change patient to dry clothing.
- Apply warm packs at axillae, groin and neck. Reapply the "insulatory layer" around the patient, as described under first aid.
- Establish IV line and start 5% dextrose (or any other crystalloid) preferably warmed to 37 to 41oC. Initial fluid challenge should be 500 ml to 1 litre in half to 1 hour.
- Start oxygen inhalations with face mask, 4litres/min, preferably warm and humidified oxygen, if equipment is available.
- If facility exists, pass an indwelling bladder catheter. Start monitoring urinary output.
- Keep monitoring core temperature. The rectal thermometer should be inserted to at least 15 cm into rectum. If there is no increase in core temp despite rewarming efforts in more than an hour or else if patient is not shivering and unresponsive, consider evacuation to a well-equipped hospital. Evacuate as a stretcher case.

temp of 36˚C and CPR fails at that temp. The dictum is "A patient of hypothermia, in finality, is never "cold and dead" but is "warm and dead".

### Localized Effects Of Cold

Frost Nip and Frostbite

Frost nip involves freezing of top layers of skin tissue. It is generally reversible and manifests as numbness and white, waxy or rubbery feeling of the affected skin but the deeper tissue is still soft. Frostbite is the more severe form and affects all layers of the skin and often the deeper tissue also. Frostbite is of four degrees, depending on the depth of the tissue involved. As an urgent first aid measure, remove any constrictive clothing or bands. Start local warming by placing the affected part in a warm water bath at 40-42˚C. If nothing is available, place the affected part in the axiliae or on the stomach of another healthy person. Analgesics and sedatives should be given for relief of pain. Initiate immunisation with tetanus toxoid and evacuate to a surgical facility at the earliest opportunity. If generalised hypothermia and local frost bite both are present, first treat the patient for generalized hypothermia. Local rewarming for frostbite should be undertaken only after core temp has returned to normal.

Non - Freezing Cold Injuries

These include chilblains and trench (immersion) foot, occurring due to prolonged exposure to cold environment with wet conditions. Chilblains manifest with initial pallor of affected area (usually fingers, toes, cheeks or earlobes) followed by erythema, pruritus and intense pain. Prevention by way of avoidance of exposure to cold and wet conditions among susceptible persons is the most important. Otherwise, there is no specific treatment, though symptoms may be ameliorated by oral nifedipine in some cases.

Trench foot is caused by prolonged exposure of feet to cold and wet conditions. The skin is reddened with tingling pain and itching. Gradually the skin becomes pale, mottled and finally dark purple, gray or blue. If the circulation remains impaired for more than a few hours, permanent damage to the affected part can occur. Treatment consists of gentle drying, elevation of the affected limb and keeping it at an environmental temperature of 18 to 22˚C while keeping rest of the body warm. NSAIDS may be given for relief of pain. The patient should not walk on the affected limb till fully cured. Prevention is, once again, very important and consists of keeping the feet clean and dry, dabbing the feet with aluminium hydroxide powder thrice daily, and changing into dry socks and shoes at the earliest .

## Epidemiology

### Environmental Factors

Cold may exist in conjunction with very low atmospheric humidity, or with high humidity. It may alternate with very hot summers as in continental environs of the plains or with mild summer as in the mountains. There may be blizzards associated with it. The exact nature of the effects of cold may vary from one type of cold environment to another. The following major environmental factors determine the severity of cold induced diseases :-

Severity of Cold

Severity of atmospheric cold and its abrupt occurrence increases the liability of incidence of cold injuries among non-acclimatised, non-resident individuals.

Duration of Exposure

It is an important factor determining the final injury. About 10 hours of exposure to minus 10˚C is needed to cause the cold injury, but may occur in shorter period of time, in intense cold.

Wind Movements

These hasten tissue cooling. The combination of ambient low temperature and wind movement is termed as the 'wind-chill factor'. The probability of cold climate to cause cold injuries is directly proportionate to the 'wind-chill' factor rather than its temperature alone. Increased wind velocity, by increasing the 'wind-chill' factor, increases chances of generalised and localized injuries due to cold. Wind makes a substantial difference; air currents on a windy day magnify heat loss because the warmer insulating air layer surrounding the body continuously loses heat to the cooler ambient air. For example, at 0˚C ambient temperature, the conditions become equal to minus 18˚C, if the wind is blowing at a speed of 40 km per hour. The danger zones, based on combinations of ambient temperature (in degrees Celsius) and wind velocity (in Km per hour) are as highlighted in table - 1.

Table - 1 : Danger zones for cold illnesses, based on Combinations of air velocity & ambient temperatures

| Ambient air temperature (°C) | Wind velocity (Kmph) at that temperature which will indicate danger zone |
|---|---|
| - 10 | 40 |
| - 12 | 32 |
| - 15 | 24 |
| - 18 | 24 |
| - 20 | 16 |
| - 23 | 16 |
| - 26 | 8 |
| - 29 | 8 |
| - 32 | Even minimal wind movements |
| | |

Moisture

Moisture is a good thermal conductor and its presence in contact with the skin interferes with the natural insulating action of the sebaceous material on the skin. Presence of moisture in the clothing increases its thermal conductivity, obliterates air-containing meshes in clothing, thereby decreasing its insulating action and extracts body heat by evaporation. Wet clothing, either due to external wetting or internal wetting due to sweat, is therefore dangerous.

Hypoxia

High altitude hypoxia deprives the cardiac muscle of oxygen and thereby decreases the cardiac output, lowering the peripheral blood and oxygen tension and reducing the tissue oxygen saturation. Hypoxia also devitalises the capillary endothelium and increases exudation into tissues. All these increase the proneness of the extremities to get cold injuries; skin, being the least vital organ, suffers the most.

Clothing and shelter

An extremely important determinant of cold illnesses and their prevention is the adequacy of clothing and shelter in such weather. Clothing insulates the body from its surroundings. It can also cause radiant heat gain (mainly from solar radiations) as well as retard conductive and convective heat loss in cold climate. The index of thermal resistance of clothing is measured in 'Clo'units. It indicates the insulative capacity provided by a layer of the clothing. A value of 'one Clo' means that for a person at rest in an environment of 21˚C and Relative Humidity (RH) of 50%, and absolutely still air (no air movement), clothing of one clo unit will maintain the core temperature of such person, under such circumstances, for indefinite periods. Thus, to maintain a person in comfort, clothing with higher clo units will be required if metabolic heat production decreases, or ambient temperature decreases, or RH decreases, or air movement increases. The values required to maintain core temperature according to various physical activity levels and at various ambient temperature are given in Table-2. The clo values of certain commonly used clothing are given in Table-3.

These values are for routine clothing used in cold climate areas; special cold climate clothing have different and higher values.

Table - 2 : Clo values required to maintain core temperature according to various physical activity levels at various ambient temperatures.

| Level of activity | | Temperature °C | | |
|---|---|---|---|---|
| | | 0 | -20 | -50 |
| | | Clo values of clothing | | |
| Heavy work | (6 MET) | 1.0 | 1.6 | 2.2 |
| Moderate work | (3 MET) | 1.6 | 2.8 | 4.2 |
| Light work | (2 MET) | 2.6 | 4.0 | 6.2 |
| Very light work | (1.5 MET) | 3.4 | 5.6 | 8.2 |
| Rest | (1 MET) | 5.4 | 8.3 | 12.4 |
| Sleep | (0.8 MET) | 6.7 | 10.6 | 15.5 |

Table - 3 : The Clo values of certain commonly used clothing

| Garment | Clo value |
|---|---|
| Brief | 0.04 |
| T shirt | 0.09 |
| Full sleeve shirt | 0.25 |
| Half slip, nylon | 0.14 |
| Flannel full sleeve shirt | 0.30 |
| Ordinary trousers | 0.28 |
| Thick long socks | 0.10 |
| Inners (full sleeve vest and pyjama) | 0.50 |
| Sweater | 0.28 |
| Thick sweater | 0.35 |
| Thick sweater, full neck | 0.37 |
| Dinner Jacket | 0.37 |
| Full Coat | 0.60 |
| Parka | 0.70 |
| Boots | 0.05 |
| Fibre coveralls | 1.03 to 1.13 |
| | |

**Human (Host) Factors in cold illnesses**

Age and Sex

People at extremes of age (less than 5 years or more than 65 years) are known to be more susceptible. Women seem to be protected possibly due to the increased subcutaneous fat. There is preliminary evidence from laboratory studies that dark skinned people may be more susceptible to adverse effects of cold as compared to whites. Circulatory Stagnation: Local circulatory stagnation allows local temperature to be lowered, increases liability of exudation through the already damaged vascular endothelium and also deprives the tissues of nutrition and oxygen, thereby increasing devitalisation. This may be caused by forced immobility due to being pinned down in shelters or vehicles, or during conditions of prolonged bad weather. Tight fitting clothes, boots or socks may also cause constriction.

Physical Inactivity

It increases risk of cold injuries. Activity increases the metabolic heat production and is an important prophylaxis against cold injuries.

Nutrition

Adequate, or even increased, calorie intake is necessary to sustain the increased heat production and the increased work required to function in a cold environment (5). It plays an important part in resisting cold effects, and malnutrition predisposes a person to cold injuries. Vitamin A deficiency increases liability to infections especially of mucous membranes. Vitamin C deficiency increases capillary permeability and decreases healing power of tissues. It also plays a part in ameliorating the cold stress and helps in the General Adaptation Mechanism. The presence of adequate subcutaneous fat definitely increases the insulation and hence protects against cold (6, 7).

Poor Physical Health

Intercurrent /chronic diseases, convalescence and physical exhaustion decrease the general tissue vitality, physical activity and also power of acclimatisation, and hence increase the liability to cold injuries.

Poor Mental Health

Mental apathy, fatigue, fear and anxiety which are common in a cold climate, especially under hypoxic conditions at high altitude, cause neglect of precautions and increase in physical inertia, thereby increasing liability to cold injuries.

### Local diseases

Local injury or skin infection predisposes the particular part to cold injuries.

### Tobacco

Use of tobacco increases the risk of frost bite due to severe vasospasm induced by it and definitely aggravates the injury itself when once established.

### Alcohol

Alcohol has been universally regarded as a very important and avoidable risk factor in cold illnesses. Its consumption, especially if followed by exposure to cold, or excessive physical activity or lethargy after alcohol consumption, increases risk of general hypothermia and also local cold injuries.

### Cold Adaptation

Adaptation to cold, although not as good as acclimatisation to heat or high altitude, is nevertheless an important factor determining individual vulnerability to cold injuries.

## Prevention of cold illnesses

### Clothing

Special attention should be given to clothing in cold weather, in a scientific manner. In providing insulation from the cold, the mesh of the cloth fibres traps air that then becomes warm. This establishes a barrier to heat loss because both, the cloth as well as the trapped air conduct heat in a poor fashion. Several layers of light clothing or garments lined with animal or artificial fur, feathers or synthetic fabrics (with numerous layers of trapped air) provide better insulation than a single, bulky layer.

The clothing layer in contact with the skin should effectively "wick" moisture away from the body's surface to the next insulating clothing layer for subsequent evaporation. Wool or synthetic (e.g. polypropylene) that insulate well, as well as dry quickly, serve this purpose. A woollen cap very effectively contributes to heat conservation since nearly a third (33%) of all body heat loss is from the head region alone. If clothing becomes wet either due to external moisture (snow or rains) or due to condensation from sweating, it looses as much as 90% of its insulating properties; this may actually start facilitating heat loss from the body rather than conserving heat. Hence, wet clothing should be changed at the earliest opportunity in cold environment. Secondly, it must be ensured that while the clothing should provide adequate insulation (by way of adequate material and layers, as described above), it should, at the same time, allow for water vapour to escape through the clothing, if sweating occurs. If this does not happen and sweat accumulates near the skin layer, its condensation may become another hazardous situation, which was faced by the expeditions to Polar Regions. Hence, scope must be left to allow some layers to be removed if required, without exposing the body to cold. Thus, the undergarments and inner layers should move the moisture (mainly from sweat) away form the skin by wicking action (by use of artificial fabric material), the outer layers should prevent the outside moisture (from rain or snow) from penetration of the clothing but at the same time allowing for sweat to move away (by using directional-flow nylon and polytetrafluorethylene material). The basic rules for dressing in a cold climate are

(a) Keep the clothing clean otherwise the wicking / moisture repelling action will be compromised.

(b) Do not sweat unnecessarily; undertake activities in a way that sweating is kept to the minimum.

(c) Keep the clothing dry; wet clothing will grossly reduce the insulatory power.

(d) Dress in layers (as explained above).

It must be noted that clothing must be worn in sequence, with undergarments and thermal inners being the innermost layer, followed by shirt, trouser, sweaters, and finally the jackets / thermal or feather coveralls. The fit of each item is very important; each item should be tried in its correct sequence. If clothing is too tight, it will restrict the blood flow and increase the predisposition to cold injury.

### Boots

In cold weather when two pairs of socks are worn, boots become tight and this may compel the individual to discard them. Therefore, boots should be a loose fit, kept soft and water proof and every person should have an extra dry pair of socks and boots to change into, if feet get wet. It is always advantageous to have "thermal lined" snow boots. If activity requires work in water or slush, gum boots are of advantage. Boots should always be purchased / issued after the individual has tried them out with thick woollen socks and walked about for some distance. As far as possible, while moving, one must try to wipe dry the inside of the boots with a cloth kept in the haversack for this purpose, after every few hours. One must remember never to sleep with boots on; before going to sleep, boots should be removed and dried. Socks: A pair of thin nylon / polypropylene socks should form the inner layer, being worn next to the skin and the next layer should be the heavy woollen socks to absorb moisture. These should not be tight. Every person exposed to intense cold should have at least four pairs of woollen socks. Socks should be inspected daily and mended if found to be torn / damaged. Badly darned socks become dangerous by adding an element of trauma. Damp socks should be changed immediately.

### Shelters

An effective shelter should meet the requirements of protection from wild life, heat retention, protection from wind, ventilation and some facility for drying the clothes. Shelter from strong wind is essential, especially when resting or sleeping. Facilities for drying clothes should be available in each camp. Shelter used in cold environment should be designed on the same basic principles of layering as for cold weather clothing. The tents should have a strong, tightly woven outer shell, which should be

impervious to rain and snow. The inside liner is a lighter weight fabric and is hung to provide an air space along the outer shell. Ideally the tent should have a floor made of impervious material.

### Precautions for Carbon Monoxide Poisoning

If ever a stove is burnt inside the tent for heating purposes, the potential dangers of Carbon Monoxide poisoning and fire hazards is to be kept in mind. Arrangements for ventilation must be ensured in such circumstances. Such hazard of CO poisoning can also occur when people sleep in vehicles whose engine has been left running and vehicle parked downwind. Alcohol can further aggravate the risk of CO poisoning and fires by decreasing consciousness and causing inebriation. Similarly, chronic smokers are more susceptible to CO poisoning, due to lowered threshold because of high baseline carboxy-haemoglobin levels in a smoker. One person of the party should always be awake when any stove is placed inside a shelter for heating purpose, to watch out against any fire.

### Nutrition

Energy requirement in the cold environment is more due to higher metabolism. In general, for civilian population, who are also likely to be indulging in some sort of winter or mountain sports activities, the energy requirement may be 3000 to 3500 Kcal for women and 3500 to 4000 Kcal for men. Provision of adequate hot and appetising meals should be ensured. Well cooked, nourishing hot foods and drinks increase resistance to cold, promote mental and physical well being and fortify the body against infection, fatigue, hazards of privations and climatic extremes. Vitamin C is also necessary for the cellular reformation, vascular endothelial integrity and as a steroid sparer. It may be given in the form of multivitamin tablets. For armed forces rations and feeding at cold climate areas, the details are given in the section on nutrition and dietetics.

### Exercise

Regular moderate exercise to keep up the circulation without causing any exhaustion or excessive sweating should be undertaken frequently. When climatic conditions do not permit movement in the open, static physical activity by frequent vigorous movements of limbs, movements of neck and back, wriggling of toes and moving of fingers should be continuously practised. Face muscles should be wrinkled to keep up the circulation.

### Venous Congestion

People should not sit for long periods cramped up in enclosed places or upon the railing with feet hanging down and especially over the edge of seats as this leads to venous congestion. Too tight clothing also causes venous stagnation.

### Alcohol

Alcohol is best avoided when confronted with harsh, cold environment. In any case, it should never be consumed in excess over a short duration and none at all when likely to be exposed to cold wind, required to undertake excessive exertion or trekking / marching, or when proper shelters for sleeping are not likely to be available.

### Smoking

It is advisable not to smoke at all. Those who cannot avoid smoking should do so in moderation. It should be definitely prohibited once the cold injury occurs.

### Buddy System

For small parties on adventures / expeditions, it is always a good practice to have a “buddy system”, i.e., to pair up people and make them responsible to look after each other, in harsh cold or wilderness type of environment. It is practised by watching each other's face and feet for observing any early tissue damage. Buddies also watch out for each other’s personal hygiene, nutrition, and behaviour so that any aberration is identified at the earliest and first aid is given. For the buddy system to be effective, the buddies must communicate very effectively with each other.

General Personal hygiene should be maintained at the highest level. Besides ensuring local cleanliness and preventing infections, it will enhance the general feeling of well being, so essential in tough, cold environment. Proper bathing is preferred; however, even a basin of water for a sponge bath will help. When no water is available, simply rubbing the body, preferably with a wool rag, is worth the effort. It is recommended that such a procedure be followed weekly. Changing to clean or even airing of soiled socks and underwear periodically will help to maintain body cleanliness. At least two or three hot baths in a week in snowbound and cold environs are necessary. Bathing places should be sheltered from wind and snowfall. However, too frequent use of too much soap is not good as it removes the greasy sebaceous material and decreases insulation.

Foot Hygiene The feet should be inspected before going to bed every night, for any swelling, ulcer or numbness. Wriggling the feet and toes before going to sleep and even within the boots, while walking, should be an inculcated habit. It is much better to make two partners responsible for inspecting each other's feet. Feet must be washed with warm water, thoroughly dried and smeared with a little Vaseline, before sleeping. This helps prevent frost bite. An individual with ulcers and abrasions on the foot should not move around until they are healed. Talcum powder should be used before wearing socks in the morning to decrease dampness during exertion and reduce friction with socks.

### Oral Hygiene

By daily cleaning the teeth with a piece of gauge or other cloth wrapped around a finger is an effective practice in the absence of toothbrush. “Feel Good” :- Keeping well is especially important when one is stranded. While physical fitness of the body decides survival, yet a positive mental attitude is just as important. Personal cleanliness, dry clothing, ventilated shelter without drought, a warm bed, and adequate recreational activities are helpful. Provision of sufficient latrine accommodation and proper disposal of all wastes must be ensured. Re-exposure: Persons who have once suffered from cold injury should be very careful when getting exposed to cold environment again.

### Adaptation to Cold

Adaptation to cold is slower and less efficient than

acclimatisation to heat or high altitude. It is automatically effected when human beings are inducted to cold areas in summers and allowed to stay on over one or two winters or gradually move up the mountains in stages. When, however, they are suddenly inducted to cold areas in winter, the effects of cold may appear in a large number of persons. Systematic acclimatisation to cold can be carried out under such circumstances by exposing newly inducted people to the atmospheric temperature of 0˚C to 5˚C for three or four hours a day for three consecutive weeks. During the first week people should be dressed in vest cotton, full sleeves flannel shirt, pullover, woollen trousers, balaclava or fleece lined cap, gloves and boots with only one pair of woollen socks. Outside the exposure hours, people can put on the additional clothing as jackets, coveralls, etc. During the next two weeks, jersey pullover is also removed, so that people stay in flannel shirt and trousers for 3 to 4 hours. The site selected for exposure should be sheltered from wind. If there is any wind or breeze, people should wear a thin nylon wind-cheater. Since physical exercise warms the body and hence impedes the acclimatisation process, during the hours of exposure, therefore, physical exercise should not be allowed; however, normal sedentary recreational work as reading, knitting, playing cards etc., which do not involve much physical activity, may be carried out. People should be assured that exposure to cold for cold acclimatisation will cause no harm. If any complaints like rhinitis, pharyngitis, fever, excessive shivering or cramps are noticed, the exposure should be discontinued for the day or until cured. It can be restarted and gradually increased day by day when the individual has recovered.

### High Altitude Acclimatization

Often, cold environment co-exists with high altitude environment. Adverse effects of high altitude will worsen the physical and psychological adversities due to cold and vice-versa. Proper acclimatization to high altitude should be therefore undertaken, as described in the chapter on high altitude.

### Prevention in Relation to Some Basic Survival Problems

In harsh, extreme cold climate, often co-existing with wilderness type of environment, one may be faced with an emergency at any time, especially when traveling. Hence, survival techniques should be a major element of preparation. Skills pertaining to shelter construction, first aid, map and chart orientation and sanitation provide a good foundation on which to base success in an emergency. Detailed guidelines from technical point of view (8 - 11) as also of general nature (12, 13) are available in various texts and websites and those interested may refer to them. Similarly, serious accidents are often the result of incompetence, ignorance or overconfidence arising from inexperience. Success and survival depends on planning, timing, common sense, and the intelligent use of supplies and equipment.

### Protection against Snow Blindness

Humans can make no natural adjustments to the reflection of bright sun from snow. Dark glasses are, therefore, a must. One must not wait until eyes start hurting. If the glasses are lost, improvised eye protection, by either wearing a muffler or stockings over one eyes through which one can barely see, or, better yet, one can make a “slit goggles” out of leather, cardboard, or any other similar material. Cut a horizontal slit 1.5 to 3 millimetres high by 25 to 40 millimetres wide in the material. Keep the goggles approximated around the head with a string, cloth or leather strip, or slung around the neck so that you donot lose them. Treat snow blindness by getting the victim to a dark place. Apply eye shades to both eyes, if required. Cool compresses may help to relieve the pain. Time is the only cure for temporary snow blindness.

### Protection against Sunburns

Sunburn can occur even at temperatures below freezing

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## Further Suggested Readings


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# Adverse Effects of High Altitude

High Altitude illness is a collective term for the syndromes that can affect unacclimatised travellers, shortly after ascent to high altitude (1) (The term "unacclimatised travellers" also includes the native highlanders who are re-inducted into high altitude after a sojourn to lower altitude or if they move to a still higher altitude from the normal place of stay in high altitude). The term "high altitude illness" encompasses the cerebral syndromes of Acute Mountain Sickness(AMS) and High Altitude Cerebral Oedema (HACO) as also the pulmonary syndrome of High Altitude Pulmonary Oedema(HAPO).(1)

With the present body of knowledge, there does not seem to be any clear cut demarcation as to the height above sea level that constitutes " High Altitude(HA)". The general opinion varies and is dependant on the altitude at which definite manifestation of high altitude illness are likely to occur in a noteworthy proportion of the subjects. Generally, an altitude of 2700 m and above defines high altitude, with increasing grades of high altitude as 2700 to 3600 m, 3601 to 4500m and 4501 to 5400m. Altitudes above 5400 m in are often referred to as "extreme high altitude" wherein permanent successful acclimatization becomes very difficult. However, the above levels cannot be sacrosanct boundaries; in fact high altitude illness is being increasingly recognised at "moderate" altitudes of 2200 to 2500m (2)

Around 140 million people over the globe live permanently at altitudes of over 2500 m (3) and approximately another 40 million enter high altitude area every year for reasons of occupation, sporting or recreation. Miners in South America go for work to altitudes as high as 6000 m, while Indian soldiers are deployed at even higher altitudes. Persons who are at a definitely increased risk of being affected by high altitude illness include Native highlanders who re-enter high altitude after stay at lower altitudes; Mountaineers; Soldiers; Trekkers; Adventurers; Miners at high altitude; and, Pilgrims and porters (4, 5).

## The High Altitude Environment

Effects of high altitude are encountered among troops deployed at high altitudes and in high altitude aviation. The environmental conditions at high altitudes which influence physiological processes are:- the lowered atmospheric pressure and partial pressure of oxygen, lowered temperature and humidity, increased intensity of sunshine and cosmic electrical conditions and the isolation under monotonous mountain conditions. The chief hazards on health, however arise from the low atmospheric pressure, coupled with low partial pressure of $O_2$ in the alveolar air leading to low oxygen tension in the blood and low ambient temperature, all of which worsen as the altitude increases. The Effects of hypothermia have been described in the preceding paragraphs. There is no difference in their aetiology, manifestation, prevention and first aid at high altitude, except that they are aggravated due to atmospheric and tissue hypoxia.

The main problem with high altitude terrestrial environment is, in fact, the declining atmospheric pressure. For instance, the atmospheric pressure which is 760 mm Hg at sea level drops down to only approx. 500 mm Hg at Leh, which is at around 11000 feet above Mean sea Level (MSL). Now, as we know from a very basic law of physics (Boyle's Law) that the partial pressure of a mixture of gasses is equal to the sum of the partial pressure (pp) of these gasses; and the partial pressure of these individual gasses is proportional to their concentration in the gaseous mixture. For all practical purposes, air is mainly a mixture of Nitrogen (N) and Oxygen (O) in the proportion of 80% and 20% respectively. Thus the pp of N will be four fifth and that of O will be one-fifth that of the atmospheric pressure at a given location. Hence, at sea level, where the atmospheric pressure is 760 mm Hg, the partial pressure of 'N' is 4/5 of 760 i.e., approx 608 and that of 'O' is approx. 152 mmHg.

Now as the atmospheric pressure drops with ascent from sea level (by very roughly, 25 mm Hg for every 1,000 feet ascent), hence at Leh (11,000 feet) it would be approx. 500 mm Hg; and, by Boyle's law, at this height, the partial pressure of Nitrogen would be (4/5 of 500) i.e., 400 mm and that of Oxygen will be 100 mm Hg. It is this progressive decline in partial pressure of oxygen in ambient air (commonly referred to as "thinning or air" or, "rarefied air') that results in reduction of alveolar oxygen pressure, with all the resultant pathological issues of high altitude. Thus, though the concentration of oxygen in atmospheric air at high altitude is still one-fifth, the net result because of such reduction of partial pressure of oxygen is as if there were a lack of Oxygen in the air. Thus, at Leh, at around 11,000 feet, the effect is as if oxygen in the air were 13.8% instead of 21% normally seen at sea level. The details are depicted in table-1. This is the basic environmental issue that triggers a massive cascade of physiological responses, intended to be protective, once a human being is inducted into high altitude.

## Physiological Adaptation

The lowered atmospheric oxygen partial pressure at high altitude causes alveolar and arterial hypoxia leading to tissue hypoxia. As described earlier, the oxygen partial pressure in alveoli is decreased at high altitude and hence, to compensate for this, more blood has to flow into the alveolar capillary bed in a given unit of time, and also, more air needs to be sucked in by the luings in a given unit of time, as compared to sea level. In order to meet the tissue oxygen demand at high altitude, in the face of such altered alveolar oxygen pressure, the cardiac output per minute has to increase and in order to ensure adequate oxygenation of the blood, the pulmonary ventilation has to increase. These requirements are initially achieved by hyperpnoea and tachycardia arising out of hypoxic drive.

As the stay at high altitude continues, the increased pulmonary and cardiac frequencies are replaced by increased amplitudes. A series of further physiological adjustment take place depending on the rate of ascent, the altitude attained, and the period of stay at that altitude, by adaptation of the haemopoietic, cardio-vascular, respiratory and nervous systems. Gluco-corticoids and vasopressin are poured in the blood stream to counteract stress of hypoxia. The number of circulating RBCs, haemoglobin concentration in RBC, the size and volume of red cells, pulmonary ventilation, vital capacity, pulse rate, circulating blood volume, circulation rate, cardiac output all undergo changes.

Circulatory and haemopoietic adjustments are variable and do not normally occur to an appreciable extent among Indians up to an altitude of 2500 m. Over that height the variation in haemodynamics and concentration of available RBCs in the peripheral circulation appear first; the increased frequency of respiratory and cardiac rhythm closely follow; haemopoietic response brought about by the erythropoietin (produced by kidneys) comes next; and finally the increased amplitude of respiratory and cardiac movements gradually replaces the increased frequency. This completes the early process of adaptation. Interstitial fluid is diverted to the vascular compartment which alters the haemodynamics and cause hypervolaemia, thereby overloading the pulmonary circulatory system and cardiac function. Due to increased pulmonary ventilation, the tissue $CO_2$ is washed out, alkalosis occurs and the $CO_2$ tension in the blood is decreased. Hypocapnia (lowered $CO_2$ tension in the blood) due to hyperventilation leads to shifting the oxygen dissociation curve to the left, and decrease in cerebral and coronary flow thus leading to other complications. The altered pH (alkalosis) of the blood is partially rectified by increased excretion of alkaline urine thus restoring the left shift of oxygen dissociation curve as the acclimatization process continues. But the major readjustment in the respiratory system is brought about by increased 2-3-diphosphoglycerate of RBC which in turn offsets the effects of left shift of $O_2$ dissociation curve and thus restores oxygen delivery to the tissues, increased sensitivity of respiratory centre to lower $CO_2$ tension and by increased diffusion coefficient of oxygen at the alveolar level. The cause for Pulmonary hypertension which is a common observation in high altitude is not known. At the initial phases it is relieved by oxygen inhalation.

Stimuli for adaptation becomes operative when the atmospheric pressure is decreased by 30 percent, which

Table - 1 : Altitude, pressure, temperature, oxygen partial pressure and percentage

| Altitude | | Pressure | Temperature | | $O_2$ partial | Equivalent $O_2$ |
|---|---|---|---|---|---|---|
| Feet | Meters | mm Hg | °C Decrease | °C | Pressure mm Hg | Percentage |
| 0 | 0 | 760.0 | 15 | 0 | 159.2 | 20.96 |
| 1,000 | 305 | 733.0 | 13 | -2 | 153.6 | 20.18 |
| 2,000 | 610 | 706.6 | 11 | -4 | 148.1 | 19.46 |
| 3,000 | 914 | 681.0 | 9 | -6 | 142.7 | 18.76 |
| 4,000 | 1,219 | 656.4 | 7 | -8 | 137.5 | 18.07 |
| 5,000 | 1,524 | 632.4 | 5 | -10 | 132.5 | 17.41 |
| 6,000 | 1,829 | 609.0 | 3 | -12 | 127.6 | 16.77 |
| 7,000 | 2,134 | 586.4 | 1 | -14 | 122.9 | 16.15 |
| 8,000 | 2,438 | 564.4 | -1 | -16 | 118.2 | 15.54 |
| 9,000 | 2,743 | 543.2 | -3 | -18 | 113.8 | 14.96 |
| 10,000 | 3,048 | 522.6 | -5 | -20 | 109.5 | 14.39 |
| 11,000 | 3,353 | 502.6 | -7 | -22 | 105.3 | 13.84 |
| 12,000 | 3,658 | 483.2 | -9 | -24 | 101.2 | 13.31 |
| 13,000 | 3,962 | 464.6 | -11 | -26 | 97.3 | 12.79 |
| 14,000 | 4,267 | 446.4 | -13 | -28 | 93.5 | 12.29 |
| 15,000 | 4,572 | 428.8 | -15 | -30 | 90.5 | 11.81 |
| 16,000 | 4,877 | 411.8 | -17 | -32 | 86.3 | 11.34 |
| 17,000 | 5,182 | 395.4 | -19 | -34 | 82.8 | 10.89 |
| 18,000 | 5,486 | 379.4 | -21 | -36 | 79.5 | 10.45 |
| 19,000 | 5,791 | 364.0 | -23 | -38 | 76.2 | 10.02 |
| 20,000 | 6,096 | 349.2 | -25 | -40 | 73.1 | 9.61 |
| | | | | | | |

occurs at the height of 2500 m. These mechanisms are usually uneventful and insensible up to about 3000 m; however, above that height when pronounced physiological mechanisms are called to action, the symptoms of 'early mountain sickness' which in reality are the symptoms of 'rapid acclimatization', become manifest. If acclimatization is inadequate, or if it breaks down, or if the ascent to higher altitude is too rapid, the essentially beneficial adaptive responses become aberrant and the disease processes occur.

The variable factors which determine the direction taken by the responses are the rapidity of exposure to atmospheric low pressure, severity and duration of oxygen lack and the physical condition of the body. The various symptoms of high altitude sickness essentially arise from the lag in adjustment of the body to increasing hypoxia and partial lack of cardiopulmonary co-ordination to meet the challenge of tissue hypoxia in the face of atmospheric hypoxia coupled with the altered haemodynamics. The symptoms are, therefore, more severe and frequent during rapid ascent and also at night time owing to the dumping of blood in the lungs due to the horizontal position of the persons. Cerebral hypoxia causes mental symptoms. The most frequent and important clinical problems encountered at high altitude are shown in box-1.

**Box-1 Clinical Syndromes At High Altitude**

- Acute mountain sickness (AMS).
- Acute pulmonary oedema of high altitude (HAPO).
- Chronic pulmonary hypertension.
- Coronary and cerebrovascular insufficiency.
- Seroche- Monge's disease.
- Flare up of precontracted infections.
- Manifestations of diabetes mellitus.

## Acute Mountain Sickness (AMS)

### Latent period

The latent period of AMS (time elapsing from entry into high altitude to onset of first symptom) is usually 6 to 12 hours. Sojourns to high altitude which last for less than 6 hours are not likely to be associated with AMS.

### Incidence

AMS is quite uncommon below the altitudes of 2000 m. The incidence of AMS has been quite variable in different studies and primarily depends on the altitude reached, the rate (speed) of ascent to high altitude and physical exertion after entry into high altitude, besides other variables. Thus, Hackett and Rennie reported an overall incidence of as high as 43% among trekkers reaching an altitude of approximately 4200 m (6). A serial and proportionate increase occurs in the incidence, as reported by Maggiorini et al, who observed the incidence to be 9%, 13 % and 34% at altitudes of 2850 m, 3050 m and 3650 m respectively (7). In another study among tourist at Colorado, arriving at altitudes between 1900 to 2940 m, the overall incidence was 25% (8). It seems that at altitudes of 4000m and above, the incidence is almost universal among the new entrants, especially if those with mild symptoms are also taken as AMS. Thus, the incidence was observed to be as high as 85% among tourists who are directly inducted, by air, to an altitude of approx 3700 m. (9). Garlland et al (10) reported that among trekkers in Nepalese Himalayas, tracking up to an altitude of 5400 m, the frequency of AMS was 29% in the year 1998, which was a clear decline as compared to the incidence of 43 % as was observed in 1986. The authors attributed this decline in AMS occurrence to better awareness which has developed among the trekkers about AMS so that they climb slowly and observe the necessary preventive measures. In another study among pilgrims, at an altitude of 4300 m in Nepal, Basnyat et al reported an incidence of as high as 68% (4) while in another study the incidence was observed to be 20 % at 4243 m as compared to 6% at 3499 m (11).

One of the reasons for the widely differing incidence rates of AMS at corresponding altitudes could be due to disparities in diagnostic criteria used by different workers. In fact, the more recent “Lake Louise consensus” on diagnostic criteria could streamline and standardize the procedure, thus ensuring comparability of data.

### Risk factors for AMS

Age

The evidence regarding susceptibility of any particular age group to AMS is equivocal. The results may be confounded due to the increase in volitional activity on arriving at high altitude among the younger people, particularly young soldiers, besides various other socio-behavioral factors. In general, it seems that children and adults seem to be equally affected, as reported by Yakon et al who observed no difference between children and adults as regards incidence of AMS. (12) On the other hand, some studies indicate that young persons are probably at greater risk (10,13 & 14) while Pollard observed that people aged more than 50 years may be more susceptible to AMS(15)

Gender

Kayser, in a study in Nepal at an altitude of 5400 m concluded that the incidence was higher (69%) among women trekkers as compared to 57% among males (16). Similarly, Basnyat et al (4) observed that the risk of AMS was much higher among women (OR-4.39, 95% CI= 1.83 to 10.68). Murdoch et al also found a higher risk among women (9, 17). However, one must consider the possibility of information bias, since women may more easily report their symptoms. At present, it may be apt to conclude that while women may be at a slightly higher risk, more studies using stronger epidemiological methodology and increase study power need to be undertaken to answer this issue.

Obesity/Overweight

There is some evidence that subjects who are slim have lesser susceptibility to AMS as compared to subjects who are overweight (or even towards the higher side of normal BMI of 25)(16,18). On the other hand Garland et al did not

find any association between body Mass index (BMI) and AMS (10). It is possible that increase in body weight, particularly the "dead weight" of obesity may impose additional load on the body during physical activity and may increase the predisposition to AMS. Though more evidence needs to be collected, it is in any case desirable that obesity be avoided for various other health reasons also.

Altitude reached

One of the most important determinants is the altitude which has been negotiated. The condition is very infrequent below the altitude of 2000 m; as the altitude reached is around 4200 m, a large majority will have the symptoms, while it is almost universal at 5000m. Even the native highlanders who return to their high altitude residence after a stay for few days at low altitude, or else the highlanders who move to higher altitude from their usual residences in high altitude are also at risk.

Speed of ascent

Next to the altitude reached, the speed of ascent becomes a major factor determining the risk. A much larger population of subjects who move to high altitude by air are likely to be affected, as compared to subjects who get inducted by road transport to the same high altitude locations. Level of Physical fitness:Prior physical fitness seems to provide no immunity against AMS; similarly pre-existing infection or disease may not be a necessary predisposing factor. It is a common-place and repeated observation in epidemiological descriptions that young, strong and healthy men may be overcome by AMS while people with lung diseases may not even get headache. This was pointed out in one of the earliest scientific descriptions on AMS, in 1913 by Ravenhill (19) and has been consistently noted thereafter. Various workers as Milledge, Brucher et al and Sowouney et al have not found any correlation between occurrence of AMS and various parameters of physical fitness, as VO2 max or physical work capacity (20-22).

Exercise

In a study conducted under controlled circumstances in a chamber, Roach et al produced simulated altitude of about 4500m for 10 hours. Subjects were subjected to physical exercise on one occasion and not subjected on the other occasion. The results clearly showed that exposure to physical exercise in high-altitude simulated environment carried a significant risk for causing symptoms of AMS (23). The finding is further supported by observations of other workers that faster rate of ascent on mountains among trekkers (indicating strenuous exercise) is related to higher incidence of AMS and vice-versa (14, 24, 25). Thus, it would be prudent to avoid strenuous exercise on arrival to high altitude for prevention of not only AMS but other high altitude illnesses as well.

History of Previous episode

It has been shown by Forster that the rank scores (or AMS score), achieved by subjects on induction to an altitude of 4200m showed strong correlation with the rank score achieved by the same subjects when they were de-inducted and then re-inducted at the same altitude after 5 days(26). However, other case series do not seem to show such consistency and, with the present status of available evidence, it seems very difficult to predict the probability with which a subject is likely to develop (or not develop) AMS, given that he/she has (or has not) developed AMS during earlier inductions to high altitude.

Dehydration

In the study by Basnyat (25), higher fluid intake (up to 5ltr per day) was found to be associated with a lower incidence of AMS. However, in an earlier controlled, experimental design, Aoki and Robinson did not observe any relationship between dehydration and AMS incidence (27). Similarly Cumbo et al (28) did not find any definite association between dehydration and AMS. At present, there does not seem to be a clear evidence-based answer to this issue and more studies are needed. Till then, a reasonable scientific practice would be to ensure proper hydration, in view of the various other physiological benefits it provides vis-à-vis a dehydrated state.

Tobacco Smoking

In an experimental design undertaken in a simulated chamber it was observed that smokers tend to have fewer symptoms than non-smokers (29). The plausible explanation is that smokers seems to be habituated to a pre-existing, modest level of carboxy-hemoglobin and hence may be having a physiological state equivalent to "pre-acclimatization". On the other hand, Garland et al did not find any association between AMS and smoking habit (10). In general, it would be prudent to avoid smoking / tobacco use, in any case, for various documented health resaons, if not for prevention of AMS.

High Carbohydrate diet

There seems to be no significant difference between normal or high carbohydrate diets as regards susceptibility to AMS (30).

## High Altitude Pulmonary Oedema (HAPO)

### Epidemiology

The first scientific description of HAPO, in English language, was provided in 1960 by Houston (31). However, there are earlier descriptions too, though the disease was not precisely identified as HAPO. For instance, the description of the death of a Doctor at an altitude of 15000 feet during a rescue mission was most probably due to this condition, (32). Similarly, Ravenhill's description (19) in 1913, of cases of cardiac failure at high altitude would have actually been cases of HAPO. It is also likely that the experiences of Hultgren and Spickard in Peru, in 1959, of cases of pulmonary oedema actually referred to description of HAPO (33). Since then, the condition has become widely recognized. Pioneering work in this field has been undertaken by Medical Officers of the Indian Armed Forces, especially after the rapid induction of thousands of troops into high altitude areas following the Sino-Indian war of 1962 and subsequently during the Indo-Pak conflict on Siachen Glacier which is considered as the highest battle field in the world.

### Incidence

The incidence of HAPO has been found to be quite

variable, as reported by various workers. In general, the incidence can be taken to be in the range of 0.1% to 4% (1) In a study on Indian Soldiers in North Western Himalayas, Menon found that the incidence was 5.7 per 1000 (34). However, in a subsequent study on the same general population in the same location, using more precise information on the number of 'inductions' into high altitude areas of 3600 m and above, Bhalwar et al, in their nested case- control study, found that the incidence was 1.42 per 1000 inductions (95% CI 1.11 to 1.73 per 1000 inductions) (35). A much higher incidence of 3.4% has been reported by Hultgren et al from the Western world (36), while a study in Nepal put the incidence of HAPO to be 2.5% among trekkers (14). In another study in Peru, at an altitude of 3750 m, the incidence of well diagnosed HAPO was 0.6% among adults, while Basnyat et al (4) observed that among pilgrims at an altitude of 7300 m, the incidence was 5%.

**High Risk Groups**

Broadly, any person irrespective of age, gender or race, who enters into a high altitude terrestrial environment, is at risk of HAPO, including native highlanders who enter into high altitude after a stay at lowlands. However, certain groups seem to be at a higher risk due to Socio-behavioral or occupational reasons. These include soldiers, mountaineers trekkers, adventurers, mountain-sports persons, miners working at high altitude, porters, and land pilgrims to high altitude shrines.

**Induction Time**

Most of the epidemiological studies indicate that the 'latent period' or 'induction time" (period elapsing from entry into high altitude to the onset of first manifestation of HAPO) is usually between 6 to 96 hours. Onset beyond this range is quite uncommon. Bhalwar et al found the induction time, among soldiers at 3600 m, to be 6 to 96 hours with a median of 54 hours (35). Similarly, in the series by Menon, (34) Singh et al (37) and Kleiner (38) it was observed that large majority of cases occurred within 3 days of entry into high altitude. From foregoing epidemiological evidence, it is logical to conclude that, firstly, if a subject, following exposure to high altitude returns to low altitude within 6 hours, the risk of HAPO would be quite low. Secondly, the period of first 72 hours following induction into high altitude seems to be important, with the initial 48 hours being most crucial for enforcing preventive measures regarding acclimatization, especially avoidance of any physical activity (except for self-care activities of a routine nature). It may be noted that though the induction time of 6 to 96 hours encompasses a very large majority, rare cases can occur as late as ten days also.

**Recurrence Rate**

The recurrence rate of HAPO i.e., occurrence for a second time on a subsequent occasion in a subject who has suffered from HAPO earlier, over a follow up period of 18 months, was worked out by Bhalwar et al, based on a well established and scientific central registry for HAPO. The workers reported that out of 152 cases who had the first attack and followed up of 12 to 18 months, a total of 5 cases occurred for the second time during the follow up period, giving a cumulative incidence of 3.29 % (95% CI 0.46% to 6.1%) and incidence density of 1.83 per 1000 person months (95% CI 0.53 to 3.13). The time period between the first and second attack was 115 to 208 days. All the five recurrent cases occurred within 48 hours of the second entry in high altitude (39).

**Risk Factors for HAPO**

Age

Case series have reported a preponderance of young adults among cases of HAPO. However, this may not represent a true cause-effect relationship. Younger people tend to visit the high altitude areas more often, besides being more inclined to exert physically after arrival to high altitude. In fact, in their nested case control analysis, Bhalwar et al (35) did not observe any significant association between age and HAPO; however, this study was conducted in a narrow age zone, mainly in the group of 20 to 40 years. There is also no evidence to indicate that children are protected; in fact, children aged 1 to 4 years are at considerable risk (40).

Gender

Basnyat et al observed that at an altitude of 4300 m, women had higher risk of HAPO (OR = 5.2, 95% CI 1.24 to 24.73) (4). However, as pointed out by Heath and Williams, it is the young male who is at higher risk (40). It is possible that males are more likely to exert physically soon after arrival to high altitude, thus making them more vulnerable. With the present body of knowledge, it may not be possible to comment with authority as regards the gender differences unless comparison of proper cumulative incidence rates between men and women, controlling for potential confounders, is undertaken. Ethnic /Racial differences:There does not seem to be any particular ethnic or racial group which is specifically predisposed to or protected from HAPO. (35).

Fresh inductees/Re-inductees

Re-exposure to high altitude environment has been described to be an important determinant of HAPO. (40). In the study by Menon, much more numbers of cases gave history of having been exposed to high altitude environment earlier, while a smaller proportion of cases were those who had come to high altitude for the first time (34). Similar findings were observed by Hultgren (36) and Marticorena (41). However, it needs to be appreciated that case series are based on simply numerator analysis and, from epidemiological point of view, suffer from the flaw that they do not compare incidence rates. It is quite likely that a smaller proportion of cases of HAPO would give a history of entering high altitude for the first time (fresh inductees) simply because, as such, of all the people who enter high altitude, a much smaller proportion is likely to be fresh inductees while a larger proportion will be those who would be entering high altitude after having been exposed to high altitude at least once earlier, i.e., re-inductees. In fact, Bhalwar et al, using valid 'denominator bases', compared the incidence rates between inductees and re-inductees, and did not find any significant difference (35). Singh et al, in their case series, also found that almost two third of their cases were fresh inductees (37). Anecdotal reason has been cited to support the

increased predisposition of re-inductees, by mentioning that the native highlanders who returns to high altitude after a sojourn to low altitude are quite likely to develop; However this only suggests that the highlanders re-entering high altitude is at risk but not that the risk is comparatively higher among re-inductees. To summarize, firstly it will be apt to treat all entrants into high altitude, whether fresh (first time) entrant or re-entrant with equal concern and apply the laid down acclimatization procedures to all with equal vigor. Previous acclimatization or previous successful sojourn to high altitude does not guarantee protection during subsequent exposure. Re-entry into high altitude, even after an absence of only few days at low altitude, may make a person susceptible to HAPO and complete acclimatization schedule must be undertaken if a person has gone down for more than 4 weeks. If the absence from high altitude has between 11 to 28 days, acclimatization should still be undertaken though in a "modified" (less strict) manner. Secondly, it must be noted that the native highlander re-entering into high altitude is in no way protected and should follow similar acclimatization procedure as that for the residents of low altitude. Thirdly, there is a need to undertake scientific epidemiological studies, by comparing 'incidences rates' (and not number of cases) between fresh entrants and re-entrants to answer this issue.

### Tobacco and Alcohol use

Tobacco smokers do not seem to be at any significant risk (35, 42). Similarly moderate consumption of alcohol after entry into high altitude does not seem to increase the risk (35). However, keeping in view the other health hazards, it would be prudent to advise avoidance of tobacco and alcohol use.

### Genetic Factors

There are some indications that susceptibility to HAPO may be, to some extent, determined by genetic drive. In a study by Hanoka et al, an association was observed between HAPO and certain HLA types, notably HLA-DR6 and HLA-DQ4 (43). Similarly Morrell et al also observed an association between pulmonary hypertension and 'D' Allele of ACE genes among native highlanders of Central Asia (44). At present only limited data are available. Candidates for further studies in this field include endothelial nitric oxide synthase gene polymorphisms, angiotensin-converting enzyme gene polymorphisms and genetic determinants of primary pulmonary hypertension (45-49).

### Previous history of high altitude illness

Persons who have earlier suffered from an episode of high altitude illness (AMS, HAPO or HACO) during their earlier sojourns to high altitude seem to be at a slightly higher risk of HAPO during subsequent sojourns. It has also been observed that if both, previous history of AMS as well as physical exertion within 24 hours of entry into high altitude are present, these two factors tend to "interact", there by multiplying the risk of HAPO. As such, a past history of AMS during earlier sojourns significantly increases the risk of HAPO (OR =2.74, 95% CI = 1.12 to 6.77) (35).

### Cold weather

Observations based on case series indicate that cases are more during the cold weather, particularly in January. It is still not clear whether this is due to an interactive effect between extreme cold weather and high altitude, because the two, in any case, often coexist. It is also likely that during cold weather, the roads leading to high altitude areas may be snow bound and hence most of the entries into high altitude are by air, thereby speeding up the "rate of ascent", a well known risk factor for HAPO. It is also possible that volitional physical activity soon after arrival into high altitude may be more during cold weather, as a part of generating body heat.

**The three most important risk factor predictors of HAPO are:-**

- The altitude reached
- The speed of ascent to high altitude.
- Physical exercise on arrival to high altitude.

### Existing physical condition

Most of the persons are young and of athletic disposition, and have to undergo a mandatory clinical examination before entering high altitude area. However, there is no way to predict that even after a meticulous clinical examination at low altitude, the person will not develop HAPO or AMS (40).

### Physical exercise after induction into high altitude

Physical exercise even of moderate intensity, undertaken within 72 hours of arrival into high altitude is an important determinant of HAPO, and is almost universally upheld by all experts. The risk has been observed in nearly all the studies (31, 35, 37, 38, 50, 51), at various places in the world, and the estimates show a strong and significant association. Thus, the association fulfils the required epidemiological parameters of strength of association, temporality, consistency, dose response and plausibility. In the study on Indian Soldiers, a very strong and significant effect was observed, of physical exercise during first 24 hours of entry into high altitude and HAPO (OR=3.19, 95% CI 1.23.to 8.51). In addition, physical exercise during first 24 hours was also strongly and significantly associated with the severity of HAPO (35). Similarly Singh et al (37) and Kliener et al (38) also reported that a large majority of cases gave history of undue physical exertion within 3 days of arrival into high altitude. Thus, it seems that physical exertion in the first 72 hours of arrival into high altitude is important, the first 24 hours being crucial as a determinant for developing HAPO. However, it is noteworthy that physical exercise is not an 'essential' determinant, since the condition can occur even among persons who have not exerted/are

**The key to prevent HAPO is to ensure acclimatization; in particular, no physical exertion (except activities of daily life) during first 48 hours of entry into HA**

asleep/are at rest, especially if ascent to high altitude has been rapid, as by air.

Lack of Acclimatization

HAPO commonly affects subjects who have not properly acclimatized themselves to high altitude environment soon after arrival. Acclimatization is a gradual process by which the body physiology gets adjusted to high altitude environment. In general, acclimatization is undertaken by 1 to 2 days of complete rest, followed by gradually increasing physical effort for next 2 to 4 days at a particular level of high altitude and the process should be repeated for every 900 m (3000 feet) gain in altitude. Armed Forces acclimatization schedule is described later on.

**Altitude of ascent**

The "critical altitude" at which the risk of developing HAPO is very high has been reported as 3350 m in the Himalayas, 3660m in the Andes and somewhat lower (2590m) in the Rocky mountains(40). This is not to be confused with the definition of "high altitude" which is generally taken as > 2500 mtrs, and, in context of Indian Armed forces, >= 2700 mtrs (9000 feet).

**Rate of ascent**

Epidemiological studies have clearly shown that the speed with which an individual reaches high altitude, especially into a crucial altitude of 3000m and above, seem to be an important determinant in causing high altitude illness. Observations have shown that both among soldiers as well as tourists who move to high altitude areas by air, ascending almost 3000m (or even more) within less than an hour, the incidence rates are much higher when compared to the same location being reached by road transport over 3 to 4 days. The slow ascent by road over a few days may allow some acclimatization.

While negotiating high altitude areas, gradual ascent, thereby giving time for acclimatization to develop, is the key strategy in prevention. In general, at altitude greater than 3000 m, each night should be spent at an altitude of not more than 300 m above the previous night, with a rest day after every 2 to 3 days (i.e., after every 1000 m of ascent) (24). In certain situations, this rate of ascent may be considered to be slow and unrealistic and may be modified so that the altitude difference between two consecutive "sleeping sites" should not be more than 600 m per day (52). All recommendations emphasise "sleeping altitude" which means that it is permissible to ascend more than the recommended daily rate as long as descent is made for sleeping, i.e., the time tested maxim of "climb/work high but sleep low". A night spent at moderate altitude of 1500 to 2500 m before ascent to high altitude, is also likely to aid in acclimatization process (1).

Other risk factors

There is preliminary evidence that neck irradiation or surgery (53) and pre-existing respiratory tract infections (54, 55) may be some of the newly described potential risk factors for HAPO which need further study. On the protective side, there are indication that ingestion of anti-oxidant vitamins prior to induction may reduce the severity and incidence of high altitude illness (56). The role of "Gingko Biloba" (80 mg of the extract twice daily for 5 days before induction) also seems to be useful by virtue of its antioxidant properties. Besides Gingko, the role of sildenafil and gaube as preventive measures has been postulated and needs further studies (57, 58). The role of acetazolamide (250mg BID orally, starting from one day before ascent) and dexamethasone 8mg per day in divided doses in prophylaxis (mainly for AMS) has been studied with convincing results (1).

## Epidemiology of HACO and other high altitude illness

**High Altitude Cerebral Oedema (HACO)**

HACO was scientifically described as early as in 1913 by Ravenhill (19), but it was only after half a century that the importance of this condition was recognized (59,60). There is very little published data on the incidence of HACO, except the study of Hackett et al (14) in which the incidence was found to be 1.8% among trekkers at an altitude of 4243 m. In another study in Nepal, among pilgrims at an altitude of 4300 m, Basnyat et al observed that the incidence of HACO was as high as 31%. Women were found to be at higher risk (OR= 3.15, 95% CI 1.62 to 6.12) (4). Experts agree, in general that HACO is a severe form of AMS. The risk factors for HACO are same as for AMS and HAPO; however, at present it seems difficult to predict who will, and who will not, develop HACO.

**Chronic Mountain Sickness (CMS) and Sub-Acute Mountain Sickness (SAMS)**

SAMS is characterized by pulmonary hypertension and right ventricular hypertrophy/ failure, either among infants or else among adults who have stayed at high altitude for few months. CMS is characterized by excessive erythrocytosis and hypoxemia, reversible on descent, among people who have stayed at high altitude for very long.

Very little published data is available on the epidemiological aspects of CMS and SAMS excepting for isolated case reports and few case series. There is paucity of data related to population denominator base for the purpose of calculating incidence rates or making analytic comparisons.

The occurrence of infantile SAMS was well known to the Spaniards who first colonized the Andes. Knowing that their infants would not thrive if born at high altitude, they used to arrange the deliveries at low altitude and did not bring the new born to high altitude till they were one year old (61). A case series from Tibetan region of fifteen infants, who died of the condition, was described by Sui et al. Majority of these infants were born at low altitude (62). There is a strong possibility of genetic determinants since infants of highlanders seem to be relatively protected, while children of lowlanders born at high altitude or else born at low altitude but moving to high altitude during infantile period seem to be at particular risk.

Epidemiological descriptions of adult form of SAMS have been provided in the form of case series among Indian

Army Personnel who had stayed at extreme altitudes for prolonged periods of many months (63, 64). A similar type of condition called as "Brisket disease" among cattle manifesting as oedema in the dependant part of the neck has been described (65). Adult SAMS could be the human counter part of Brisket disease. The condition manifests with pulmonary hypertension, right ventricular hypertrophy and /or failure and dependent oedema.

Chronic Mountain Sickness (CMS) was first described in 1925 by Monge, followed by case series in 1928, and also known as Monge's Disease (66). Thereafter another case series was reported by Hurtado (67). Descriptions from Tibet indicate that lowlanders migrating to high altitude are at much higher risk vis-à-vis the native highlanders. Males and tobacco-smokers are likely to be at higher risk (68). However, the condition is now being reported among the native Tibetans highlanders also (69). Among the native highland populations, it seems that the native Tibetans highlanders have lower hemoglobin values and are less likely to be at risk of CMS as compared to the native Andean highlanders, possibly due to certain (still unknown) genetic determinants (70).

#### Flare-up of Precontracted Infections

Viral and amoebic hepatitis in individuals who had contracted the infections at lower altitudes run a considerable risk of a more fulminating course with increased fatality, at high altitude. The course is otherwise prolonged, resolution seems to be difficult and unless evacuated to sea level, chronic protracted hepatitis may result. However, serum biochemistry pertaining to Liver Function is not altered in normal individuals located at thigh altitude and do not indicate any adverse effects on the normal liver except that the glucose tolerance may be slightly impaired and a lag curve may be seen. Cases of amoebiasis, who have been successfully treated by all measures even before five years, may flare up into frank amoebic hepatitis within 3 to 4 weeks of their arrival at high altitude. An abscess may form without evidence of liver tenderness, fever or leucocytosis and may even rupture before the patient reports sick. The initial response to emetine is satisfactory but a cure becomes extremely difficult or impossible if the patient is treated at high altitude. Infections of malaria which have been kept suppressed with chemoprophylaxis regime at lower altitudes also break through when the drug is withdrawn and the person is exposed to cold and hypoxia at high altitude. An acute diabetes mellitus may be precipitated at high altitude, more so among the patients who have been stabilized at sea level. The condition remits completely within a few days of return to sea level.

#### Other Effects

Prolonged exposure to hypoxia after acclimatization may produce other minor effects insidiously after a long latent period. Dimness of vision, loosening of teeth, progressive diminution of work capacity, loss of weight, flatulence, indigestion, loose bowels, anemia, thyroid deficiency and increased severity of infections may be encountered. These symptoms usually disappear within 3 to 4 weeks of move to the plains. A very long stay at high altitude somewhat habituates the tissue to low oxygen tension, but causes subnormal tissue metabolism. A high protein diet is thus essential. The atmosphere being cold, the air has very low atmospheric moisture content. The exhaled air on the other hand is at body temperature and hence contains more moisture. Much water is thus lost from the body through the breath. Lack of interest, irritability, insubordination and irrational reaction and lengthening of reaction time may occur. There is no increased incidence of frank psychiatric disease at high altitude in comparison with the plains. Lack of concentration and mental impairment, which may occur on arrival at high altitude, as part of acute mountain sickness, usually subsides within a few days. Some individuals may take a few weeks to acclimatize. In general, there is no scientific evidence to indicate that long term decline in memory or decrease in libido / sexual functions would occur either during stay at high altitude or after return to sea level.

### Prevention of adverse effects of high altitude

Individual tolerance to hypoxia varies and has no correlation with physical fitness in its ordinary sense. Complacency or bravado which in itself is one of the symptoms of hypoxia, encourages excessive physical activities without proper and adequate acclimatization. Rapid ascent without acclimatization followed by physical activity increases the risk of effects of hypoxia. As said earlier, even after acclimatization physical activity of even the most robust persons is less at high altitude than in the plains. Therefore, commanders may be reminded that more man-hours or more personnel are required to perform similar physical tasks at high altitude than in the plains (see next paragraph). Lack of appreciation of this fact can result in expectation of a high output of heavier tasks in short duration or desire on the part of men themselves to show off their prowess. Due to this, many casualties have occurred. Adequate details of prevention of adverse effects of high altitude and cold are laid down in concerned Army Order and DGAFMS Medical Memorandum (cited under "Further suggested readings" at the end of this chapter) and armed forces medical officers should consult these documents. The

**Box - 3 Preventive measures for adverse effects of high altitude**

- Ensure acclimatization (details given subsequently).
- Measures against adverse effects of cold (given in previous chapter).
- Education and motivation of Comanders and troops about acclimatization and planning of manpower for given tasks. Avoidance of tobacco; moderation in alcohol
- Adequate hydration
- Hot palatable meals
- Adequate shelter
- Maintain morale and psychological well-being

cornerstone of preventive measures is "ACCLIMATIZATION", which should be supplemented with general measures as outlined in box-3.

**Physical performance at High altitude**

It needs to be noted that even after complete and successful acclimatization, the capability to perform any given exercise or physical task will be reduced at high altitude in comparison to lower altitudes. This was clearly evident during Mexico Olympics of 1968, held at an altitude of 2300m wherein most of the world class athletes experienced as much as 13% reduction in their performance. Leaving aside the world class sports persons, evidence suggests that for normal, healthy and properly acclimatized subjects, the physical capability will be just about 70 to 75% at an altitude of 3100 m (Compared to capability at sea level altitude) and would be about 50 to 60 % at 4000 m. Care should be taken, therefore, by all subjects moving to high altitude, to make realistic readjustment in their expectations regarding task performance. Medical officers of armed forces should also impress this aspect on their respective commanders, so that they can make realistic estimates of requirements of manpower for a given operational task at high altitude. Available evidence also does not suggest that there would be any definite, especially long term increase in performance at sea level, among people who have trained at high altitude (71).

**Acclimatization**

It is important that troops when posted above 2700 m should be systematically acclimatized. It should be on the pattern followed by mountaineers, i.e. the individual works at a higher altitude than one at which he sleeps during the period of acclimatization. When the troops have acclimatized to a certain height, they can operate at those heights or even at slightly higher heights without any ill effect. This initial acclimatization is enough as long as the individuals do not go beyond 3600 m. If they are required to be stationed at a height of more than 36000m they will require a further period of acclimatization. For individuals who return to high altitude after a period of stay in plains for more than 10 days at a time, re-acclimatization is necessary. The tenure of stay should be such that an individual remains in an excellent state of health and physical fitness during his stay. It has been found that the desirable maximum period of stay should be 24 months between 2700-4200 and 12 months above 4200 m but below 4800 m, and about 2 months at a stretch for staying at altitudes beyond 4800 m. However, these recommendations need to be guided by operational requirements. Medical Officers of armed forces should advise the commanders regarding needful rotation of personnel, with a view to maximize the performance and minimize the ill-health.

Acclimatization Procedure

In Indian Armed Forces it is done in three stages.

**First Stage Acclimatization**

Applicable to individuals posted above 2700m and upto a height of 3600 m. The acclimatization period of 6 days will be as under: -

(a) 1st and 2nd day - rest except for short walks in the unit lines only, not involving any climb.

(b) 3rd and 4th day - walking at slow pace for 1½ -3 km, avoiding steep climbs.

(c) 5th and 6th day - can walk up to 5 km and climb up to 300 m at a slow pace.

**Second stage Acclimatization**

This applies to heights above 3600 and up to 4500 and is carried out for 4 days and is as under :-

(a) 1st and 2nd day - slow walk for a distance of 1½ -3 km avoiding steep climbs.

(b) 3rd day - slow walk and climb up to 300 m

(c) 4th day - climb 300 m with equipment.

**Third stage Acclimatization**

This is for height above 4500 m, lasting for 4 days and is on the same lines as second stage acclimatization.

**Re-entry**

Individuals who have left high altitude area will require acclimatization again if they were away for more than 10 days. Individuals away for more than 4 weeks will require complete acclimatization in 3 stages, as described above, while those who have been away for more than 10 days but less than 4 weeks, will have acclimatization for 4 days at each stage as under: -

(a) 1st and 2nd day - rest except short walk.

(b) 3rd day - walk at slow pace for 1-2 km, avoid steep climb.

(c) 4th day - walk 1-2 km with climb upto 300 m.

**Notes**

(a) If an individual is directly taken to a higher stage, the complete acclimatization as applicable for first stage should be recommended. For example, if a person is inducted by air, from plains, directly to a height of 14,000 feet (4200 mtr), he should have six days of first stage acclimatisation (and not only 4 days of schedule normally recommended for this height, for second stage).

(b) For induction via Road axis Pathankot - Manali-Upshi - Leh, specific instructions of Northern Command regarding acclimatization for persons inducted by this route are given in the succeeding paragraphs and may be further checked form Headquarters Northern Command (Medical Branch).

(c) The role of Acetazolamide, Aspirin, Ascorbic acid and oral antioxidant vitamins is under study but no evidence based proof is available for their introduction for mass prophylaxis.

**Acclimatization schedule : Leh-Manali Axis**

Details of acclimatisation schedule to be followed with base at "P1" for all 6 days ( with entire day to be spent at "G" hts (9000 ft) and night at "P1" transit camp will be as per AO 110/80 with modifications as under:

**New inductees**

(a) Day 1 & 2 : 12 hrs at 9000 ft and 12 hrs at 8000 ft. Troops to be taken up to "G" in vehicles for rest at HAA at 9000 ft during the day for 12 h and

brought down to transit camp, "P1" for night for 12 hrs

(b) Day 3 & 4: Walking 3 km. Troops taken up to "G" stay there for 12h. Only activity is to walk for 3km without much climb during their stay of 12 h at "G" and brought down to transit camp, "P1" for night for 12 h

(c) Day 5 & 6 : Walking 5 km with climb up to 300 mtrs. Troops taken upto "G" stay there for 12h.Walk up-hill for 2.5 km (Climb should be upto 300 mtr) and men walk down hill for distance of 2.5 km during their stay of 12h at "G" and brought down to transit camp, "P1" for night for 12h.

(d) Day 7 : Adm halt at "P2"

(e) Day 8 : Adm halt at "P3"

**Re-entry in HAA. (Away from HAA more than 10 Days but less than 4 wks).**

(a) Day 1 & 2 : 12 Hrs at 9000 ft and 12 hrs at 8000 ft. Troops to be taken up to "G" in vehicles for the Rest at HAA at 9000 ft during the day for 12 h and brought down to transit camp, "P1" for night for 12 h.

(b) Day 3 : Walking 1-2 km. Troops taken up to "G" to stay at 9000 ft for 12 h. Walk for 1-2 km during their stay of 12 h at"G" and brought down to transit camp, "P1" for night for 12 h.

(c) Day 4 : Walking 1-2 km with climb upto 300 mtrs.Troops taken upto "G" stay there for 12 h walk up-hill for 1-2 km (Climb should be 300 mtr) during their stay of 12 h at "G" and brought down to transit camp, "P" for night for 12 h.

**Box - 4 : Essential first aid for HAPO / HACO at forward post**

- Complete rest; no physical activity; manage as stretcher case
- Reassure the patient
- Oxygen inhalations 4 – 5 ltrs / min
- Establish intravenous line
- Call for evacuation

**Note**

Exact names of locations "P1", "P2", "P3" and "G" may be checked from HQ NC (Med Branch)

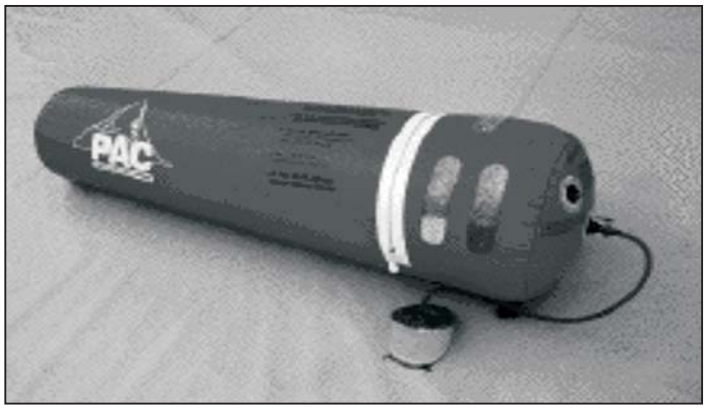
## Early Diagnosis, Treatment and First Aid

Adverse effects of high altitude, particularly HAPO and HACO should be managed as medical emergencies; prompt first aid and evacuation would be life saving. Medical officers should be familiar as to how to distinguish between AMS on one hand and HAPO / HACO on the other; Unnecessary evacuation in case of AMS may unnecessarily deplete the manpower while not evacuating a case of HAPO / HACO could be disastrous for the patient.

The mainstay of quick management is immediate evacuation of a case of HAPO / HACO to sea level or to as low an altitude as possible, with minimal exertion. If this is not possible, artificial recompression in a "Portable HAPO Bag" (see below) or else in recompression chamber at the dependent hospital should be undertaken. At the level of RMO / Nursing Assistant at the periphery, the essentials of first aid are outlined in box-4.

If evacuation is not possible, a viable alternative is to place the patient in recompression chamber which, in effect, deinducts the patient to lower altitudes. The pressure is maintained at 1 atmosphere. Hyperbaric pressure, beyond 1 atmosphere, is not indicated. Severe cases of HAPO, and the patients with evidence of cerebral oedema should definitely be treated in recompression chamber, if not evacuated to sea level. The average duration of treatment in a chamber is 16 hrs. In forward areas where a portable one-man recompression bag is available, all

Fig: HAPO Bag



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Gp Capt Sandip Mukherji

# Meteorology

Weather forecasting helps us in planning for the prevention and control of diseases, predict the level of human efficiency, forecast the dangers of climatic extremes and vagaries on men and plan for the prevention of their effects. Weather forecast and knowledge of climate conditions at particular places in particular periods of the year are necessary for the Armed Forces medical officers so as to enable them to advise the commanders on preventive aspects and also plan the control and therapeutic measures. Forecasting of weather and climate is done by correlating the present and previous meteorological observations with norms observed over considerably long retrospective period i.e. the 'climatic habits' of the place.

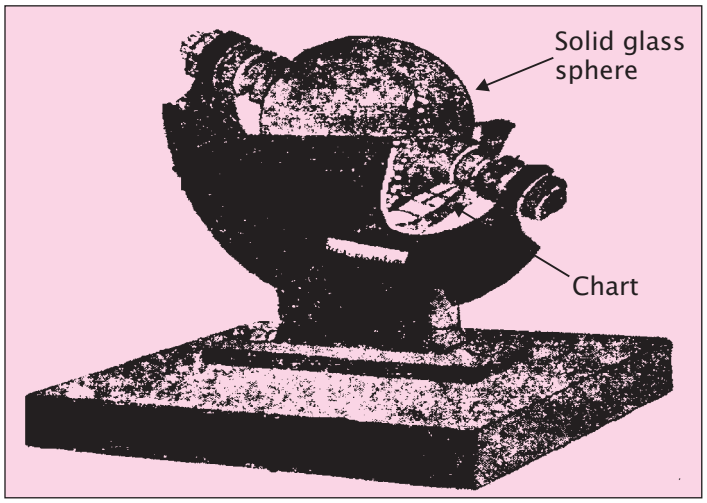
The important data required to be collected for weather forecasting are the atmospheric temperature, atmospheric humidity (wet bulb reading), the barometric readings, the directions and velocities of wind, the presence, type and direction of movements of clouds, the rainfall or snowfall, and the solar radiation. Out of these, the atmospheric temperature and pressure remains the most valuable data for weather forecasting. Various instruments are used to measure these meteorological factors; various modes of expressing the quantitative degree and qualitative types of these factors have been evolved; and various scales of expressing their total effect on human sensation have been innovated. These are briefly described in the succeeding paragraphs.

### Measurement of Solar Radiation

(a) Campbell- Stokes Sunshine Recorder

The number of hours of sunshine is estimated by the Campbell-Stokes Sunshine Recorder (Fig.1) in which sunrays are brought to a focus on a charted paper by means of a glass globe. The charred line gives the total number of hours of sunshine.

Fig - 1 : Campbell stokes sunshine recorder



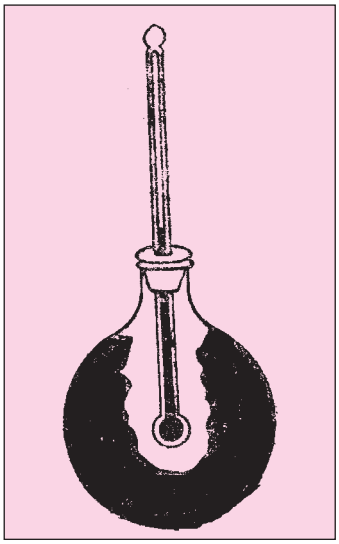

(b) Solar Radiation Thermometer

The intensity of solar radiation is measured by a solar radiation thermometer. It is a black bulb thermometer enclosed inside a glass shield devoid of air. The difference between the black bulb reading taken when exposed to sun rays and the maximum thermometer reading taken inside the Stevenson Screen denotes the intensity of solar radiation.

(c) Black Globe Thermometer

A black globe thermometer (Fig. 2) records the mean radiant temperature of the environment. It consists of a hollow copper globe of 15 cm diameter whose outer surface is coated with matt-black paint, which absorbs the radiant heat from the surroundings. If the place is windy, a black globe with 20 cm diameter should be used. The sphere has circular opening through which a mercury thermometer is inserted into the globe. The instrument is placed in the environment for about 20 min and the temperature is recorded. The mean radiant temperature (M.R.T.) is calculated from the chart provided. A modification called the wet Globe Thermometer consists of a dial thermometer enclosed by a blackened copper sphere which is commonly covered with wet, black cloth (1).

Fig - 2 : Black Globe Thermometer.



### Measurement of Atmospheric Temperature

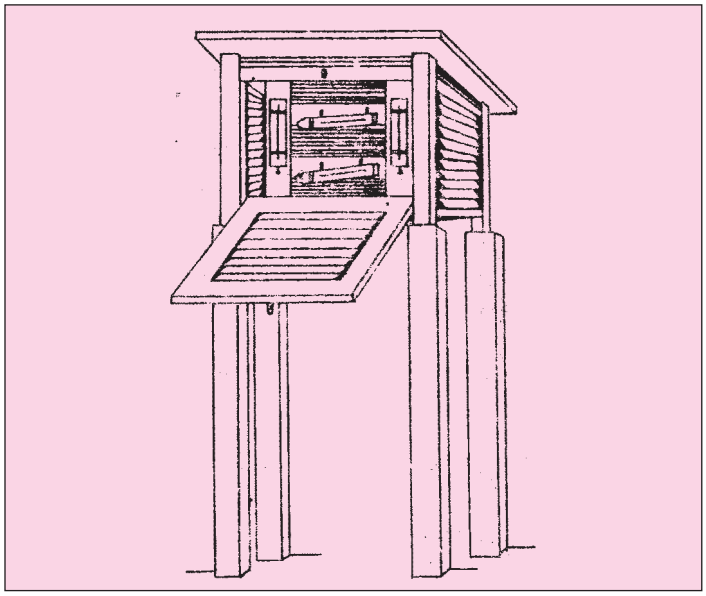
Atmospheric temperature is recorded in the shade by mercury thermometer.

(a) Stevenson Screen

To ensure free access of air to the bulb of the thermometers and their protection from the sun and rain, the thermometers are mounted in a box of approved pattern called the 'Stevenson Screen' (Fig. 3). It is a double louvered box, internal dimensions being, length 76 cm, width 45 cm and height 48 cm. It has a double roof, the upper one projecting 5cm beyond the sides of the box and sloping from front to back, and has an open base. At the front is a hinged door opening downwards. The box is mounted on four posts with its door opening to the North (South in the Southern hemisphere), at such a height that the bulbs of the thermometers are 138 cm from the

ground, and at least 6m away from buildings, large trees and other obstructions to prevailing wind. The thermometers are hung up inside the box so that they can be read without being touched and moved, and arranged

Fig - 3 : Stevenson screen



in such a way that no bulb comes within 8 cm of the roof or sides.

(b) Maximum Thermometer

It records the highest temperature attained at any given time of observation. It is hung up almost horizontally with the bulb end slightly lower than the other end. Maximum thermometer is a mercury thermometer, in the capillary stem of which there is a small metal indicator which is pushed along by the mercury and fits tightly enough to remain behind when the mercury recedes. The lower end of the indicator gives the highest temperature reached during the period of observation. To reset the instrument the indicator is pulled down by means of a magnet until it comes in contact with the mercury.

(c) Minimum thermometer

It is a spirit thermometer with a small metal pin-shaped indicator, which lies free in the column of spirit in the stem. To set the thermometer it is held with the bulb-end uppermost so that the indicator runs down the stem until stopped by the surface tension of the spirit. It is hung up similarly as the maximum thermometer without disturbing the indicator. As the temperature falls, the indicator is dragged down by the contracting spirit; when it rises the spirit flows past the indicator. At the end of any period of observation, the position of the end of the indicator farthest from the bulb shows the lowest temperature reached during the period.

(d) Combined Maximum and Minimum Thermometer

It comes in several types. The commonest of these is the James Six's Thermometer. This instrument consists of a glass tube bent into three limbs and combines the principles of the maximum and minimum thermometers described above. It is convenient for ordinary routine purposes but it is not accurate enough for exact meteorological observations.

**Means of Temperatures**

To convey a proper idea of the prevailing warmth of a locality, a full range of 'normal' data for the whole year and extending over a number of years should be given. They are as under:-

(a) Daily Mean Temperature.

It is the mean of the maximum and minimum temperatures recorded during the day; or at stations equipped with self-recording instruments for temperature, the mean of the twenty-four hourly values from midnight to midnight.

(b) Weekly Mean Temperature

It is the mean of seven consecutive daily mean temperatures.

(c) Monthly Mean Temperature

It is the mean of daily mean temperature of the number of days in the month in question.

(d) Yearly Mean Temperature

It is the mean of 12 monthly means.

(e) Diurnal Range of Temperature

It is the difference between the maximum and minimum temperatures of any day. The mean weekly, monthly and annual ranges of temperatures are obtained in the same way as the mean daily range of temperature.

**Measurement of Atmospheric Humidity**

Absolute humidity is the amount of water vapour actually present in the air expressed as g/l of air, as estimated by means of absorption hygrometers. Relative humidity is the ratio of the amount of water vapour actually present in the air at any given temperature to the amount that would be present in the air, were the air saturated at the same temperature. It indicates the percentage of saturation. Amount of water vapour necessary to cause saturation of the air varies directly with the temperature; the higher the temperature of the air more the water vapour it can hold before saturation point is reached. When atmospheric saturation is reached, evaporation ceases altogether. The relative humidity (RH) can be estimated by first finding out the dry and wet bulb temperatures by means of a self-recording hygrometer and then by calculating RH from the standard tables. Mason's hygrometer and whirling or sling psychrometer are used for this purpose.

(a) Mason's Hygrometer

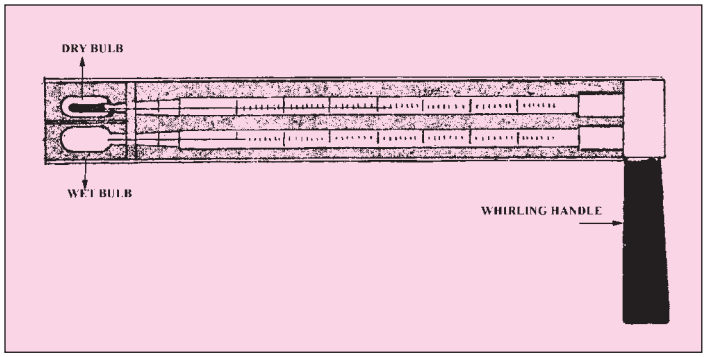
It has two mercury thermometers mounted side by side on a frame in the Stevenson Screen. The dry bulb is exposed in the ordinary way and the wet bulb has its bulb covered with muslin kept moist by a cotton wick, which dips in distilled water. The wet bulb thermometer records air temperature as influenced by the rate of evaporation from the muslin cloth. The drier the air the greater the rate of evaporation and the lower will be the wet bulb readings. In a saturated atmosphere the readings of the dry and wet

thermometers coincide. The difference between the dry and wet bulb readings, known as the 'depression of the wet bulb', is inversely proportional to the amount of atmospheric moisture. Hygrometric tables enable the relative humidity, the vapour, and the dew point to be read directly for any reading of Mason's hygrometer. This hygrometer is used for meteorological purpose at permanent meteorological stations.

(b) Whirling or Sling Psychrometer

It has the dry and wet bulb thermometers mounted side by side on a metal strip, which is pivoted to a frame with a handle. A small cylindrical water container is provided for soaking the piece of a wick. This is whirled by hand until the wet bulb reaches the lowest value. Successive observations are made to get a constant reading. The wet bulb reading should be taken first (2). An aspirating

Fig - 4 : Sling Psychrometer



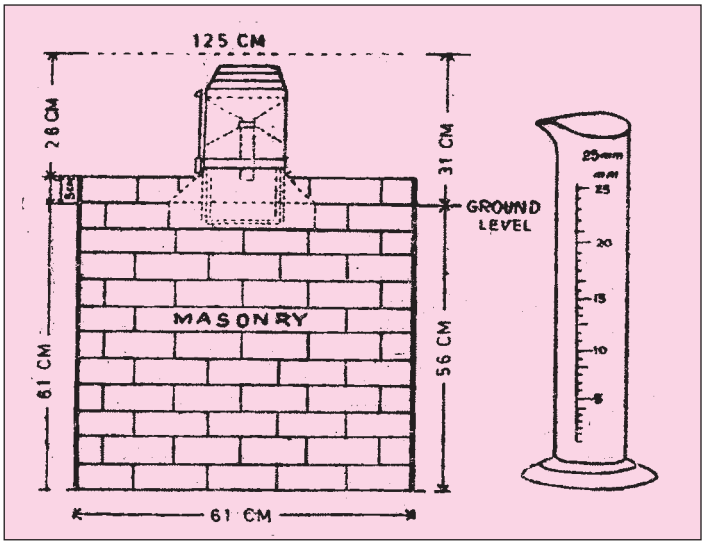

psychrometer is rotated by a motor and is more accurate but expensive. The sling psychrometer is used in physiological studies in enclosed places, to assess the occupational environment. (Fig 4).

**Measurement of Atmospheric Pressure**

The atmospheric pressure is estimated by the use of a mercury barometer of which there are several types, or by an aneroid barometer which, however, is not so accurate as the mercury barometers. Pressure observations are expressed in inches or millimeters of mercury, or more correctly as millibars. Barographs are also available which can make continuous records of barometric pressure, during a 24-hour period. The instrument is supplied complete with recording device and spare recording charts. Highly sensitive barographs are also available which are called microbarographs. The working of this apparatus is simple but for field work aneroid barometers are the instruments of choice. They should, however, be calibrated with a standard mercury barometer at frequent intervals.

**Measurement of Rainfall**

Rainfall is expressed in terms of inches or millimeters. A rain gauge consists of a collecting funnel, a receiving vessel and measuring glass. The funnel, which is made of copper, is cylindrical in its upper part with a diameter of 20.3 cm; in some instruments it is 12.7 cm. The receiving vessel is a small copper can, which fits inside an outer casing. A measuring glass graduated for the particular instrument is provided with each gauge. To take an observation, the outer casing of the instrument with the receiving vessel and collecting funnel in situ is sunk into the ground in an open space so that the top of the receiving funnel is about one foot above the ground. After




the desired time has elapsed the collecting funnel is removed, the receiving vessel lifted out, and its contained water poured carefully into the measuring glass and read off. Snowfall is also measured with the similar apparatus and method (Fig 5).

Fig - 5 : Erection of Rain Gauge

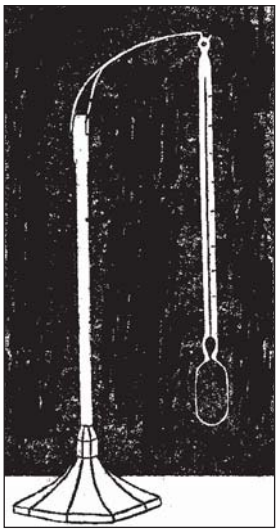
**Measurement of Air Movement**

The instruments that can be used are the kata-thermometers rotating vane or propeller anemometers, thermoanemometer and hot wire anemometer.

(a) Kata-thermometer.

The standard silvered kata-thermometers are of three types with appropriate cooling ranges:-

Fig - 6 : Kata Thermometer



(i)The standard Kata (Red coloured) Cooling range between 100ºF - 95ºF.

(ii)The high temperature Kata ( Dark blue coloured) - cooling range between 130ºF - 125ºF.

(iii)The extra high temperature Kata (Magenta coloured)- cooling range between 150ºF-145º F

The Kata thermometers are alcohol thermometers with a glass bulb 4 cm long and 1.8 cm in diameter. The kata thermometers are useful for measuring air velocities upto 250cm per sec. When air currents are mainly horizontal, vertical air

movements cause error due to convection currents from the large heated bulb. Each kata-thermometer has a given kata-factor and is provided with standard charts with instructions for use. Immerse the silvered bulb of kata into a flask containing hot water. The coloured fluid from the bulb will rise up into the stem upto small upper bulb. Remove the kata-thermometer from the flask and suspend it on a stand 60 cm away from the observer so that his respiratory air current does not vitiate the result. Wipe out all moisture from the surface of the thermometer with a clear chamois leather piece. Note with a stop watch the time in seconds for the fluid column to traverse the marked distance while cooling. Take five readings and estimate the mean value. The wind velocity is calculated from kata- factor and kata-charts available with instruments (3). Fig - 6 depicts the Kata-thermometer.

(b) Anemometer

Anemometer of the rotating vane or propeller type are used to record the speed of a unidirectional air current. For low air velocities and for measuring the combined air movement of eddies, the kata-thermometer is, however, preferable. Moreover, for biometeorological studies omnidirectional air movement is more important than unidirectional air current .

(c) Thermo-anemometer and Hot Wire Anemometer

These are used in laboratories for precision experimental work

(i) A thermo-anemometer is a mercury thermometer with an electrically heated metallic coil round its bulb. A rheostat regulates voltage. The velocity of air can be measured upto 5000 cms per sec or more by suing suitable voltage and a calibration chart.

(ii) A hot wire anemometer is made of three pieces of electrically heated fine platinum wires. The change in resistance produced by the cooling effect of the air current is measured by a potentiometer or a galvanometer. This instrument is sensitive to very low air movements below 100 cms per sec.

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Col PS Chawla

# Water Supply

> "We shall not finally defeat AIDS, tuberculosis, malaria, or any of the other infectious diseases that plague the developing world until we have also won the battle for safe drinking water, sanitation and basic health care."
>
> **Kofi Annan, United Nations Secretary-General**

Water is a prime natural resource, a basic human need and a precious national asset. Water is the most important of all the necessities for sustenance of life. Water is essential for drinking, cooking, bathing and washing, laundering, ablution, domestic sanitation, domestic animals and industries. The first two uses require very pure water and the remaining require relatively pure or clear water. Water for industries should be chemically suitable. However, water can become a vehicle for transmission of faeco-oral group of infections, because the faecal contamination of water is extremely common and its avoidance and subsequent purification is very difficult. Therefore, a strict water vigilance and control is to be maintained at all times. Water may also create unhealthy conditions if some organic or inorganic poisons such as lead or arsenic are present; excess of fluorides causes osteofluorosis and mottling of dental enamel; deficiency of fluorides causes dental caries and deficiency of iodine may cause goiter.

### Global Situation

Present estimates suggest that nearly 1. 1 billion people lack access to improved water supply and 2. 4 billion without access to any sort of improved sanitation facility and that at least 5 million deaths per year can be attributed to waterborne diseases. Eighty percent of all sickness in the developing countries, as stated in the International Conference on Primary Health Care at Alma Ata in 1978, was attributable to contaminated water supply. To tackle this global problem, the United Nations Conference on Human Settlement held at Vancouver in 1975 and the Water Conference held at Mar del Plata, Argentina in 1977, had earlier declared the period from 1981 to 1990 as International Drinking Water Supply and Sanitation Decade. Efforts within the countries were directed towards giving higher government priority to Decade activities, changing the technology mixed with a shift towards lower cost solutions; mobilizing community based resources through maximum participation by the beneficiaries and use of local materials; increasing manpower and taking all opportunities to couple water sanitation with health education programs and other developmental efforts, e. g. , agriculture and irrigation projects.

### National Situation

In India, the main sources of water supply are the perennial rivers and ground water resources. Because the annual precipitation is concentrated during monsoons, only a portion of this water is harvested; the bulk of it flows down to the sea and is lost as a source of supply. The groundwater is the principal source of water supply for personal, agricultural and industrial uses. Due to rapid increase in agriculture, industry and population, there has been consistent depletion of groundwater sources. This coupled with deforestation affecting water retention has resulted in depletion and receding water tables.

#### Availability and Demand

Total annual rainfall over India is 4000 cubic kilometers (CKM). Out of this, surface flow is only 1880 CKM annually. Due to topographical, hydrological and other constraints only 700 CKM of surface water per year can be put to beneficial use. The quantity of annual replenishable groundwater is 600 CKM, but only 420 CKM is usable. The estimated annual requirement of fresh water for the year 2000 and 2025 are 750 and 1050 CKM respectively. The present quantity of usable water is just sufficient to meet the demand of the country by 2025 AD.

#### Groundwater

In our country, the groundwater is consumed directly, without any sort of treatment and disinfection, therefore its quality is a cause of concern. Almost all highly industrialized areas in the country have contaminated their groundwater due to industrial wastes and agricultural run-offs (CPCB, 1994). Even all the villages too, do not have access to safe water. A "problem village" is defined as one where no source of safe water is available within a distance of 1. 6 km or where water is available at a depth of more than 15 meters or where water source has excess salinity, iron, fluorides and other toxic elements or where water is exposed to the risk of cholera and guinea worm.

**In India, under the International Drinking Water Supply and Sanitation Program the laid down target was 100 percent safe water supply, in both urban and rural areas.** As per available reports, till 1994-95, 85 percent of the target has been achieved (3 - 5).

## Importance of Water in the Armed Forces

Since Armed Forces personnel are particularly vulnerable to the danger of water related disease because of the nature of their duty under adverse conditions beyond their control, strict water vigilance and control is to be maintained at all times. The provision of adequate and safe water supply for use of Armed Forces personnel is an important responsibility of every Commander as it is important in the maintenance of health and fighting efficiency of troops. The Engineers are responsible for the supply of wholesome water and the Medical Services for the advice as to its safety and procedure to render it safe for consumption. In the field, all untreated water should be regarded as polluted but practically all waters can be made safe by modern methods; however, the better the initial supply the better is the final result. In every instance it must always be properly treated to render it fit for drinking. All units are responsible to maintain the following number of men trained in water and sanitation duties (AO 339/74 Course of training in sanitation and water duties) (See Table 1)

They will work under the supervision of the unit Quarter Master. Their duties consist of :

(a) Sanitation of source/storage of water supplies
(b) Supervision of sanitation within the unit lines
(c) Sanitation of cook houses and canteen
(d) Disinfection
(e) DDT spraying
(f) Anti fly, anti-mosquito and anti-rodent measures. Men previously trained are required to be sent on refresher courses annually. Necessary courses for the training of personnel are organized and conducted by RMOs / SEMOs / SHOs / Fd Ambs.

## Safe and Wholesome Water

Drinking water should be safe as well as wholesome. Water is termed safe when it does not harm the consumer even when ingested over prolonged periods. Safe water, however, need not necessarily be wholesome. It may be unsightly in appearance and unpleasant to taste and smell.

Water for drinking and cooking purposes, therefore, should be safe as well as wholesome. Such water is also termed potable water. Water is called polluted when it contains infective and parasitic agents, poisonous chemicals, industrial and other wastes or sewage.

**Safe and wholesome water thus, must be**

(a) Free of pathogenic organisms
(b) Free harmful chemical substances
(c) Acceptable to taste and appearance
(d) Usable for domestic purposes

## Water Requirements

The supply of water must be satisfactory in quality and adequate in quantity, readily available to the user, relatively cheap, and easily disposed after it has served its purposes. The water requirement depends upon climate, extent of physical activity, its availability, standard of living and habits of the people. In an urban area having water carriage system of sewage disposal, about 150 to 200 litres per head per day supply is considered adequate.

Man's requirement of water is known to depend upon the thermal stress resulting from the heat production in him due to physical work as well as due to heat gained by the body from the environment. It is well known that when the severity of this total stress increases the water requirement also increases.

Many studies have been conducted by Defence Institute of Physiology and allied sciences (DIPAS), Delhi Cantt, to find out qualitatively the optimum and minimum water requirements for troops under various environmental conditions. Based on the findings of these studies the optimum and minimum daily requirement for different activity patterns of troops under varying weather conditions in desert where the air temperature ranges from 41° to 44°C and the wet bulb temperature is about 26 °C to give a heat stress equal to 35 ° C WBGT (Wet Bulb Globe Temperature) are recommended as follows :

(a) When the troops are engaged in sedentary activities the optimum daily fluid requirement as drinking water and beverages is 6. 8 litres and the minimum requirement is 5. 5 litres.
(b) When the troops are engaged in 3 hrs of route march with 12 Kg load in open sun the optimum daily water requirement is 8. 3 litres with minimum of 7 litres.
(c) When troops are engaged in strenuous military exercises like digging of trenches, route marches, bayonet fighting, battle exercises like advance to contact, counter attack, withdrawal etc for a period of six hrs per day the optimal daily requirement is 10 litres and the minimum 8 litres.

Table - 1 : Men trained in Water and Sanitation duties

| Unit | Water and Sanitation Duties | | |
|---|---|---|---|
| | NCO | OR | |
| Major units commanded by Lt Col and above | 4 | 6 | Plus 20% as reserve |
| Minor units commanded by Major and below | 2 | 3 | |

To prevent occurrence of heat causalities or ill effects of heat, the above scale of water for troops in desert should be ensured (Auth : AHQ letter No A/46032/AG Coord dt 10 Dec 81)

The scales of water consumption in the Armed Forces are given in Table - 2.

## Sources of Water

The ultimate source of all natural potable water on the earth is rain. When rain falls, it runs off into streams, in the case of heavy rains, or soaks into the ground, percolating through porous strata until it reaches an impervious stratum, upon which it collects, forming groundwater. Groundwater is the source of wells and of the springs that feed streams, rivers, and lakes. In its course, groundwater dissolves soluble mineral matter, and often the surface waters of rivers and lakes are polluted by the influx of sewage or industrial wastes. The water is impounded by a system of dams, and flow by gravity, or is pumped, to the local distribution system. The quality of water from these sources varies greatly. Surface waters generally contain larger quantities of turbidity and bacteria than ground waters, but groundwater contains higher concentrations of dissolved chemicals

### Rain Water

Rainwater is used as a direct source on islands, such as Bermuda, where the rain is collected and led into cisterns to serve as the only available water supply. Catchment areas for direct capture of rainwater are also useful for

Table - 2 : Scales of water consumption (litres per head per day)

| Class | Married | | Single | | Military Area | | | | |
|---|---|---|---|---|---|---|---|---|---|
| litres | No of family members | Servants and families | No. | Servant | With water borne sanitation | | Without water borne sanitation | | Add for garden conservancy in per day |
| | | | | | Plains | Hills | Plains | Hills | |
| Officers Mil/ Civilians | 5 | 5 | 1 | 1 | 225 | 160 | 160 | 90 | 225 L per married Officer and 135 L per single officer |
| JCOs and their equivalents in the Navy & Airforce | 5 | - | 1 | - | 205 | 145 | 145 | 80 | 115 L per married JCO and 70 L per single JCO |
| NCO & equivalents | 5 | - | 1 | - | 205 | 145 | 145 | 80 | 45 L each for married and single |
| OR & equivalents | 5 | - | 1 | - | 205 | 145 | 145 | 80 | - |
| Followers (Non-Combatants) | 5 | - | 1 | - | 205 | 145 | 145 | 80 | - |
| Regimental shops | - | - | - | - | 7 | 45 | 45 | 45 | - |
| Wet Canteens | - | - | - | - | 1135 | 910 | 910 | 680 | - |
| Animals | - | - | - | - | - | - | - | - | 70 |
| Labour employed in Depots/installations | - | - | 1 | - | 45 | 15 | 35 | 15 | - |
| Office/Schools with water borne sanitation | - | - | 1 | - | 45 | 25 | 25 | 15 | - |

individual households as in South West USA or small communities as in Gibraltar where paved catchments are used. Historical sources mention the use of rainwater for domestic water supply some 4000 years ago in the Mediterranean region. In the hills near Mumbai, the early Buddhist monastic cells had an intricate series of gutters and cisterns cut into the rock to provide domestic water on a year-round basis. Bird droppings in rain water have been reported to cause salmonellosis in Jamaica. Rain water is usually soft, plumbosolvent and mildly acidic due to its reaction with carbon dioxide in the atmosphere to form carbonic acid. Acid Rain is a form of air pollution, which occurs when oxides of sulphur and nitrogen combine with atmospheric moisture to yield sulphuric and nitric acids, which may then be carried long distances from their source before they are deposited by rain. The pollution may also take the form of snow or fog or be precipitated in dry forms. The problem of acid rain originated with the Industrial Revolution, and it has been growing ever since. The widespread destructiveness of acid rain, however, has become evident only in recent decades as it has been found to erode buildings and other structures, injure crops and forests, and threaten or deplete life in lakes.

**Surface Water**

It includes rivers, streams, upland reservoirs and lakes. Surface water is moderately soft and contains variable degree of pollution from human and animal excreta. The extent of contamination at a particular time and place will depend upon the proportion of pollution to the amount of water available, from the feeding streams, upstreams or springs, the extent of stagnation or outflow over a given time and the extent of natural self purification.

Upland Waters

These are the collections of water harnessed in the impounding reservoirs by constructing earth, concrete or masonry dams across at convenient places in the valleys in the mountainous regions. These collections are relatively pure in general but may get polluted due to grazing of animals and human activity. During storage, sedimentation takes place and the number of faecal coliforms and faecal streptococci are considerably reduced. Destruction of organic matter by atmospheric

oxygenation, solar radiation and aquatic flora and fauna also occurs. Algal growth and loss of water through evaporation are the chief drawbacks. Storage in reservoirs and lakes may degrade water quality through eutrophication, biomagnification, and thermal stratification. Eutrophication (over-nourishing) occurs due to the influence of nutrient materials, particularly phosphorus and nitrogen which support the growth of algae. These nutrients accumulate in algae, which settle and tend to fill the lake. The increasing amounts of algae impart unpleasant taste and odours to the water. Biomagnification :There is also bioaccumulation of chemicals and contaminants taken up by aquatic life like fish whose quality is affected. Thermal Stratification: During summer, the warmer, lighter water accumulates at the top and the density difference prevents mixing. Microorganisms tend to accumulate at the thermocline, the zone of rapidly changing temperature and density that separates upper and lower layers.

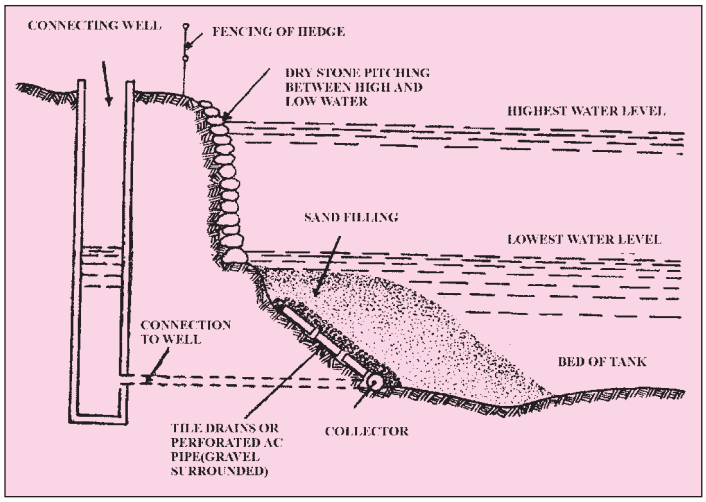
### Lakes

Lakes are increasingly becoming vulnerable to pollution as they are quite accessible for human activities. Eutrophication of lake waters is also common due to runoffs of chemical fertilizer from cultivated fields. The process of eutrophication can produce aesthetic problems such as bad tastes and odors and unsightly green scums of algae, as well as dense growth of rooted plants, oxygen depletion in the deeper waters and bottom sediments of lakes, and other chemical changes such as precipitation of calcium carbonate in hard waters. Another problem, of growing concern in recent years, is acid rain, which is leaving many lakes totally devoid of life.

### Ponds

Surface ponds without inflow of fresh water from upland streams or natural springs are stagnant. The degree of pollution and contamination is very high due to surface inflow and seepage from the surroundings. The concentration of pollution increases as water evaporates. The degree of self purification is negligible and the amount of pollution added to it each day is unpredictable.

Fig - 1 : Slow filteration of tank water




Therefore, water from fresh water lakes, which are properly protected, fenced and patrolled is generally pure and can be made potable whereas that from a pond is never recommended for human consumption. Unfortunately, it constitutes one of the main sources of water supply in the rural areas of this country. Research at national and international level has now come out with plans for improvement of village tanks as a source of relatively safe water supply. The improvement can be achieved as shown in figure - 1 by applying the basic techniques of modifying a part of the pond into a filter bed. The filtered water is then drawn into gravity fed well and finally chlorinated before supply.

### Rivers and Streams

These are natural drainage channels of the land. The quality of river water depends upon the geological strata through which it has travelled, the seasons of the year, and the amount of pollution that has occurred during its course. Generally it is moderately hard and holds organic and inorganic pollutants. Some river waters are brackish and may have an aperient effect and except in rivers arising directly from snow or mountains above human habitations, they are grossly contaminated and traversing long distances, they collect more pollution from sewage discharge from habitations located along their course. Other sources of pollution are the industrial effluents, carcasses and human dead bodies. Rivers, however, have considerable powers of self purification through the physical and biological processes. The degree of self purification depends upon the length, breadth and depth of the river, velocity of the water, nature of river bed, presence of saprophytic organisms, volume of water, presence of aquatic and animal life, and exposure to sun's rays. It should be ensured that water supply is procured upstream and that the industrial and other effluents discharged into a river downstream conform to the laid down standards and that the place around is properly protected. The inadequacy of traditional methods of water treatment to tackle gross river water pollution may be indicated by the outbreaks of viral hepatitis in New Delhi in 1955-56, when there were 30,000 cases, and in 1958, at the time of the outbreak, drought conditions prevailed, and the water abstracted from the river was estimated to contain about 50% of wastewater. Some rivers carry such a high proportion of treated and untreated wastewater that their use as a water source can be considered as essentially wastewater reuse. However, quite often, the same body of water serves both as a source of water and as a recipient of sewage and storm drainage. In wet periods, the water in rivers and streams may be low in dissolved solids content but often of a high turbidity. In dry periods, river flows are low and the load of dissolved solids is less diluted.

### Sea Water

The most appropriate method for desalination of sea water is thermal distillation as done in Middle East and the West Indies. Several different processes, including electrodialysis, reverse osmosis, and direct-freeze evaporation, have been developed for this purpose. With

brackish waters, where the salt content is much less than that of sea water, reverse osmosis or electrodialysis may be used. An additional problem is that with almost 80 percent of the planet covered by oceans, people have long acted as if those bodies of water could serve as a limitless dumping ground for wastes. Raw sewage, garbage, and oil spills have begun to overwhelm the diluting capabilities of the oceans and most coastal sea waters are now polluted.

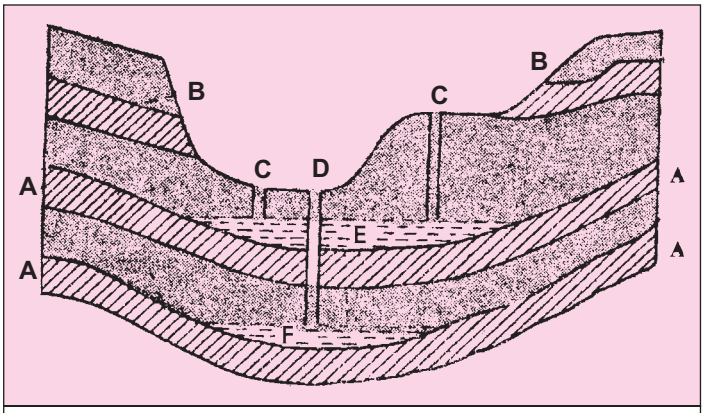
**Underground Water**

Underground water (Fig. - 2) is of major importance to civilization, because it is the largest reserve of drinkable water in regions where humans can live. Underground reservoirs have the following major advantages :

(a) They do not lose water through evaporation

(b) Their quality is not so likely to be affected by natural, urban or industrial pollution

Fig - 2 : Underground Water




(A) Impermeable layers (e.g. Clay) (B) Land springs (C) Shallow wells (D) Deep wells (E) Superficial water table (F) Deep water table

(c) They do not require expropriation of large areas of land

(d) They may be located nearer to the points of use than are surface impoundments.

Although groundwater is a renewable resource, reserves are replenished relatively slowly. Because groundwater is recharged and flows so slowly, once polluted it will remain contaminated for extended periods. Contamination arises from leaking underground storage tanks, poorly designed industrial waste ponds, and seepage from the deep-well injection of hazardous wastes into underground geologic formations. When groundwater is depleted in coastal regions, oceanic salt water commonly intrudes into freshwater supplies. Sometimes, withdrawal of water from a new well may cause an appreciable reduction of the yield of existing wells nearby. When heavily populated or highly irrigated arid areas withdraw water from the ground at too rapid a rate, the water table in such areas may drop so drastically that it cannot be reached, even by very deep wells. Excessive abstraction of groundwater has not only lowered the water table in many places but also has resulted in subsidence of the ground above in some places, threatening structures and increasing the potential for flooding.

Shallow Wells

These tap the 'superficial water table' i. e. the water table above the first impervious layer of the earth. Their yield fluctuates according to the subsoil water percolating to it during the year. The quality of water depends upon the geological formation and the degree of pollution by seepage from the adjacent area, which is unpredictable. Shallow wells are, therefore, inferior to deep wells as sources of water for human consumption. The Cholera outbreaks in Delhi in 1988 were due to contamination of shallow wells. For improvement of the existing shallow wells which are usually 'kutcha' and are most commonly used in rural areas, the Planning, Research and Action Institute (PRAI) Lucknow has developed a modification plan at nominal cost. Such a well can be made sanitary by deepening the bottom, installing a handpump with screen and then filling the well with coarse sand upto water level; clay is then put over sand till it reaches a little above the surface level and then left for consolidation. When the material used for filling is consolidated a platform and drainage may be constructed. Samples of water from such wells are found to be satisfactory. In the well-watered regions of the world, successful wells of moderate depth and diameter in hard rock may be expected to yield from 1 to 50 gallons per minute (1 gpm = 1440 gpd), whereas similar wells in coarse sand and gravel and in coarse sandstone will deliver 50 to 500 gpm.

Deep Wells

These tap the deep water table lying between the two impermeable strata and their yield is constant. Water in a deep well is usually cool, pure and sparkling but likely to have a lot of mineral contents. Normally it forms a very good source of water supply if it is well protected. A deep well is also liable to pollution if there are cracks in the impermeable layer especially in chalky strata. Faulty staining also makes them liable to surface pollution as in the case of shallow wells. An ideal deep well is the one which is sunk to a sufficient depth below the first impermeable geological stratum, well stained with stones or bricks set in cement concrete provided with a covered parapet with a coping or sloped platform around and fitted with a pump. The depth of water should be sufficient to ensure an adequate quantity and sedimentation. Wells in deep aquifers may yield 100 gpm or more in favourable circumstances.

Tube Wells

These are made by boring into the ground. These wells could be shallow or deep. A lot of emphasis is presently being given nationally as well as internationally to provide safe water through tube wells in rural areas. The hand pumps are so constructed that their levers can withstand reasonable degree of rough handling. Boring and inserting a tube and fitting a pump are works of some magnitude. The difficulties lie in the apparatus required for construction, the uncertainty of striking water and,

when found, its suitability. Such water when tapped is often brackish or heavily charged with magnesium salts. The capacity of tube wells varies over a wide range, from less than 1 litre/sec for shallow small-diameter wells in fine sand aquifers, to over 100 litres/sec for large diameter deep wells in coarse sand or sedimentary rock deposits. A tube well has a casing consisting of pipes (tubes) - plain pipes opposite non-water bearing ground formations, and perforated or slotted screen sections opposite the aquifer. Tube wells can be drilled to over 200 metres deep, even through hard rock.

### Artesian Wells

Artesian groundwater is groundwater, that is, by an overlying impervious layer, prevented from rising to its free water table level, and therefore is under pressure. The name is derived from French Artesian of Artois, a province where such wells were first drilled in modern times. Artesian wells are not common in India.

### Step Wells

These are a kind of 'pucca' wells where steps are constructed leading to these wells to fetch water. There is considerable contact between the user and the water. Guineaworm infestation was a public health problem in areas having such wells. Fortunately, these wells are now becoming obsolete.

### Springs

These are natural wells formed when for some reason the underground water over flows upon the surface where the geological formation is favourable for an outcrop. Springs can be 'shallow springs' and 'deep springs' depending upon whether the water comes from the superficial or the deep water tables. They may be intermittent or constant. Intermittent springs are merely the reappearance of upland surface water, which has temporarily passed underground. Until it is made certain that the water is from the deep spring its purity should be viewed with suspicion. Water from a deep spring is generally hard and less suitable for washing and cooking but is passable for drinking. Deep springs can be turned into well like reservoirs by building parapets around them.

### Driven Wells

Driven wells are essentially suitable for soft, sandy formations, which are readily penetrated by the well point. They are usually limited to shallow wells of less than 10-15 metres depth. The diameter is also about 5-10 cm only. The yield is only about 0. 1 to 1. 0 litre/sec.

## Selection and Protection of Water Sources

It is important that in order to expect a purified and safe water supply for human consumption, the proper source and tapping site should be selected keeping in view the liability and degree of pollution and its dilution, power of self purification, daily yield, duration for which available, wholesomeness of water, and the approach to the area. The area around the source, tapping point and delivery point should then be protected against pollution by fencing and prohibiting entry of animals and unauthorized men, bathing and washing. No sanitary installation should be allowed in the vicinity. Water pumped out of wells, when that is the source of water, should be received in a reservoir and chlorinated. The storm water should be led away by a channel constructed around the outer platform to a garden or a large soakage pit. The well should be fenced and no unauthorized persons should be allowed into the area. Periodic inspection, repairs and desilting of the well should be carried out. Springs should also be provided with a coping and parapet. They should be fenced and bricked in. The surface storm water should be diverted away by means of channels dug around the spring.

Water from streams and lakes should be drawn from the upstream side of the township and as far from the banks as possible and pumped into the treatment tanks. In the field several alternative sources and sites should always be examined and the best of them selected for immediate use. The others should then be graded according to merits and improved upon for use in an emergency. When there is no freedom of choice, the only available source and site should be improved upon. Consideration must always be given to yield, extent of pollution, extent of dilution, power of self purification and the outflow of water from the selected or available source and site. Personnel attending to the water treatment/distribution should be protected against typhoid and medically inspected.

## Water Pollution

Natural water, from a chemical point of view, is never pure. The impurities could be either natural, derived from atmosphere or catchment area and soil or due to human activities. Water pollution may come from point or non-point sources.

Point sources discharge pollutants at specific locations from, for example, factories, sewage treatment plants, or oil tankers. Technology is available for point sources of pollution to be monitored and regulated.

Non-point sources run off water containing pesticides and fertilizers from areas of agricultural land, for example are much more difficult to control. Pollution arising from non-point sources accounts for a majority of the contaminants in streams and lakes. The pollutants may be classified as under :

### Natural Pollutants

(a) Dissolved gases Carbon dioxide, ammonia, hydrogen sulphide and nitrogen.

(b) Dissolved minerals Salts of calcium, magnesium and sodium.

(c) Suspended impurities Clay, silt and mud washed by storms and floodwater from croplands, unprotected soils, strip mines, roads, and bulldozed urban areas.

(d) Microscopic plants and animals Plankton, algae, saprophytes and insects.

### Manmade Pollutants

(a) Sewage and other oxygen-demanding wastes (largely carbonaceousorganic material, the decomposition of which leads to oxygen depletion) and infectious agents

(b) Plant nutrients, including fertilizers, that can stimulate the growth of aquatic plants, which then interfere with water useand, when decaying, deplete the dissolved oxygen and produce disagreeable odours

(c) Exotic organic chemicals, including pesticides and herbicides, various industrial products, surface-active substances in detergents, and the decomposition products of other organic compounds.

(d) Petroleum, especially from oil spills

(e) Inorganic minerals and chemical compounds, metal salts and synthetic organic chemicals.

(f) Radioactive substances from the wastes of uranium and thorium mining and refining, from nuclear power plants, and from the industrial, medical, and scientific use of radioactive materials.

(g) Heat may also be considered a pollutant when increased temperatures in bodies of water result from the discharge of cooling water by factories and power plants.

**Hazards**

Health may be affected either directly by consuming contaminated water or indirectly through food chain and also by use of water for recreational, agricultural, trade and other purposes. The health hazards of water pollution may be classified as follows :

Biological

The diseases related to water supply and caused by biological agents of disease are summerised in Table - 3

Chemical

These pollutants are of diverse nature and are derived from industrial, trade and agricultural wastes that are being discharged increasingly into bodies of water. The chemical pollutants include detergents, solvants, cyanides, heavy metals, minerals, organic acids, nitrogenous substances, dyes, pigments, bleaching agents, sulphates, ammonia and many such other toxic substances. Acute toxic effects on human health by these pollutants presently are presumably of less concern than their long term low level exposures. Some of these substances are either known or suspected of having carcinogenic, mutagenic or teratogenic effects. Deficiency of some substances such as iodine and fluorine may cause goitre and dental caries respectively. Excess of some of them may also cause harmful effects; excess fluorides may cause fluorosis; excess of nitrates & nitrites may cause methaemaglobinaemia in infants.

Radio active substances

In modern world with radio active substances being used in wide range of fields, extending from peaceful use such as medical diagnostics and treatment to its wide use in Armed Forces. In future these substances may pose a major health hazard due to water contamination by its residues.

## The Water (Prevention and Control of Pollution) Act 1974

This Act was passed by the Parliament in 1974 to counter and contain ever growing pollution of natural water resources. This Act is comprehensive in providing the

Table - 3 : Diseases related to water supply

| Group | Diseases |
|---|---|
| **Water borne diseases**<br>Diseases transmitted by water where water acts as a passive vehicle for infecting agent. All these depend also on poor sanitation | Cholera, typhoid, bacillary dysentery, viral hepatitis, leptospirosis, giardiasis, gastroenteritis |
| **Water washed diseases**<br>Diseases due to lack of water. Poor personal hygiene favours spread. Intestinal infections depend on lack of proper human waste disposal. | Scabies, skin sepsis & ulcers, yaws, leprosy, lice, typhus, trachoma, conjunctivitis, bacillary and amoebic dysentery, salmonellosis, worm infestations |
| **Water based diseases**<br>Infecting agents spread by contact or ingestion of water. An essential part of life cycle of agent takes place in aquatic animal. | Schistosomiasis, dracunculiasis |
| **Water related vectors**<br>Transmitted by insects living close to water | Yellow fever, dengue, encephalitides, filariasis, malaria, onchocerciasis, sleeping sickness |
| **Faecal disposal diseases**<br>Caused by infecting agents - by eating uncooked fish and other food | Clonorchiasis, diphyllobothriasis, fasciolopsiasis, paragonimiasis |

legal basis for prevention and control of water pollution, maintenance and restoration of wholesomeness of water sources in the country. To execute the aforesaid purposes the Act provides for the constitution of Central, State and joint Boards having prescribed powers and functions. The main function of the Central Board shall be to promote cleanliness of watercourses in different areas of the States. The Board has been conferred the power to perform several functions i. e. , advisory to the Central Govt; co-ordinating the activities of the State Boards; provide technical assistance and guidance to the state board, carry out and sponsor investigations and research relating to problems of water pollution and their abatement; plan and organize training of persons engaged or to be engaged in programmes for prevention and control; collect, compile and publish technical and statistical data related to the subject; to lay down, modify or annul the standards for a water course; plan and cause to be executed nationwide programmes and so on. The Board may establish or recognize laboratories to enable it to perform its functions including the analysis of samples of water, sewage or trade effluents. The State Boards, under the guidance of Central Board, are similarly responsible to plan and execute comprehensive programmes in their respective territories. They have also been conferred the powers of entry into any premises after giving due notice to the owner and collect samples of water, sewage and trade effluents for analysis and recommend necessary legal steps. The State Governments, under advice from the Board, are also authorised to take emergency measures when pollutants have entered or threatened to enter the watercourse due to accidental or unforeseen event or act of omission or commission. A joint Board is set up on subjects of common interest by mutual agreement either between adjacent states or between the states(s) and the Central Govt. when the latter has been appointed as the executing agency for the Union Territories.

## Water Purification

Comprehensive details of water treatment processes in settings of small scale communities, as well as large scale community supplies are laid down in standard publications (6 - 9). Reference No. 6 is generally accepted as a standard reference by various Public / civil engineering agencies in our country. Medical Officers dealing with water supply systems are advised to refer to these manuals.

**Water purification may be required to be carried out either on**

(a) Large scale

(b) Small scale

### Purification of water on a large scale

Aim

The aim of water purification is to diminish

(a) Organic and inorganic suspended matter

(b) Pathogenic organisms

(c) Deleterious salts and poisons in solution

The method of treatment to be employed depends upon

(a) The nature of raw water

(b) The desired standards of water quality

For example, ground water may need no treatment, other than disinfection. Surface water which tends to be turbid and polluted, requires extensive treatment. The components of a typical water purification system comprise one or all of the following measures :

(a) Storage

(b) Filtration

(c) Disinfection

Clarification followed by sterilization by various methods generally renders water safe for human consumption. Clarification removes suspended matter and sterilization kills pathogenic organisms. The elimination of deleterious salts is a difficult problem and no simple practicable method has yet been devised for employment in the field. Sterilization without clarification may be practiced if water is beyond any doubt free of pollution and is visibly clear, or under extreme urgency.

### Clarification

Even when water appears very clear, clarification should be insisted upon particularly for surface water. Minute particles of suspended organic matter which usually give lodgment to microbes particularly the viruses are not usually destroyed by the usual dosage of chlorine. Efficient clarification, therefore, eliminates besides the suspended matter, harmful organisms, cysts, ova, mollusc and Cyclops, and thus reduces the chlorine demand of water. The two methods available for clarification are sedimentation and filtration. Filtration is superior to sedimentation provided that the suspended matter is not too dense. Sedimentation requires more time (several hours) than filtration and the amount of water that can be dealt with is limited by the size of tanks available. Sedimentation less efficiently eliminates ova and cysts than filtration. However, efficient sedimentation prior to filtration definitely results in a better final clarity of water, and relieves the filters of the clogging debris.

### Sedimentation

It is carried out by allowing water to stand in concrete, masonry or canvas tanks over a variable period from 2 to 6 hours for settling the coarse suspended matter. This process can be hastened and improved in quality by coagulation and flocculation, which precipitates particulate and colloidal matter.

(a) Coagulation

The chemical coagulants employed are pure aluminium sulphate (alum) or more commonly alumino ferric, which is an impure form of alum containing about 1 percent of ferric sulphate. Both salts are readily soluble in water and being acid in reaction, tend to lower the pH of the water in which they are dissolved. When either is added to water with a pH of not less than 6, a precipitate of aluminium hydroxide is formed which engulfs and precipitates with it the minute particles of suspended matter. If the pH is less than 6, no precipitate forms and if it is above 8 the

precipitate becomes too gelatinous and sedimentation is delayed. The optimum reaction for rapid and efficient sedimentation is about pH 7 at which the addition of 35 g of alum or aluminoferric per 1000 l will rapidly clarify any but very turbid water. If water is exceptionally turbid, as much as 70 g per 1000 l may have to be used. To immediately disperse the entire dose of chemicals throughout the mass of raw water, it is necessary to agitate the water violently and to inject the chemical in the most turbulent zone. Generally large sludge volumes are produced with alum which requires frequent desludging operations at the treatment plants causing increased wastage of water. There is also the possibility of aluminium carry over in water treated with alum. High levels of aluminium in potable water are reported to cause Alzheimer's disease, a form of senility. However at present there is no clear evidence to suggest a link between aluminium and Alzheimer's disease (Cole, 1990). Poly aluminium chloride (PAC) has been developed as an alternative coagulant for alum by an Indian manufacturer.

PAC hydrolyzes with great ease as compared to alum, emitting polyhydroxides with long molecular chains and greater electrical charge in the solution, thus contributing to maximize the physical action of the flocculation. Better coagulation is obtained with PAC as compared to alum at medium and high turbidity waters. Floc formation with PAC is quite rapid. The sludge produced by PAC is more compact than that produced by alum.

(b) Flocculation

Flocculation is the process of gentle and continuous stirring of coagulated water for the purpose of forming flocs through the aggregation of the minute particles. After coagulation, the individual floc particles are easily observed by the naked eye, being of the order of 1-2 mm in diameter. In practice, the velocities in flocculation tanks vary from 1 m/s at the entrance, decreasing to about 0. 2 m/s near the outlet, with a retention time of 30 minutes. Flocculation is designed to accommodate the worst situation, which generally occurs in winter.

In actual practice this quantity of alum or aluminoferric brings the natural alkalinity of the vast majority of waters down to a pH of 7 and no other treatment is required. If sedimentation does not occur the water may be too acidic and the addition of half the quantity of lime as that of the coagulant is generally enough to correct the pH. For very turbid water sedimentation may be better carried out in two stages; initial settling of the bulk of the coarse debris followed by chemical flocculation. Leading the flow of water through long tortuous broad channels at slow velocity and storage in large reservoirs before its entry into the sedimentation tanks helps to achieve better sedimentation. This also exposes water to the natural purifying effects of the sun's rays and fresh air, and the biological effect of minute aquatic fauna and flora. These processes render the water highly suitable for filtration and bring down the bacterial content of water considerably.

### Filtration

It is almost universally adopted in a large scale purifying process of water in municipal, cantonment, garrison or base areas where permanent water works exist. Storage and sedimentation, with or without flocculation depending upon the quality of water, almost always precede the process of filtration. Filters are slow and rapid sand filters and mechanical filters. Mechanical filters are used in small, more sophisticated water plants and also in the water tank trucks and trailers.

### Slow Sand Filters

These are large masonry tanks 2. 5m -4 m deep containing sand supported on gravel and the water is passed through them slowly from above downwards. As the filter plants need extensive tracts of land these are usually situated on the outskirts of town located on the bank of a river. To avoid choking of the media preliminary sedimentation is necessary, chemicals may be used for hastening up clarification if the water is too turbid. The filter beds are usually rectangular in shape, arranged side by side in rows and may be either open on top or covered. Each bed usually covers an area from one tenth of an acre to one acre land.

The filter bed from below upwards consists of

(a) Under drainage system
(b) A bed of graded gravel
(c) Sand
(d) Supernatant raw water.

The **underdrainage system** which is about 16 cm in depth, consists of porous or perforated pipes which serves the dual purpose of providing an outlet for filtered water as well as supporting the filter media above.

A layer of **graded gravel** of about 30 cm thickness is placed over the perforated pipes.

Above the gravel is the **sand bed** having a thickness of about 1. 2 m.

The depth of **supernatant raw water** varies from 1-1. 5m. It provides a constant head of water to overcome the resistance of the filter bed.

Slow sand filter acts primarily biologically by forming a slimy 'zoogleal' layer also known as 'Vital Layer' containing algae, plankton and other minute plants and protozoa formed in two or three days time over the surface of the sand bed. Till the vital layer of the filter bed is fully formed, the filtrate is run to waste. To obviate cracks in the biological film, the rate of filtration should not exceed 100 $m^2$ of filter surface per hour. After several months of running of the filter, the bed resistance increases necessitating cleaning. This is done manually by scraping the vital layer. After several years of operation when the thickness of the sand bed reduces to about 0. 5 to 0. 8 m, the plant is to be closed down and a new bed is to be constructed.

#### Mechanism of Action of Slow Sand Filters

In a slow sand filter, due to the fine grain size, the pores of the filter-bed are small. The filter is capable of reducing the *Esch. coli* content and the total bacteria count. It will remove protozoa such as *E. histolytica* and helminths

such as *S. haematobium* and *A. lumbricoides.* Trouble free operation is only possible when the average turbidity of the raw water is less than 5 nephelometric turbidity units (NTU) with occasional peak values below 20 NTU permissible.

Removal of impurities is brought about by different processes such as

(a) Straining
(b) Sedimentation
(c) Adsorption
(d) Biochemical and microbial actions.

In straining, suspended particles that are too large to pass through the pores are retained at the surface or top layer of the filter.

In the upper part of the filter-bed, sedimentation of fine suspended solids also takes place. Settling efficiency is very high due to the large surface area (10, 000 to 20, 000 sq. m per cu. m of the filter sand) and slow rate of filtration.

Most of the remaining suspended solids with colloidal and dissolved impurities are removed by adsorption onto the sticky gelatinous coating formed around the sand grains or through physical mass attraction and electrostatic attraction. Clean quartz has a negative charge and so are the particles of bacteria and colloidal material. Initially positively charged ions are adsorbed over the sand grains and over saturation occurs after which negatively charged ions are adsorbed after ripening of filter bed. Then, there is a varied series of negative and positive charged grains that are able to adsorb most impurities from the passing water.

Organic matter is partly oxidized providing energy for bacteria and partly transformed into cell material used for their growth. Since the organic matter is limited, there will be a simultaneous die-off of bacteria releasing organic matter. Gradually, the organic matter is broken down and transformed to inorganic compounds like carbon dioxide, nitrates, sulphates and phosphates which are released with filter effluent. In practice, it is seen that full bacterial activity extends for a depth of about 0. 6 m of filter-bed. For intestinal bacteria, the filter-bed provides unfavourable conditions because the water is generally colder than their natural habitat, and usually does not contain sufficient organic matter of animal origin for their living requirements. The microorganisms in the filter also produce antibiotics and other agents that kill or at least inactivate intestinal bacteria.

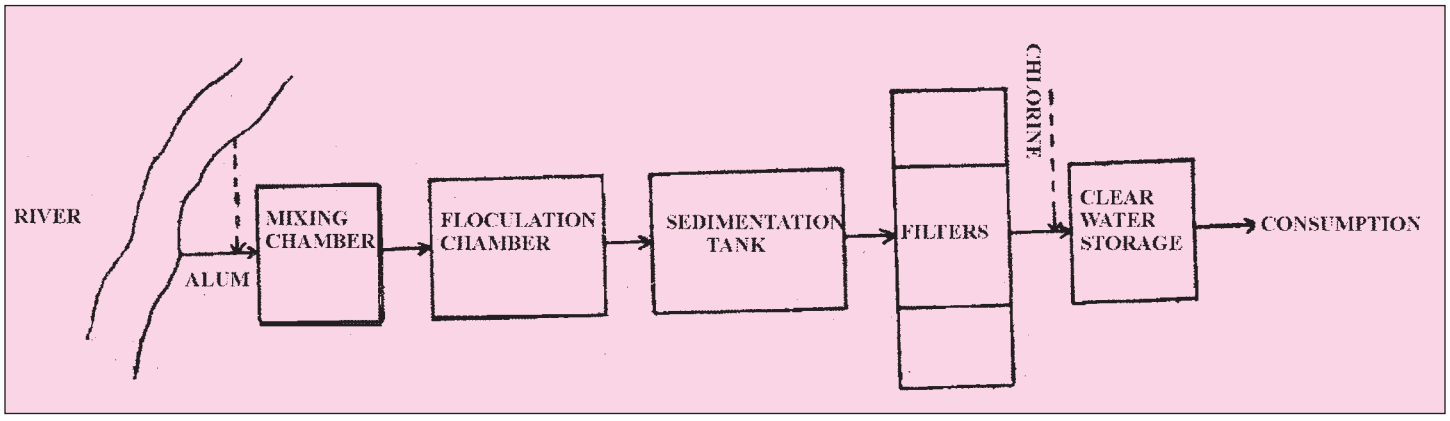
## Rapid Sand Filters

These are of two types 'gravity type' (Paterson's filter) and the 'pressure type' (Candy's filter). While the former is usually used in large installations, the latter is used in smaller installations such as swimming pools. The various steps in the working of a gravity type rapid sand filter are shown in figure - 3. The raw water is first treated with calculated dose of alum or aluminoferric and is then subjected to violent agitation in a mixing chamber for a few minutes. It is then allowed to move gently for half an hour in a flocculation chamber by mechanically operated paddles. A thick floc is formed which entangles suspended matter and bacteria. The coagulated water is then taken to sedimentation tanks where it is detained for 2-6 h when flock settles down. About 95 percent of flock is removed and then the partly clarified water is taken to the filter bed. The filter bed is a watertight rectangular chamber with a surface area of about 90 $m^2$. The depth of the sand bed is usually one meter having sand particles whose sizes are bigger than the ones used in slow sand filters. Below the sand bed is a layer of graded gravel of about 40 cm thickness. The under drainage is below the graded gravel layer. The supernatant water height is about 1 to 1. 5m. The alum floc makes a tough slimy layer (chemical) over the sand bed, which acts mechanically. In this system there is no time wasted for ripening of the bed. When the bed gets clogged after use for a day or so, it is cleaned by back washing by reversing the flow of filtered water. Backwashing is usually preceded by loosening of the sand bed by passing compressed air through it. After backwashing, the filter bed is put to use immediately and not after 24 hours or so as is required for the formation of biological film in a slow sand filter. The rate of filtration in a rapid sand filter is about 100 times faster than of slow sand filter

## Mechanical Filter

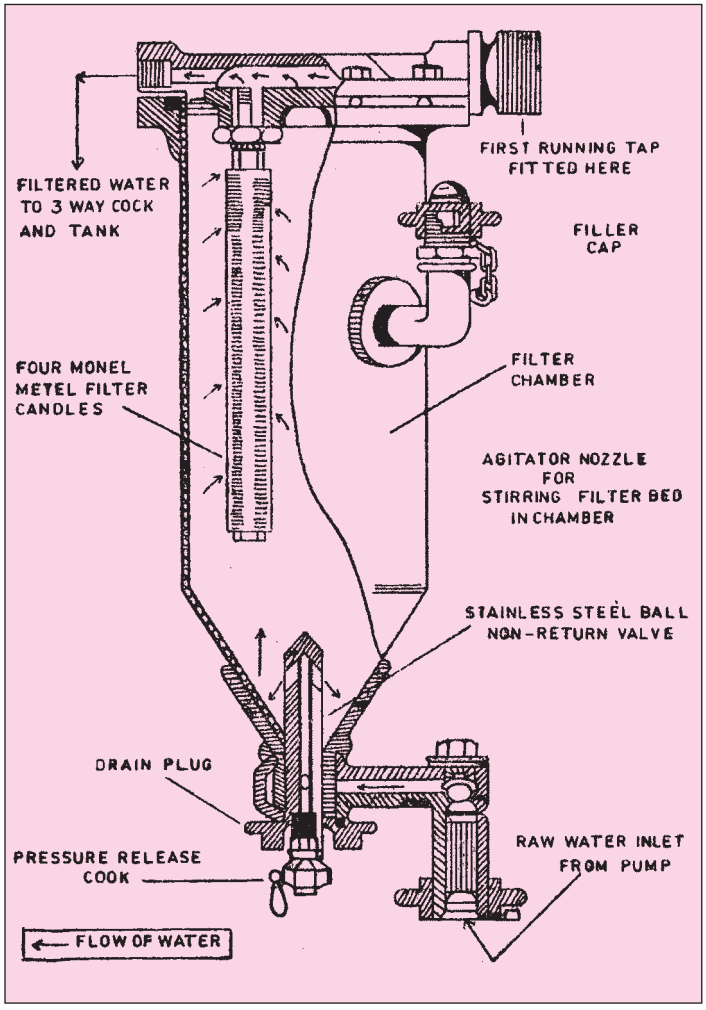
It consists of a cylindrical metal chamber surmounted by a filterhead. Into the undersurface of the filterhead are

Fig - 3 : Flow diagram of a rapid sand filtration plant



screwed four to six filter elements (candles). There are two types of filter candles used in the Armed Forces-meta filter and the stellar filter. The meta filter consists of thin monel metal discs with embossed faces. When these discs are superimposed on each other and held in position by clamping rods they form a column of a candle. Each disc has a central hole. As the discs lie on one another, a central channel through the column is formed. The embossed faces leave a space of 8 m in between each pair of discs. The stellar filter candle, on the other hand, consists of brass former with a central channel and a spiral thread on its outer surface round which a monel metal wire is wound so as to allow a space of 8 m between the adjacent coils of wire. Water from outer side of the meta or stellar filter candles can only pass through the interstices. To increase the filtering efficiency and to reduce chocking of interstices, filter powder is introduced to form a filter bed around the filter candles in the chamber. The powder is mixed in water and then poured onside the filter

Fig - 4 : Mechanical filter (Stellar filter)




chamber. Water is then pumped by using engine power of the water tank truck or trailer into which are mounted these filters. Under field conditions when regular water points cannot be established, these filters could be used as mobile water plants (10). (Fig. - 4)

## Hardness of water

Hardness of water may be defined as its soap destroying power. It is due to presence of bicarbonates, sulphates, chlorides or nitrates of calcium and magnesium in water. Hardness is undesirable because it wastes soap as stated already, retards washing, causes encrustation of the water carrying system and heating utensils resulting in wastage of fuel and even explosion of boilers, although rarely**(6 - 10).** . Vegetables cooked in very hard water may be less digestible. It reduces the life of fabrics also. Hardness is expressed in terms of milliequivalents per litre (m Eq/L) One m Eq/L of hardness producing ion is equal to 50 mg ($CaCO_3H$) (50 ppm) in one litre of water. Based on this scale the degree of hardness of water is classified as soft water (less than I m Eq/L), moderately hard (1-3 m Eq/L), hard water (3-6 m Eq/L) and very hard water (above 6 m Eq/L). Softening of water is recommended when hardness exceeds 3 m Eq/L. Drinking water should be moderately hard. It has been observed that in some localities supplied with soft drinking water death rates due to arteriosclerotic heart diseases and IHD were higher.

### Carbonate Hardness (Temporary)

It is due to the presence of bicarbonates of calcium and magnesium which can be removed by boiling that drives out carbon dioxide and precipitates carbonates, or by the addition of 60 g of quick-lime to 1000 L of water for each degree of hardness (Clark's process). If hardness is due to magnesium bicarbonate, double this dose is required, thorough mixing and filtration are necessary, as complete sedimentation may not occur even after 12 hours.

### Non-Carbonate Hardness (Permanent)

This is due to sulphates, chlorides and nitrates of calcium and magnesium, which is removed by the addition of a calculated amount of sodium carbonate (Soda ash). In the case of water, which contains temporary hardness as well, use of lime and sodium carbonate will remove both. This is followed by sedimentation and filtration. Base exchange silicious zeolites are used for removing permanent hardness in large establishments. Zeolite is a mineral having a complex formula of Sodium Aluminium Silicate. It exchanges the sodium cation for calcium and magnesium ions of the water. When hard water is passed through Zeolite, calcium and magnesium ions are entirely removed by the sodium ions of the Zeolite. As the filtered water has zero hardness it is mixed in appropriate proportion with hard water before its supply. Regeneration of sodium Zeolite takes place when the so formed Ca and Mg Zeolite is washed with sodium chloride.

### Sodium Chloride

Many waters in the desert and elsewhere contain excessive salt making it undrinkable. Below 1000 ppm of salt, the taste is not appreciable. Sodium chloride can be eliminated from water by condensation or by the ion exchange demineralization process. The condensed water should then be blended with the brackish water in

such proportion that the salt content of the mixture falls below 1000 ppm.

#### Bitter Aperient

Water having them can be treated by the gradual addition of lime at the scale of 2 to 3 kg per 1000 L of water and stirring vigorously. From time to time a small quantity is filtered in a cup and few drops of silver nitrate solution are added to the filtrate. If a brown colour appears the process is stopped. 50 L of raw water is added to precipitate excess lime. After complete settling of lime, water becomes free from aperient action.

#### Other elements

Iron

A trace of iron is almost always present in water. Iron upto 0. 3 mg/L is acceptable. Above that it causes constipation, colic and results in the colouration of vegetables while cooking and staining of linen. It also causes deposits in the distribution mains and reservoirs and leads to the growth of iron bacteria. Iron in water is commonly found as bicarbonates and rarely as oxides and sulphates. Exposure to air causes oxidation of ferrous salt, which makes the water opalescent, discoloured and produces a deposit. The usual clarifying processes and Clark's lime process of softening water remove iron to a certain extent. A special manganese Zeolite removes iron more efficiently.

Fluoride

Its removal is necessary when the concentration in drinking water is more than 1. 5 ppm. The optimum concentration in countries like India where people consume a lot of water should be between 0. 5 to 0. 8 ppm. Fluoride concentration over 1. 5 ppm causes dental fluorosis. A still higher concentration causes skeletal fluorosis. Some Armed Forces Establishments in the States of Rajasthan and Punjab are presently facing this problem of water supply. The excess quantity of fluoride in water may be removed by 'Nalgonda technique'. On the other hand if fluoride content of water is less than 0. 5 ppm fluoridation is necessary for prevention of dental caries.

## Disinfection

Disinfection of water means making it fit for drinking by destroying all pathogenic organisms that may be present in it. To be used in water treatment, an ideal disinfectant must possess the following properties :

(a) It must destroy bacteria, viruses and amoebic cysts in water within a reasonable time despite all variations in water temperature, composition and concentration of contaminants.

(b) It must not be toxic to humans and domestic animals, unpalatable or otherwise objectionable.

(c) It must be reasonable in cost and safe and easy to store, transport, handle and apply.

(d) Its residual concentration in the treated water must be easily, and preferably automatically determinable.

(e) It must be sufficiently persistent so that the disappearance of the residual would be a warning of recontamination.

Boiling is of course the best method of destroying all organisms, but it is impracticable to boil water for urban populations or communities like the Armed Forces in the Field. Moreover, the objective aimed at is not the total sterility of water in a strictly scientific sense but to ensure safe water for human consumption and domestic use by eliminating pathogenic organisms, ova and cysts.

## Chlorination

Chlorine has been found to be very efficient to achieve this objective. Disinfection of water is therefore, usually carried out by the use of chlorine. When chlorine is added to water it forms hydrochloric acid and hypochlorous acid ($Cl_2 + H_2O = HCl + HOCl$). The hypochlorous acid further ionizes to $H^+$ and $OCl^-$ (hypochlorite ion). The disinfection action of chlorine is mainly by hypochlorous acid and partly by hypochlorite ion. Chlorine acts best when pH of water is around 7 because of predominance of hypochlorous acid. When pH exceeds 8. 5 hypochlorite ion mostly acts. Fortunately most waters in India have a pH between 6 to 7. 5. However sporing organisms, protozoal cysts, helminth ova, molluscs, cyclops and cercariae are not affected by the usual dosage. Organic matter or reducing salts deviate chlorine which results in uncertainty of its action. Therefore, for efficient action of chlorine, freedom from such organic matter, resistant organisms and reducing salts is essential. Efficient clarification is, therefore, necessary to render the final results predictable and certain, to economize chlorine expenditure and to estimate the quantity of chlorine needed for water disinfection.

#### Chlorine Demand

0. 5 parts of chlorine per million in well clarified water, free from reducing organic matter is normally adequate to render it safe for drinking after 30 minutes. Thereafter persistence of free chlorine in water is essential as a safeguard against any incidental entry of pathogenic bacteria prior to its actual consumption. Therefore, for effective treatment a concentration of above one part of chlorine in a million parts of water which is procured from a safe source and has been well clarified, is necessary so as to leave adequate residual chlorine after destroying all the pathogenic bacterial fauna. However, the sporing organisms like the welchii group, the protozoal cysts like those of *E. histolytica*, helminth ova, moluscs, cercariae and viruses of infectious hepatitis and poliomyelitis in water require a higher concentration of chlorine maintained over a long time. Water must, of course, be very efficiently clarified to achieve attenuation of these organisms even with such a high dosage.

When estimating the chlorine requirement of water, therefore, the chlorine absorption by oxidizable organic matter and the free chlorine desired after 30 minutes have to be taken into consideration. While the amount of chlorine absorbed by the oxidisable matter is called chlorine demand of the water, the sum of chlorine demand and the amount of free chlorine desired after a

specified time of contact, viz 30 min is the total chlorine requirement of the particular sample of water. The chlorine demand, is therefore calculated by subtracting the amount of free chlorine present from the actual amount of chlorine added to the water. The point at which chlorine demand of water is met is called 'breakpoint chlorination'. If chlorine is added further, it only increases free chlorine.

### Chlorinous Taste

A high chlorine dose creates unpleasant chlorinous taste in water. Initial high organic contamination, imperfect clarification or presence of reducing salts necessitates increase in the 'disinfection dose'. An uncertain dose of chlorine application resulting from a doubtful clarity of the water or the uncertain chlorine content of the unstable bleaching powder used may also result in excessive chlorine application. Free chlorine in the strength of 0. 5 ppm in water is imperceptible; over 0. 5 ppm the chlorine taste becomes faintly noticeable; whilst above 1 ppm a definite chlorine odour and taste are apparent. Chlorinous taste can be prevented by :

(a) Careful selection of a good source of water, which should remain qualitatively constant

(b) Efficient clarification

(c) Administration of a minimum 'disinfecting dose' adequate to permit the desired free chlorine persistence.

### Dosage of Chlorine

Under conditions assuring efficient clarity of water a minimum 30 min of contact with the 'disinfecting dose' and persistence of 0. 2 to 0. 5 parts of free chlorine per million parts of water is considered adequate to achieve health safety with freedom from chlorinous taste. On active service in the field or under less efficient conditions, however, persistence of 1 ppm of free chlorine after 30 min of chlorination is considered as a safe standard. Under worse conditions or in the presence of actual or potential danger of outbreak of intestinal infections 2 ppm persistent chlorine i. e. superchlorination is considered necessary. The period of contact with the disinfecting dose may be reduced to 15 min instead of 30 min when superchlorination is resorted to, and dechlorination should be carried out before consumption of water.

## Methods of Chlorine Application

Disinfection of large quantities of water with chlorine may be achieved by one of the following chlorine preparations :

### Chlorine Gas

In the modern water works application of gaseous or liquid chlorine with the help of mechanical injector called 'Chloronomes' is the method of choice. In this process the charging of the water supply with chlorine, ascertaining persistence of free chlorine content are all carried out automatically. The standard of chlorination to be aimed at when chlorinating through chloronomes with an efficient quality control of water is carried out is the persistence of 0. 2 ppm free chlorine at the consumers' end. This can be achieved by ensuring 0. 5 ppm of free chlorine at the plant provided that the delivery of water is not delayed for more than 6 hours. If quantity of water to be treated is more than 500, 000 litres per day, chlorine gas has been found to be the most economical.

### Chloramination

Chloramines are loose compounds of chlorine with ammonia. They impart less chlorinous taste in water and give a more persistent type of residual chlorine. This prolonged residuum confers the power of long resistance to contamination during the flow of water through the pipe system and hence may be advantageously used in large urban water plants where the pipeline runs for several million meters. Their drawback is that they have slower and inferior action than chlorine.

### Bleaching Powder

Since neither of the above mentioned highly efficient but sophisticated methods can be adopted in less developed urban areas or rural areas or under field service conditions, use of bleaching powder for sterilization of water is resorted to in these situations. Bleaching powder also known as chlorinated lime ($CaOCl_2$) was first introduced for sterilization of water by Horrocks in 1914. It is a white amorphous powder with pungent smell of chlorine. When freshly made it contains about 33 percent of available chlorine. It is, however, very unstable and its chlorine is readily set free by the action of moisture, $CO_2$, heat, light, and possibly even by continued vibration sustained during long journeys. As a result it has been frequently delivered in the field with very scanty chlorine content. Estimations to determine the amount of available chlorine in each tin of bleaching powder has to be made before dosing the water involving considerable labour and much error. Bleaching powder is also difficult to introduce in accurate doses into large quantities of water, leading to further error in the dosage and finally to taste trouble. Bleaching powder is stored in corrosion free containers made of wood, ceramic or plastics.

### Water Sterilising Powder (WSP)

Bleaching powder is considerably improved in its keeping quality by the addition to quicklime in the proportion of 80:20 when it is known as water sterilising powder. Its available chlorine should not be less than 25 percent. WSP is usually used for disinfection of water under field service conditions. It is an ASC Store item supplied by the Supply depot (POL Sec) along with Hygiene chemicals in packs of 50 g, 100g, ¼ kg, ½ kg, 1 kg and 25 kg. WSP is soluble in about twenty times its weight of water, yielding an insoluble precipitate consisting mostly of Calcium Hydroxide $Ca(OH)_2$, silica etc. This settles quickly, if too thick a paste is not made; otherwise a gelatinizing action takes place and great difficulty in settling is encountered. It is not necessary or desirable to grind or break up the lumps thoroughly and too much agitation is detrimental to prompt settling. 500 g of WSP mixed with 5:1 water contains approximately 2. 5 percent available chlorine if the powder is of 25 percent strength. Chlorine solution can maintain its strength for weeks if properly corked in

brown bottles.

## Agents Other than Chlorine

### Ozone

It is a powerful oxidizing agent. It removes undesirable odour, taste, colour and organic matter. It even inactivates viruses in a few seconds and hence can be used most advantageously for destruction of enteropathogenic viruses. Since ozone decomposes and disappears within short time there is no residual germicidal effect. Hence, a minimal dose of chlorine may be added to the ozonised water before distribution. In this combined treatment, the two methods complement each other. The ozone dosage required for potable water treatment varies from 0. 2 to 1. 5 mg per litre. Ozonisation of water is presently practiced in the advanced countries. The combination of ozone for pretreatment while providing some disinfection, to be followed by chlorination, has become a popular sequence in Europe and is beginning to be used in USA to reduce the level of trihalomethanes in finished water.

### Ultraviolet Irradiation

Germicidal effect of this method is limited due to its expense, non-residual germicidal effect and its somewhat lesser effect in presence of turbidity. A mercury vapour arc lamp emitting invisible light of 25-37 Angstrom units applied to a water free of light absorbing substances, particularly suspended matter that will protect microorganisms against the light, is a useful method of disinfection used in the Soviet Union.

### Other Halogens

In view of the formation of organochlorine compounds by chlorine which are either known or suspected carcinogens, many chlorine alternatives such as bromine and iodine substances are receiving renewed interest. These substances for the present, however, do not seem to be a viable alternative to chlorine.

## Chlorination on Field Service

Practice of sterilizing water adopted on field service and in some semi-permanent or even a few permanent camps where chloronomes are not available, is by use of WSP, added manually or by dosers. The standard procedures in the field are 'chlorination' and 'superchlorination,

The 'chlorination' aims at obtaining 1 part of free chlorine in a million parts of water after half an hour's contact. The quantity of water sterilizing powder required is estimated by Horrocks' test. The number of scoopfuls (of two grammes) of water sterilizing powder required to chlorinate the given quantity of water are calculated and added to water. The water must be allowed to stand at least 30 min after addition of the requisite amount of WSP before it is taken into use.

Superchlorination' of water aims at obtaining the free residual chlorine of 2 parts per million parts of water. This is achieved by adding one scoopful of water sterilising powder per 500 l of water more than that required for 'chlorination'. A contact of 15 min instead of 30 min is allowed. This method of treatment is adopted when efficient clarification is not possible; safety of source and initial purity of water is doubtful; outbreak of any water-borne disease is threatened; or water is required for use in a very short time.

Superchlorination by a 'fixed dose' of 4 scoopfuls of WSP per 500L of water is carried out when the clarity of water is doubtful and the Horrocks box is not available 30 min contact is allowed before consumption.

In all these processes the required amount of water sterilising powder is first mixed in a little water and made into a strong solution in a bucket and then this solution is evenly added to the whole bulk of the water to be treated and mixed thoroughly. The cadmium iodine starch colour test is then carried out at the end of 30 min for chlorination and 15 min for superchlorination. If a blue colour is not obtained, one scoopful of WSP per 500 L for chlorination and two more scoopfuls per 500 L for superchlorination must be further added to the water. After mixing and allowing a 30 min or 15 min lapse as the case may be, the colour test is repeated. Except in water containing schistosome or cercariae, these doses should not be exceeded.

### Dechlorination

It may become necessary to remove the chlorinous taste after superchlorination. This is done by adding 2 tablets of 0. 5 g each of sodium thiosulphate (taste removing tablets or TRT) per 500 L of water. A contact with chlorine for a minimum of 15 min should be allowed before dechlorinating, but preferably contact time should be prolonged as long as possible until just before the consumption of water. The danger of a premature use of the taste removing tablet and its use in un-superchlorinated water must be appreciated and guarded against.

Sometimes rain water or water recently polluted with organic matter contains ammonia, which forms chloramines on the addition of water sterilizing powder. Chloramines are not deviated by organic matter as chlorine is and hence give the blue colour even in the presence of oxidisable organic matter when a cadmium iodide starch indicator solution is added. Moreover, there will be a lag in disinfection owing to the slower bactericidal action of chloramine. Therefore, while superchlorinating water of this nature it is better to extend the contact time to a minimum of 30 min or even more.

### Prechlorination and Rechlorination

Sometimes prechlorination has to be employed before filtration of water by a water tank truck in order to decrease the organic matter load on the filters and to reduce its subsequent chlorine demand, specially in a newly occupied area in field service. At times the chlorinated water obtained from local civil sources needs to be rechlorinated before consumption by troops if there is a longer lapse of time between chlorination and consumption.

### Horrock's Test

The object of this test is to determine the quantity of the

particular sample of WSP required to sterilize any particular sample of water. The test is carried out by means of the 'case water testing sterilization' (HORROCK'S BOX). The Horrock's box contains six white cups of 200 ml capacity each and one black cup of 240 ml capacity; two metal scoops, each of which holds 2 g of WSP when filled level with the brim; a bottle of stock cadmium iodide-starch solution; a bottle containing 85 ml of 50 percent glacial acetic acid; 25 sodium thiosulphate tablets 100 mg each; six glass tubes; and four glass stirring rods. The test should be carried out while the water receptacle is being filled with clarified water(10).

A standard solution of the particular sample of WSP is prepared in the black cup. First a thin paste with one level scoopful of the WSP and a little clarified water is made and then gradually more water is added up to the mark on the inside of the cup and the mixture is stirred with a clean glass rod. The lime in suspension gradually settles down.

The six white cups are then filled with clarified water to within half a centimetre from its top.

Drops of the standard WSP solution from the black cup are added to each of the white cups by the pipette, so that the first cup receives one drop; the second cup receives two drops and so on serially increasing until finally the sixth cup receives six drops. One drop represents one part of chlorine in a million parts of water when added to the white cupful of water. The pipette must be held vertical when delivering the drops.

The contents of each cup are stirred with a clean stirring rod, starting at the first cup, and allowed to stand for half an hour, shading them from sunlight.

After that time three drops of the starch-cadmium iodide indicator solution are added to each cup from the drop bottle and stirred with a clean stirring rod.

Some of the cups will show a blue colour. This indicates that the water in those cups contains one or more parts of chlorine per million parts of water.

The serial number of the first of the cups showing definite blue colour indicates the number of scoopfuls of the particular sample of water sterilizing powder required to sterilize 500 L of water and to leave 1 PPM of chlorine after chlorine demand of that sample of water is satisfied during half an hour contact with chlorine.

For example, if cups 3, 4, 5 and 6 show a definite blue colour, then three scoopfuls of WSP are required to sterilize 500 L of the particular water sample and leave I ppm residual free chlorine after half an hour contact. If superchlorination is indicated one more scoopful of WSP per 500 L of water is required to be added. This will give 2 ppm of free chlorine in water after 15 min contact. In the example given above a total of 4 scoopfuls of WSP per 500 L will be needed for superchlorination. The WSP used for chlorination or superchlorination should be from the same tin from which the WSP for Horrock's test was used.

An indicator solution is made by first preparing a uniform paste of 1. 5 g of starch in 25 ml of distilled water and then adding it slowly to 75 ml of boiling distilled water and continually stirring it while, still boiling for the subsequent 15 min. After cooling, 7. 5 g cadmium iodide is added to the mixture and dissolved by shaking. In an emergency potassium iodide may be used if cadmium iodide is not available. The solution should be stored in a well-corked dark brown bottle in a dark and cool place. The keeping quality of the solution is enhanced by the addition of 1 ml formalin to this solution.

### Test for Chlorination Control

A control must be kept on chlorination by a regular examination of the treated water to make sure that the requisite amount of free chlorine has persisted in the water for the requisite time. This can be done by means of starch-iodide, thiosulphate with starch-iodide, orthotoluidine, orthotoluidine arsenite or neutral red.

#### Colour Test

Fill a white cup with chlorinated water to be tested and stir into it 10 drops of fresh cadmium-iodide-starch indicator solution. If there is one or more parts of free chlorine in million parts of water a blue colour will appear. In this test the residual chlorine replaces iodine and combines with cadmium radicle; iodine so released combines with starch and turns it blue.

#### Thiosulphate Test

Make a solution of 300 mg of sodium thiosulphate (100 mg-3 tablets) in a white cup full of clarified but unchlorinated water. Add this solution drop by drop with a glass pipette to the cup in previous para and continually stir until the blue colour just disappears. The number of drops of thiosulphate solution required divided by 10 approximately gives the parts of free chlorine in a million parts of the chlorinated water.

#### Orthotoluidine (OT) Test

This test carried out with the 'Comparator type of apparatus' (Lovibond Comparator) indicates chlorine below 1 ppm. It is used in peace stations, cantonment and garrison water supplies. A fixed amount of orthotoluidine solution is added to a specific quantity of the water in a standard glass cell or tube. The yellow colour, which develops, is matched against tinted glass discs. The immediate (flash) reading shows the free chlorine and that taken after 5 min (delayed) gives the combined content of chloramines and free chlorine. In the absence of the Comparator, the appearance of yellow colour on the addition of orthotolidine to a white cupful of treated water shows the presence of free chlorine without any indication of the proportion thereof.

#### Orthotoluidine Arsenite Test (OTA)

It is a modification of OT test. Certain interfering substances such as nitrates, iron, managanese etc which when present in water also gives yellow colour with orthotoluidine. The OTA reagent overcomes this drawback and hence gives better determination of free and combined chlorine separately.

#### Neutral Red Test

This reagent can be used as a tablet or as a 0. 03 percent solution in 50 percent glacial acetic acid. This has a purple

red colour. This colour is bleached to a light yellow tinge by a chlorine concentration of two parts per million parts of water. The method therefore only indicates superchlorination. Superchlorination by the 'fixed dose' method without Horrock's test is resorted to when this reagent is employed. It does not indicate the extent of chlorine demand of a sample of water or available chlorine in WSP, as is done by the Horrock's test. The actual method is as follows :

(a) Add 4 scoops of WSP per 500 L of water, stir well and wait for 15 min.

(b) Fill the white cup with chlorinated water and crush one neutral red tablet or add one scoop of solution to it.

(c) If the water becomes colourless or yellowish after one minute it is safe for drinking. If it is still red, add 2 more scoops of WSP per 500 L and repeat the test after 15 min and repeat the process until the test shows bleaching of neutral red.

(d) Add 4 taste removing tablets for every 500 L of water before consuming.

#### Chlorine Content in WSP

The chlorine content of a WSP sample is determined by either the Penot's arsenite test or by the thiosulphate test. A mixture of 10 ml of 1 percent WSP solution and 10 drops of fresh cadmium-iodide-starch indicator solution is taken in a beaker. The neutralizing reagent is then slowly run into it from a burette. The neutralizing reagent in Penot's test is a 0. 5 percent sodium arsenite solution which is prepared by dissolving 0. 5 g of arsenious oxide ($As_20_3$) and 2. 5 g of sodium carbonate ($Na_2CO_3$) in 100 ml of distilled water. In the thiosulphate test it is a 2. 48 percent sodium thiosulphate solution. The ml of neutralizing reagent required to decolourise the blue WSP indicator solution mixture multiplied by 3. 55 indicates the percentage of chlorine in the WSP sample under test. These tests require well-equipped laboratories and therefore cannot be carried out in field service.

A rough and ready field test can be carried out by the use of the Horrock's Box. A WSP solution is made by mixing one level scoopful of the WSP powder to be tested in the black cupful of clarified water. One scoopful of this solution is mixed with a scoopful of cadmium-iodide indicator solution in a white cup and a tablet of acid sodium bisulphate is added to it. The 0. 05 percent neutralising reagent is prepared by dissolving a 100 mg tablet of sodium thiosulphate in a white cupful of water. Scoopfuls of this solution are added to the blue mixture of indicator-WSP solution and stirred. The number of scoopful of the thiosulphate solution added until the blue colour first disappears indicates the percentage of chlorine in the WSP under test.

### Water Supply in the Armed Forces

The water supply for the Armed Forces is organized at various levels of echelons according to facilities available, with various grades of refinements in clarification and chlorination depending on the situation and availability of resources. All efforts should be made to avoid deficiencies in supply, such as the following:

(a) Pollution of the source

(b) Inadequate treatment

(c) Cross connections with sources of contamination

(d) Inadequate capacity resulting in low pressure

(e) Inadequate operation of the facilities

(i) inadequate disinfection

(ii) failure to provide standby facilities in the event of power or other equipment failure.

After floods, when water supply distribution system remains intact, the pressure in the pipelines should be raised so as to prevent polluted water from entering the pipes. Superchlorination is also an additional measure. Pipelines are routed alongside roads or public ways to facilitate inspection (for detecting leakage, unoperative valves, damage etc.) and to provide ready access for maintenance and repair. The most common pipe materials are cast iron (CI), ductile iron, steel, asbestos cement (AC), polyvinyl chloride (PVC), and high-density polyethylene (PE). General guidelines on sanitary control on water supply, its supervision and water quality surveillance are being given in subsequent paragraphs. Medical Officers are also advised to refer to standard manuals for detailed references (6, 11, 12).

#### Cantonment Water Supply

In Military cantonment and permanent garrisons well established permanent water works function under the management of the State or Central PWD. In some permanent garrisons where Cantonment Boards do not exist, similar water plants are established under the jurisdiction of the MES. Usually the sources of water supply are streams or deep wells. Clarification of water is carried out by sedimentation, first without and later with flocculation, followed by filtration. Large reservoirs for holding raw water, masonry or concrete settling tanks, slow or rapid sand filters and high level reservoirs for holding finally treated and chlorinated water ready for delivery are created. Chlorination or Chloramination is carried out with gaseous or liquid chlorine by chloronomes. Delivery of treated water from the overhead or high level reservoirs is through pipes. Quality control is maintained by regular chemical and bacteriological examinations and automatic orthotouidine testing and recording. The delivery of water to Armed Forces units may occasionally be through the unit or centralized station transport.

#### Garrison Water Plants

In semipermanent camps at the Corps HQ or Com Zone bases in field areas, the MES establishes central water points. Generally sedimentation with flocculation is carried out in masonry tanks. Chlorination by gaseous or liquid chlorine is usually the method of choice but sometimes it is carried out by either bleaching doses or manual application of WSP depending on the nature and duration of stay of the garrison. The sources of water have to be much more carefully selected as filtration is not

usually possible. Quality control is ensured by initial chemical and bacteriological examination repeated whenever the quality of raw water is likely to change. The Horrock's test is regularly carried out to assess the WSP requirements. Orthotolidine testing of water and recording is carried out every time the fresh quantity of water is chlorinated. Delivery of water may be through pipes, but quite commonly it is through unit or station transport.

#### Central Field Water Points.

In forward areas the MES or Corps of Engineers establishes various grades of 'central water points' at the Divisional and Brigade levels. The sources are most meticulously selected from the hygienic point of view and for the initial clarity of water. Purity of water and protection is ensured by fencing, policing and imposing strict prohibitory orders against the entry of unauthorised persons. The sources are the streams, deep wells or natural springs. For clarification and chlorination, masonry tanks can be constructed at the Divisional levels but usually the canvas tanks are used. Filtration is normally not feasible and only the sedimentation with flocculation is relied upon. If for any reason e.g. in mobile warfare it becomes impossible to establish a static water point, only the filtration without sedimentation may be carried out centrally, provided that the water tank trucks fitted with large size stellar or metafilters are available. Chlorination is carried manually with WSP after determining the quantity required. The Horrock's test is mostly carried out daily. Quality control is maintained by a colour test but the cadmium iodide-starch solution or the orthotolidine test is carried out every time the delivery tank is filled and chlorinated, but not earlier than half an hour after chlorination. Water is collected by units in water tanks or lorries with metal or improvised canvas tanks hoisted on them. Chlorination may be carried out at the units instead of at the central water point. If the quality of raw water shows wide fluctuations, superchlorination is preferable with dechlorination carried out just before consumption but not earlier than 30 minutes after adding WSP.

#### Unit Water Points

When central (Divisional or Brigade) water points are not feasible or when units are located at a long distance from such water points, water is collected, clarified and chlorinated under unit arrangements. Normally springs, wells or streams are used as sources. The selection of a source and collecting point has to be on much more rigid standards. The MO is required to exercise utmost caution in accepting the particular source. Checks on alternative sources should also be carried out. If water tanks with a meta or stellar filter are available they are used to collect and filter water. Otherwise, water is clarified in canvas tanks or CGI drums by flocculation. Chlorination is carried out by WSP after daily assessment of the required WSP dose. Quality control requires strict supervision and is carried out by a colour test or orthotolidine test.

#### Sub-Unit Arrangements

When such unit water points are too remote e.g. detachment and piquets, water is collected from clear reliable sources such as springs or wells in small containers like pakhals, drums or canvas tanks and manually superchlorinated after the Horrock's test, or by 'fixed dose method' if a Horrocks' box is not available, and is tested by the colour test. Dechlorination may be carried out just before consumption. Training needs to be given to personnel in its adoption.

#### Individual Water Sterilization

When troops have to rely solely on individual resources on piquets, patrols, reconnaissance or trekking , water from as clean a source and spot as possible is taken in water bottles, chaggals or buckets and super chlorinated with WSP by the fixed dose method or by the use of an individual water sterilizing outfit.

#### Arrangements While on the March

On a long march when a long halt is contemplated, a staff officer accompanied by an engineer officer and water duty personnel, medical officer and sufficient regimental police personnel should be sent forward to select halting grounds near a good source of water. They should arrange for the purification and chlorination of the water supply and take measures for its protection until the main body arrives. Thereafter systematic distribution to units/sub-units should be arranged. In movements by rail, troops must not use water supply without authority from a Railway Transport Officer.

### The Field Water Point

On active service in the field, water points are organized under the administration of the Corps of Engineers. The medical services in the field collaborate with the field engineers in the selection of a proper water source and water collecting point. The responsibility of ensuring the initial quality of raw water, recommendation on processes to be adopted for clarification and the dose of chlorination required is that of the Medical Services while the achievement of the Medical recommendations and quantity to be provided rests with the engineers. Medical services are also responsible to check the quality of water and standard of chlorination from time to time and advise on measures to be adopted for achievements and maintenance of the quality of water. The field water points is organized as under: -

(a) The sources of supply are usually a stream or well. The banks of streams or lakes should be suitably earmarked for drawing water for various purposes and indicated by different flags e.g. white for drinking-water, blue for watering animals and red for bathing or washing of clothes and animals in that order from upstream downwards (Fig.5).

(b) If water is obtained from springs, they should be bricked in and trapped. If a well is used as a source of water it should be properly constructed and maintained.

(c) Methods of water treatment adopted at the field water point are the sedimentation followed by chlorination or super-chlorination. The processes are generally carried out in 6000 L canvas tanks.

(d) The tanks should be raised on a properly laid gravel, clinker or stone base, which is properly drained.

(e) The raw water is either pumped or led by gravity into one or more canvas cisterns for sedimentation.

(f) Entry and exit roads, adequate drainage, fencing to protect the tank area, and military police or guards should be provided. Protection and policing of the whole water supply area from the moment the campsite is selected is absolutely essential.

(g) The treated water is delivered into unit water tanks or receptacles by hand or mechanical pump.

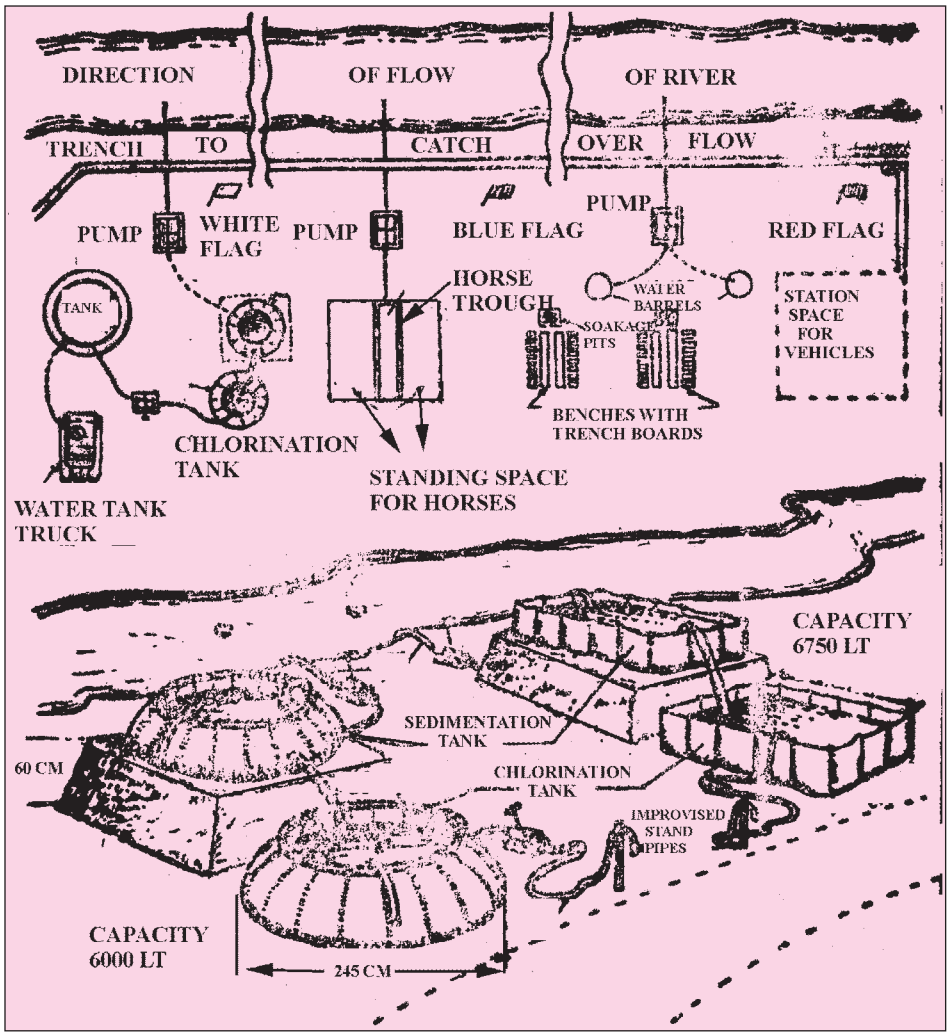
(h) The process of purification of water should be efficiently carried out under the constant supervision of a trained officer/JCO of the Corps of Engineers and checked by an Officer of the AMC. The Horrocks' test and colour test (orthtoluidine test) should be carried out by an AMC NCO trained and deputed specially for this purpose. Water duty personnel of the Field Coy Engineers or other unit organizing the water point must also be specially trained . The details of the process of water treatment is as under (Fig. 5)

Canvas cisterns should be arranged in as many sets as required to meet the water requirement, Each set should have 2 to 3 cisterns as decided to use for the water treatment. One cistern is used for sedimentation with flocculation and the second for chlorination and delivery. When available, the third may be used for storing water pending delivery. When water is more grossly turbid, the first tank may be used for sedimentation of coarse debris, flocculation is carried out in the second tank and chlorination in the third tank.

The first cistern of each set is filled with water to within 8 cm of the brim by a pump. For flocculation, 35g alum or alumino ferric per 1000 L of water is added as a coagulant. This is first dissolved in a bucket of water and the solution is distributed evenly throughout the water in the cistern. If the water is very turbid, upto 70 g per 1000 L of the coagulant may be necessary. Alternatively, a sandbag containing the requisite amount of crushed coagulant may be tied over the mouth of the delivery pipe so that water flows into the cistern through the bag.

The contents of the cisterns are then well stirred for a few minutes and allowed to stand for two to four hours or until the suspended particles have settled to the bottom leaving the supernatant water clear.

Fig - 5 : Layout of water points




If flocculation does not begin within a few minutes, the addition of lime (half the quantity as that of alumino ferric added) will produce flocculation and sedimentation.

The clarified water is then transferred to the next cistern either by pumping or by siphoning, care being taken not to disturb the sludge at the bottom of the setting cistern. A simple plan is to lash the hose pipe of the pump or siphon to a post near the cistern so that the intake end of the hose pipe is 15 cm above the floor of the cistern, or tie an empty sealed tin to it so as to serve as a float.

A sample of the clarified water should be taken and the Horrocks' test started just as the clarified water starts pouring into the tank.

The amount of WSP required is made into a thin paste with a litre or so of clarified water in a bucket and more water gradually added until the bucket is full of an even solution of WSP.

This is then evenly added to clarified water in the second cistern. If superchlorination is desired one more scoopful of WSP is added per 500 L of water.

The water is well stirred and allowed to stand for half an hour, or fifteen minutes if superchlorination has been carried out.

At the end of this time a sample of the chlorinated water is tested by the colour

test in a white cup. If a blue colour does not appear, the water is not safe to drink until sufficient additional WSP has been added to give a blue color after a further half an hour.

Dechlorination is carried out by adding two taste removing tablets per 500 L before consumption of water.

(j) Delivery of water to units should be made in their unit transport by pumping it in and not by manual lifting. The approach and exit to the water point should be free from dust and slush and made hard by coping or paving the paths. The water tank fitted in the lorry should be always cleaned and washed before receiving water in it and periodically sterilized by chlorine.

**The Water Tank Truck**

The water tank trucks, lorries or trailers equipped with mechanical filters are used in forward areas by forward formation and units whenever central water points cannot be established under the arrangement of the field engineers. By the judicious use of a water truck very often water from otherwise satisfactory local sources can be easily purified instead of obtaining it form the central water point situated several miles away. The essential functional parts and equipment on the truck or lorry are the water tank of varying capacity; the mechanically (or sometimes manually) operated pump; a pair of mechanical filters equipped with meta or stellar filter candles; water proof and leak-proof suction hoses on the farther end of which are carried the float and strainer. The filters are the most important equipment fitted one on each side of the front of the tank and connected to the pump. These filters have already been discussed.

**Chlorination in Small Containers in the Field**

When detachments are separated from the main bodies, the clarification of water to any great extent will not be possible. After short period of sedimentation by flocculation if possible, in small containers, it is chlorinated, or more commonly superchlorinated as under

In Pakhals, Buckets, Petrol Tins

The number of scoopfuls of WSP as indicated by the Horrocks' test should be mixed with clarified water in the black cup from the Horrocks' box. For supercholorination one extra scoopful of WSP should be added. The cup is filled with water upto the mark, stirred and allowed to stand until the chalk powder in suspension settles. One scoopful of this stock solution per 5 l of water will be required. The treated water is allowed to stand for 30 min before consumption. When superchlorination is carried out , dechlorination may be carried out before consumption but not earlier than 15 min contact. For this purpose the thiosulphate solution is prepared by dissolving two taste removing tablets( 1 g) in the black cup which is filled to the mark. One scoopful of this solution per 5 l of superchlorinated water is added. When Horrocks' box is not available a stock solution of 16 scoopful of WSP should be made in a water bottle. One scoopful of this stock solution to every five liters is required. For dechlorination dissolve 16 thiosulphate tablets in another water bottle full of water. One scoopful per 5 L of this is added after it has had 30 min contact with the chlorine or just before consumption.

In Water Bottles

**(i) By Individual Water Sterilising Outfit**

This aims at achieving superchlorination by a fixed dose. In the tin there are two bottles. Fifty sterilising white tablets, each containing 0.2 g of a mixture of 7.5 per cent halogen(para-sulphondichloramino-benzoic acid), 10.5 per cent anhydrous sodium carbonate and 82 per cent anhydrous sodium chloride, are continued in one bottle. Fifty taste removing blue tablets, each containing 0.1 g of a mixture of 85 % of sodium chloride and 15 % anhydrous sodium thiosulphate, are contained in another bottle. The bottles should be kept tightly corked when not in use and the tablets should only be taken out of the bottle when actually required for sterilizing water. One sterilizing tablet added to the full water bottle ensures 4 parts of chlorine per million parts of water. A minimum of 30 min contact is necessary to ensure sterilization. The longer the period of contact the better it is. The water bottle should be well shaken two or three times during this period. One taste removing tablets may be added to the bottle and the bottle well shaken before consumption of water but not earlier than 30 min after the addition of the white tablets.

(ii) Water sterilising powder

When the 'Individual Water Sterilizing Outfit' is not available, a stock solution of WSP should be made by adding to a water bottle full of water the number of scoopful of water sterilizing powder as indicated by the Horrock's test. For superchlorination add to the stock solution one scoopful more WSP than indicated by Horrock's test. If a Horrock's box is not available a fixed dose of four scoopful of WSP should be used to make a stock solution in the water bottle. One scoopful of this stock solution should be added to each water bottle. At least 30 min contact should be allowed before consumption. For dechlorination after superchlorination one scoopful of taste removing solution made by adding 4 TRT to a water bottle should be added to each water bottle before the actual consumption of water.

(iii) Aquatabs

Recently, Aquatabs (Bayer) have been included in the hygiene chemicals. The active ingredient is Sodium dichloroisocyanurate (Na DCC) (3.5 mg Tabs). One Tablet is added to the water bottle of capacity one litre and takes 30 minutes for the effect to build up. These tablets release limited amount of chlorine in the form of HOCl depeding upon the level of contamation and hence always maintain a baisc level of residual chlorine in water (13).

**Summary of Field Appliances**

(a) Water Bottle

Its capacity is 1.14 L

(b) Chagul

It is a bottle shaped receptacle of 4.5 or 9 L capacity. They should be well soaked before use. The contained water is cooled by evaporation from its surface.

(c) Pakhal

It is a zinc, or zinc coated, metal tank with a large brass screw on cover. It is oblong in shape and is covered with felt, which can be soaked for cooling the contents. Over the felt is a stout net and it is designed essentially for pack transport. Mule pakhal (cistern mule) has about 30 L capacity. Camel pakhal (cistern camel) has a capacity of about 60 L.

(d) Canvas Cisterns ( 225 and 450 L)

These are cubical with a lid and a tube delivery pipe. The cistern is usually supported in a collapsible wooden iron frame. They are most useful for small units and detachments.

(e) Iron Cistern (1820 L)

This is a normal size water cistern for small storage made of 5 sections of standard square steel plates. Larger sizes are made by adding more standard sections as required. Such tanks are usually painted red for preservation. For cooling they should be painted white or heavily white washed on the outside.

(f) Galvanized Cistern ( 225 and 450 L )

These are cubical cisterns, which may or may not be fitted with a lid and / or a draw-off cock.

(g) Canvas Cistern ( 6000 L)

These are used for water points in the field. In dusty areas, covers should be provided. The normal method is to use these tanks in pairs, one for sedimentation and the second for chlorination of the clarified water siphoned from the first. A third one may be used either for storing chlorinated water pending delivery or for initial gross sedimentation before flocculation is carried out in the second sedimentation tank.

(h) Circular Canvas Cisterns

These are 5500 L capacity with a kapok collar which rises as the cistern fills.

| Well (circular) |
|---|
| Depth of water X square of diameter X 785 = liters of water in the well. |
| Well (rectangular) |
| Depth of water X length X breadth X 1000 = liters of water in the well. |
| Unit of measurement : Meters |

(j) Water tank Truck

This consists of a 9900 L (working capacity 9000 L) tank mounted on a standard motor truck, provided with a mechanical force pump driven from the truck engine. Water is clarified by means of mechanical filter( meta or stellar filters) aided by alum or keiselguhr coagulant. Disinfection is carried out by chlorination or super chlorination.

| Yield per hour |
|---|
| Difference in two levels x square of diameter x 785 divided by the number of hours = yield of water in liters per hour. |

**Estimation of Yield**

Yield per hour

(a) Lower the water level rapidly by pumping out

(b) Measure water level from top of the well in meters

(c) After a few measured hours, measure the water level from the top again

Stream

Select 100 m length where the channel is uniform and where there are no eddies. Take the average breadth and depth in three or four places. Drop a chip of wood and find the time in seconds it takes to travel a measured distance which when divided by the time in seconds gives the surface velocity per second. 4/5 of this is the mean velocity of the stream. This multiplied by the sectional area in meters x 1000 gives the yield per second in liters.

## Surveillance of drinking water quality

Drinking-water supply surveillance is "the continuous and vigilant public health assessment and review of the safety and acceptability of drinking-water supplies" (WHO, 1976). This surveillance contributes to the protection of public health by promoting improvement of the quality, quantity, accessibility, coverage, affordability and continuity of water supplies (known as service indicators) and is complementary to the quality control function of the drinking-water supplier. Drinking-water supply surveillance does not remove or replace the responsibility of the drinking-water supplier to ensure that a drinking-water supply is of acceptable quality and meets predetermined health-based and other performance targets.

Surveillance is an important element in the development of strategies for incremental improvement of the quality of drinking-water supply services. It is important that strategies be developed for implementing surveillance, collating, analysing and summarizing data and reporting and disseminating the findings and are accompanied by recommendations for remedial action. Follow-up will be required to ensure that remedial action is taken.

It is appropriate for the drinking-water supply surveillance agency to carry out independent testing of water supplies and assess findings and report to and advise suppliers and communities.

**Surveillance of drinking water quality in a military station**

**1. Initial Baseline Survey**

Population characteristics

(a) List the units/Ests in the area of responsibility

(b) Divide the area into five sectors with the strength of troops and families.

(c) Prepare a layout map showing the five sectors with markings for units/ests and population density.

(d) Calculate the quantity of water required in each sector and the quantity supplied to find out the deficiency, if any.

Layout map of water supply system to include both the civil water works and the MES pumping stations.

(a) Mark the location of the civil water treatment plant, the major reservoirs/sumps, chlorination facilities available, Overhead reservoirs, the major pipe lines and the units/establishments being supplied.

(b) Similarly for the MES pumping stations mark their locations with chlorination facilities at each of these stations, if any. Identify the Major sumps with rechlorination facilities, the overhead reservoirs, the major pipelines and the units/establishments supplied pump house wise.

Initial sanitary survey of the following should be carried out

(a) Source stations

(b) Treatment facilities

(c) Layout of the major pipelines to identify

(i) Leakages

(ii) Sewage line cross connections

(iii) Deliberate break in lines

(iv) Water lines crossing the drains

(d) Any unauthorised source(s) being used by the units.

**2. Surveillance of supply system**

Civil Water Works

Liaison with PWD and CMO should be carried out and the civil water works should be visited at least once a quarter by the Officer Commanding Station Health Organisation (OC SHO).

Main sump/reservoir in which water supply from civil is received.

(a) Once a month by the health staff

(b) Once a quarter by the OC SHO.

MES Deep Tube wells

Each tube well along with storage and chlorination facility should be checked once a week in rotation as per plan ( 5 sectors) by the Health Inspector. Chlorination at pump and bleaching powder will also be checked besides chloronomes and dosers.

Water supply lines

Daily in rotation in the concerned sector so as to cover the enire area once in a week. Check for leakage /breakage /potential contamination by sewage. This should be done daily by the health staff, and once a week by the OC SHO. It should be planned in such a way that the entire area is covered by the health staff once a week and by the OC SHO once a month.

**3. Surveillance of water purification efficiency**

Free residual chlorine check

Consumer end points will be identified at least 2 fixed and 2 random end points in each sector (Total 20 points in entire area.) Identification of these points will be in a way that each source (6x MES pumps and 1 x civil source) is covered at these end points.

Free residual check at each sector by unit RMO should be carried out daily (results to be obtained by OC SHO on telephone).

Free residual check at railway stations at least once a week on the day when the concerned sector is being checked.

Once a week free residual check from the station swimming pool, the day on which sector coverage falls.

Bacteriology

Water samples from consumer end points- sector 1 Monday of First week/ sector 2 Monday of second week and so on till sector 5 on Monday of fifth week. Once a month last Friday from swimming pool. Minimum of 250 ml of water sample collected with aseptic precautions should be sent to the local MH lab and liaison should be done with the pathologist to ensure correct interpretation of the results.

Chemical analysis should be carried out on the following occasions

(a) on initiation of a new water source

(b) evidence of contamination on bacteriology/ Free chlorine check

(c) Any other situation decided by SHO

(d) Samples as per laid down procedure by AFMC

Water Poison detection

(a) Kit to be kept in readiness

(b) On as required basis in consultation with SEMO and Stn cdr

**4. Warning points and controls**

(a) If free residual chlorine is <0.2 ppm at any consumer end, inform MES and Station HQ on telephone to ensure chlorination and OC SHO should visit the source pump.

(b) If free residual chlorine is <0.5 ppm at any source pump, intimate GE and call for special joint inspection.

(c) If water bacteriology is 'suspicious', inform MES on telephone to bring chlorine level to 1 ppm, and repeat bacteriology.

(d) If 2nd sample also suspicious or any sample 'Unsatisfactory' ask for immediate joint inspection with GE and station HQ staff; and superchlorinate immediately.

(e) If any potential of cross contamination of water seen, immediately inform GE, CWE, Station HQ and SEMO, ask for immediate joint inspection and urgent repairs.

**5. Cleaning and Maintainence**

(a) Cleaning of OHT/Reservoirs should be done once in six months by MES; and certified by OC SHO

(b) All OHT/reservoirs to be kept covered, this should be checked by SHO and implemented by MES

(c) Any cross connection or leakage of water supply lines to be immediately repaired by MES in 24 hrs and certified by SHO as repaired. Instructions for repairs to be issued by Station Commander.

**6. Joint Inspection**

(a) Once a week a joint inspection of the water points should be carried out by SHO staff, Staff of GE and rep of Stn HQ

(b) Once a month a joint inspection of the water points should be carried out by OC SHO, GE and Adm Comdt.

(c) Emergency joint inspection if contamination suspected.

**7. Records**

(a) Spot map showing various sectors, Units, water sources, sumps, OHTs and major water pipe lines.

(b) Register of daily free chlorinechecks by SHO

(c) Register of daily free residual chlorine check by RMO

(d) Bacteriology register and file

(e) Chemical analysis register and file

(f) Water poison test register

(g) register of joint inspections

(h) Record of cleaning of OHTs

(j) Record of Station Quarterly Health Committee meeting and Antimalaria meetinh (points of water surveillance to be reflected)

(k) Station plan of sectorwise check of Free residual chlorine and Bacteriological tests.

(l) Water correspondence file.

## Swimming Pool

A swimming pool is an artificial structure where water volume per swimmer is relatively small. The water is thus exposed to contamination by ammoniacal and other organic substances as well as organism from skin, nasopharynx and other orifices of the swimmer. The health hazards associated with swimming in these pools are usually fungal, viral and bacterial infections of the skin, eye, ear, nose, throat and upper respiratory tract, intestinal tract and so on. Proper maintenance of pools is, therefore, of vital importance. General guidelines on sanitation of swimming pool are being given in subsequent paragraphs. Further details are available in standard texts (14).

A continuous inflow or a daily change of water, though ideal, is usually not feasible. The modern pools are equipped with continuous filtration and chlorination system. The "fill and empty" system is also encountered. Considerable attention is thus necessary to ensure that water is maintained continuously in a pure state in such pools. If the water is turbid provision for sedimentation in a separate settling tank may become inescapable. The water must be renewed at least once a week and 10-15 percent of the water should be replaced by a fresh daily inflow. When the pool is emptied, the floor and the sides should be thoroughly scrubbed and lime washed. Addition of copper sulphate 2g per 1000 l once a week will prevent algal growth and accumulation of slime.

Chlorination is carried out by injecting gaseous chlorine by the use of chloronome. Continuous maintenance of 1 ppm of free residual chlorine provides adequate protection against bacterial and viral agents. When chloronomes are not installed or not functioning, the required amount of WSP as calculated by Horrock's test is first made into a thin mixture and distributed evenly over the surface of water. The water is then stirred with paddles. Subsequently, each day until the next filling, half that amount of WSP should be added half an hour before the swimming time. Tests for free residual chlorine is to be carried out daily half an hour after adding WSP. It will be ideal to keep the pH of water between 7.4 to 7.8 as irritation of eyes due to chloramine formation will be minimum. In a swimming pool the process of chlorination preferred is 'breakpoint' chlorination. When chlorine is added to water it immediately forms chloramines with ammonia, which is always present. The process continues till all the ammonia present is used up and the concentration of chloramines reaches its peak. Chlormines are, however unstable and react with excess free chlorine present in water and get oxidized completely to nitrogen and thus water contains no longer any free chlorine. Break point is said to have been reached when water no longer gives 'flash' reaction of free chlorine. Any further addition of chlorine hereafter causes a proportionate rise in the residual free chlorine, which acts as efficient germicidal agent. The bacteriological quality of swimming pool water should reach as nearly as possible the standard of drinking water. The test should be carried out weekly.

## Purification of Water on a Small Scale

The growing use of household filters and bottled water, a sign that public has lost faith in the quality of the water supply, should stimulate corrective action by water surveyors and regulatory agencies. House hold purification of water could be carried out by the methods stated below :-

### Boiling

It is very effective and kills all bacteria, viruses, spores, cysts and ova when the water is boiled for 5 to 10 min. It also removes temporary hardness. The taste of water is, however, altered. Boiled water has also no residual protection against subsequent contamination and hence care to be taken to avoid contamination during storage.

### Chemical Disinfection

It may be carried out with either chlorine solution, bleaching powder, WSP, perchloron, chlorine tablets or iodine solution. The chlorine tablets manufactured by the National Environmental Engineering and Research Institute, Nagpur (NEERI) are about 15 times more potent than ordinary halogen tablets and are available in the market. A single tablet of 0.5 g is sufficient to disinfect 20

l of water. Potassium permanganate is no longer recommended, as it is not a satisfactory water disinfecting agent although it is a powerful oxidizing agent. It has other drawbacks such as alteration of color, smell and taste of water.

**Filtration**

It is done through ceramic filters such as Pasteur Chamberland, Berkefeld and Katadyn filters. The essential part of a filter is the candle, which is made of unglazed porcelain in Pasteur Chamberland type, and of Kieselgurh in Berkefeld type. The surface of the candle in Katadyn filter is coated with a sliver catalyst. The bacteria coming in contact with filter candle get killed by the oligodynamic action of silver ions. Filter candles are liable to be clogged. These are to be cleaned by scrubbing with a hard brush under running water. The candles should be boiled at least once a week. Relatively clean water should be used with ceramic filters. Filter candles, however, do not remove filter-passing viruses.

**Disinfection of Wells**

It is sometimes necessary on a large scale during epidemics of cholera and other gastro-intestinal infections. Chlorination with bleaching powder is the most effective and cheapest method for this purpose. The quantum of water in the well is first worked out and the amount of WSP required is then estimated by Horrock,s test. The required quantity of WSP is then made into a thin paste with little water in a bucket. The bucket is filled three-fourth with water stirring all the time. About 5 to 10 min time is allowed for the chalk to settle down. The supernatant clear solution is then transferred to another bucket and the chalk is discarded. The bucket containing the clear chlorine solution is lowered into the well and the well water agitated by lowering and drawing the bucket several times. After half an hour's contact, orthotolidine test is carried out. If fresh residual chlorine is less than 0.5 mg/ l, additional quantities of WSP will have to be added. During epidemics, wells should be disinfected every day.

## Examination of Water and its Sources of Supply

The appearance and taste of water afford no warning of contamination. Moderately contaminated water may sometimes be quite palatable and sparkling. The laboratory assessment of water quality comprises of physical, microbiological and chemical examinations; each having its own usefulness. On active service in the field, however, the quality of raw water is judged mainly by purity at its source and sanitation of the surroundings of the source and appearance of water. The source of water and its surroundings offer indications of the extent of pollution and purity of water at its source and the procedure to be adopted to maintain the purity and enhance safety until it is delivered for consumption. Frequent examination by the Horrocks' test and efficient chlorination are relied upon to further safeguard the water supply. Indeed, the bacteriological examination in the field assumes mainly the role of field test to judge the efficacy of the methods of purification rather than the purity of the raw supply. In any case the full laboratory examinations are not always feasible as a routine measure in the field. They are, however, essential when the establishment of permanent or semi-permanent water points are contemplated, while investigating the outbreaks of water related diseases and for a routine check on supplies in townships, garrisons and cantonments.

**Hygiene Inspection.**

The hygiene inspection of the source, surroundings and site of water supply is carried out by making a plan and following it systematically. The inspection should include the presence of any habitation on the banks of the stream or near the water source; the presence of any water-logging nearby, the sanitation of the surroundings; the presence of any waste disposal area, latrines or urinals; the presence of any cattle sheds or horse stables in the vicinity; any seepages or surface pollution especially of human and animal waste products and industrial effluents affecting the potability and purity of water; amount of vegetation in the vicinity, in the water course or reservoir; the use of the source by local inhabitants and their health status including the presence of enteric fevers, viral hepatitis type A and gastrointestinal flux; the amount of flow of water, and the factor of dilution of pollution in water. The presence of living and actively multiplying fish generally indicates low pollution, and absence of disease among the inhabitants consuming the water indicates its general wholesomeness. Quick filling power may indicate the presence of fresh springs in lakes and wells and a good yield in the case of a stream. However, the likelihood of seepages from surroundings may also cause increased yield and should be guarded against. The site for obtaining water for human consumption from the selected source should also be properly examined before final selection. A sanitary survey is an on-site inspection and evaluation by a qualified person of all the conditions, devices, and practices in the water supply system which pose a danger to the health and well being of the water consumer. No bacteriological or chemical examination can take the place of a sanitary survey as the pollution is often intermittent and may escape the laboratory testing. Surveys should be undertaken when

(a) a new source is contemplated;

(b) laboratory analysis indicates hazard to health;

(c) an outbreak of waterborne disease occurs in the area;

(d) to interpret bacteriological, chemical and physical analyses of samples;

(e) when any change takes place that can affect the water system, e.g., industries coming up in watershed and

(f) also on a regular basis depending on size and available staff and resources and population / area under coverage. Majority of samples should be from problem areas, i.e., those with poor results in the past, low pressure zones, areas with high leakage, densely populated areas with inadequate sewerage, dead ends on pipelines, areas far away from waterworks etc.

## Water Quality Standards

WHO guidelines on variaous parametres for drinking water quality are laid down in standard references (12, 15, 16, 17) and should be referred to as and when required. The methods of examination of water are also given in details in the publications of ICMR (18) and American Public Health Association (19). In brief the standards and procedures are as follows :

### Physical Parameters

Wholesomeness and acceptability of drinking water is determined by the following factors:-

Turbidity

On aesthetic grounds, drinking water with obvious turbidity, i.e., turbidity above 5 NTU, becomes unacceptable to the consumer. Turbidity indicates incomplete treatment of water and also interferes with disinfection of the water.

Colour

The acceptable limit for colour in drinking water is 15 true colour units (TCU). Colouration of water may be due to presence of organic matter such as peat, metals like iron and manganese or due to industrial wastes.

Taste and Odour

Even though no guideline limit values have been laid down, any water with significant degree of taste and odour is unacceptable to the user. Taste and odour may be due to mineral matter, presence of organic matter and occasionally due to excessive residual chlorine in treated waters.

Temperature

Cool water is generally more palatable and no guideline value is recommended for temperature since its control is usually impracticable.

### Inorganic Constituents

Total Dissolved Solids (TDS)

The amount of TDS in water has an important effect on its taste. Waters with very low concentrations of TDS, such as the rain water are not relished by the consumer because of the flat, insipid taste. The palatability of waters with TDS levels below 600 mg/litre is considered to be good and those above 1200 mg/litre become unpalatable and objectionable due to scale formation in pipes, heaters and household appliances. The guideline value is for TDS to be below 1000 mg/litre.

pH

The guideline value for pH of water is 6.5 to 8.5. Water with pH levels below this range may corrode pipelines, resulting in increased levels of certain chemical substances, such as lead, in water. At pH levels above this range, the efficiency of the disinfectant action of chlorine is reduced.

Hardness

Depending on the interaction of other factors, such as pH, water with a hardness above 200 mg/litre may cause scale deposition in the distribution system and may result in excessive soap consumption. On the other hand, water with a hardness of less than 100 mg/litre has a low buffer capacity and is corrosive for water pipes.

Dissolved Oxygen

Even though no health based guideline value has been laid down, depletion of dissolved oxygen content in water encourages microbial reduction of nitrates and sulphates to nitrites and sulphides respectively, with consequent odour problems.

Hydrogen Sulphide

The presence of hydrogen sulphide in poorly oxygenated, stagnant waters is easily noticed by the consumer by its characteristic 'rotten egg' odour. The guideline value for hydrogen sulphide is 0.05 mg/litre.

Ammonia

Ammonia in water is an indicator of possible bacterial, sewage and animal waste pollution. It may be present in a non-ionised or ionised form. Ammonia retards the efficiency of treatment processes including disinfection and may also give rise to taste and odour problems. The guideline value is 1.5 mg/litre.

Sodium

The taste threshold of sodium depends on the associated anion and the temperature of water. The guideline value is 200 mg/litre.

Chlorides

The guideline value for chloride is 250 mg/litre even though the maximum permissible level is kept at 600 mg/litre. Chloride content of water variers a lot from place to place and tends to be high in the neighbourhood of the sea. Any sudden increase in background levels of chlorides in water from a place should raise suspicion of contamination of water.

## Presumptive Coliform Test

This test is based on estimating the most probable number (MPN) of coliform organisms in 100 ml of water. The water samples are collected in 180 ml sterilised bottles with all necessary precautions. If possible the bottle should contain culture medium and be inoculated on the spot. If not, they should be packed in ice and sent expeditiously to the laboratory. Bottles containing a mixture of McConkey's broth, the sample of water and a small inverted tube are incubated for 24 to 48 h at 37$^{o}$C. The multiplication of the faecal organisms present in water under test produces acid and gas. From the number of samples turning acidic, as shown by the pink color of the mixture, and which have produced gas, as seen in the inverted tubes, the probable number of the coli-aerogens group of organisms per 1000 ml water is ascertained from the standard tables. The estimates are therefore 'presumptive' and not actually existing. Details of the proceedure are given by Cheesbrough (20). There are two methods usually employed in the laboratories: the 'ordinary method' and the 'field method'.

**Ordinary Method**

This method is used while examining water from urban water works. Two series of bottles are put up. Series 1 is used for the samples that are likely to be satisfactory and series 2 when water is obviously unsatisfactory. Samples showing upto 2 presumptive coli in 100 ml are considered 'good' while those showing above 10 are 'bad'; the intermediate grade samples from an otherwise good source may be acceptable in an emergency, provided that the efficient clarification and chlorination show no presumptive *E coli* in 100 ml. Table - 4.

Table - 4 : Composition of the ordinary & field methods

| Method | Series | No. of bottles | Quantity of water | Quantity single strength | Broth ml double strength |
|---|---|---|---|---|---|
| Ordinary | 1 | 1 | 50 | - | 50 |
| | | 5 | 10 | - | 10 |
| | | 5 | 1 | 10 | - |
| | 2 | 5 | 10 | - | 10 |
| | | 5 | 1 | 10 | - |
| | | 5 | 0.1 | 10 | - |
| Field | | 5 | 10 | - | 10 |

**Field Method**

This method gives rapid results enabling one to take quick decision in the field about the comparative merits of two or more water sources. Five bottles containing inverted tubes and 10ml double strength McConkeys broth are inoculated with 10 ml of the sample of water on the spot and incubated for 24 h after which none of the bottles should show gas or acid.

**Membrane Filtration Technique**

In some countries membrane filter technique is used as a standard procedure to test for the presence of coliform organisms. A measured value of the water sample is filtered through a membrane made of cellulose ester. Bacteria present in water are retained on the surface of the membrane. The membrane is then directly inoculated face upwards on suitable media at appropriate temperature. Within 20 h the colonies grow and can be counted (20).

| Water at the point of consumption | Plate count after 2 days at 37ºC | Plate count after 3 days at 22ºC |
|---|---|---|
| Disinfected | 0 | 10 |
| Not disinfected | 20 | 100 |

**Faecal Streptococci and Cl. perfringens Detection**

The significance of these two tests have been discussed earlier.

**Colony Count**

The colony count on nutrient agar at 37ºC and 22º C provide an estimate of the general bacterial content of water. A single count is of little value, but counts from the same source at frequent intervals are of considerable value. A sudden increase in the count serves as the earliest indicator of contamination and hence this test is gainfully used in the public water works. The recommended plate counts are:

Plate count on yeast extract agar at 22ºC for 7 days is even a better indicator due to the absence of chlorine residue when there is uninhibited bacterial growth.

**Colilert Method**

The World Health Organization (WHO) recommends the measurement of *E. coli* in drinking water samples as the best indicator of water quality. The WHO guideline for potable water is less than one *E. coli* per 100 ml of drinking water (World Health Organization 1998). Multiple tube fermentation, membrane filtration and Colilert (IDEXX Laboratories, Inc., Westbrook, Maine) are laboratory methods used to qualify or quantify the level of bacteria in drinking water samples. The multiple tube fermentation and membrane filtration tests measure total coliforms and *E. coli* and are standard methods for water quality assessments. Both tests assess the number of bacteria based on lactose fermentation with production of sheen colonies, gas, or acid and gas.

Results from the multiple tube fermentation method estimate the most probable number (MPN) of coliforms or *E. coli* per 100 ml after growth of coliforms in liquid medium. Results from the membrane filtration method approximate the number of coliforms or *E. coli* colonies per 100 ml after growth of bacteria on the surface of agar.

Colilert is a recently available method to determine the MPN of coliforms. Colilert uses defined substrate technology to detect and quantify total coliforms and *E. coli* from water samples (22). As coliforms grow, they use l3-galactosidase to metabolize the nutrient indicator o-nitrophenyl-l3-D-galactopyranoside and change it from colourless to yellow. E. coli use l3-glucuronidase to metabolize 4-methylumbelliferyl-l3-D-glucuronide, which creates a molecule that fluoresces under ultraviolet light. Colilert is simpler to use, allows greater throughput, and requires less time to standardize than standard methods.

Colilert is an acceptable method to measure the presence and quantity of coliforms in water samples in a developing country setting. (23)

## Chemical Examination

This test is assuming greater importance due to ever increasing chances of industrial and agricultural pollutants finding their way into the sources of raw water. In the Armed Forces, the test is carried out prior to establishment of a water works/permanent water point. The existing sources are also subjected to the test annually once or as frequently as desired. When a chemical examination is indicated commonly the presence, type and quantities of hardness and inorganic salts acquired from the geological strata, and estimation

of chlorides, nitrites, ammonia and 'oxygen absorbed' figures to determine the extent of pollution are required to be ascertained. Estimation of iodides, fluorides and calcium is required under special circumstances when subnormal or abnormal quantities of these in water are suspected. A complete chemical examination also includes analysis for toxic metals, pesticides, persistant organic chemicals and radioactivity. Potable water from a chemical stand point alone, however, is not adequate as the indicators cannot be relied upon to detect minute quantities of sewage contamination . For this, bacteriological examination is needed.

The organic matter increases the chlorine demand of water. Ammonia interferes in the process of chlorination due to the formation of chloramines. High salinity affects adversely the taste and consumption of water. On decomposition of nitrogenous organic matter, carbondioxide ($CO_2$) and ammonia ($NH_3$) are produced. Ammonia is oxidised to nitrites and then to nitrates. In recently polluted water, ammonia and nitrites are found in larger quantities than nitrates. Given below are the interpretations of some of the usual chemical contents of water :-

**Ammonia**

It may be free (F), saline(S), or Albuminoid (Alb). Free and saline ammonia most commonly result from the decomposition of urine. Rain water and deep well waters (containing reducing iron salts from green sand strata) may also have high F and S ammonia content but other constituents may be small. Sewage pollution of water also shows the same results, but other figures in that case will also be high. If both types of ammonia are low i.e. F and S are 0.05 ppm or less and Alb. 0.1 ppm or less, the water is probably good. If both types of ammonia are higher than the above figures the water is bad. Alb ammonia is typically a product of vegetable organic matter. Low F and S and high Alb. Ammonia indicate vegetable contamination, specially if the 'oxygen absorbed' figure is high.

**Oxygen**

It will be absorbed as long as there is oxidisable matter in the water. Some streams may be so heavily polluted with crude sewage that all dissolved oxygen is removed from the water and the aquatic animals might die. The 'oxygen absorbed' figure after 15 min when acidic potassium permanganate is used as an oxidising chemical agent, indicates the amount of reducing inorganic substances such as nitrites and ferrous salts, but at the same time it may indicate the presence of certain rapidly oxidisable substances in sewage. An examination of other figures in the analysis and the absence of iron will assist in forming an opinion. The $O_2$ absorbed figures after 4 hrs gives an indication of the total oxidisable matter present in the water including that described above and organic matter mainly vegetable (co-related with albuminoid) and also to some small extent sewage. If the difference between the two oxygen absorbed figures is high i.e. 0.8 or more probably vegetable pollution is present but this must be confirmed by noting if the albuminoid ammonia is also high and free and saline low, and whether the water is acidic and soft or peaty.

**Chlorides**

These are increased by pollution with sea water, sewage (urine) and water from certain deep strata. A figure of more than 30 ppm in surface waters may be due to contamination with sewage; comparison must be made with the average 'chloride figure' for the area or previous concentration of the same sample before attributing it to pollution in some deep wells, the figures may run from 10 to 200 ppm or more. Deep well waters in coastal regions may have chloride content as high as 1000 ppm .Other indications of pollution will also help in arriving at conclusions.

**Nitrites/Nitrates**

These are the first stage in oxidation of ammonia and indicate recent pollution. They can also be present in waters from a green sand strata due to reduction of nitrates. Nitrites should be zero in potable water unless it comes from a green sand stratum. Nitrates represent remote pollution and if found in amounts above 1 ppm in a surface water or above 5 ppm in a deep well, the water should be regarded with suspicion.

**Hardness**

For domestic use the amount of hardness of water should not be more than 300 ppm . For laundries and boilers the softer the water the better.

**Total Solids**

These have little importance if other figures are satisfactory. Potable water should not exceed a value of 500 ppm.

The above standards are not hard and fast dividing lines above which water is to be immediately condemned or below which it is safe to drink. The following table gives examples of some water analysis and their interpretation (Table-5). The interpretation of these samples (A to F) are as follows :

**Interpretation**

(A) Rain Water

F and S ammonia very high (from air) Alb ammonia absent and $O_2$ is absorbed very low. No nitrites or nitrates, very low chlorides, hardness and total solids. A pure rain water.

(B) Peat Surface Water.

Acidic brown colour, F and S ammonia very low, alb ammonia and $O_2$ absorbed very high. Nitrites and nitrates absent. Chlorides is about normal for surface water, Very low hardness and total solids and Iron is present. A soft water, presumably plumbosolvent not showing sings of animal pollution, either recent or remote.

(C) River Water Derived from Chalk Springs

F and S ammonia low; alb ammonia and $O_2$ absorbed very low. Nitrites absent, nitrates and chlorides higher than normal for clean surface water. Temporary hardness is high whereas permanent is low. A good river water, but showing some evidence of past animal pollution (nitrates and chlorides).

(D) Water From River (C) After Receiving Sewage

Table - 5 : Interpretation of Water Analysis Report

| | A | B | C | D | E | F |
|---|---|---|---|---|---|---|
| **Physical Characters** | | | | | | |
| **pH Value** | 6 | 5.3 | Alk | Alk | Alk | Alk |
| **Turbidity** | Nil | Nil | Nil | Slight | Turbid | Nil |
| **Colour** | Nil | Slight brown | Green Blue | brownish | Brown | Nil |
| **Odour** | Nil | Nil | Nil | Nil | Unpleasant | Nil |
| **Chemical Characters (In Parts per million)** | | | | | | |
| **Ammonia F & S** | 0.49 | 0.008 | 0.014 | 0.122 | 4.5 | 0.6 |
| **Ammonia Alb** | Nil | 0.160 | 0.020 | 0.098 | 4.7 | 1.1 |
| **$O_2$ absorbed** | | | | | | |
| 15 minutes | 0.03 | 1.03 | 0.05 | 0.42 | 6.9 | 5.0 |
| 4 hours | 0.05 | 1.8 | 0.52 | 1.46 | 2.9 | 8.4 |
| **Nitrites** | Nil | Nil | Nil | Present | Present | Nil |
| **Nitrates** | Nil | Nil | 3.1 | 3.6 | 8.0 | 6.0 |
| **Chlorides** | 1.5 | 11 | 16 | 19 | 6.25 | 4.5 |
| **Hardness** | | | | | | |
| Temporary | 2 | 8 | 228 | 196 | 20 | 150 |
| Permanent | Nil | 8 | 14 | 180 | 50 | 100 |
| **Total Solids** | 23 | 40 | 284 | 296 | 267 | 400 |
| **Metals** | Nil | Iron | Nil | Nil | Nil | Nil |
| | | | | | | |

Note turbidity and color changed from blue to brown. F and S ammonia very high, alb ammonia low, $O_2$ absorbed high. Nitrites present. Nitrates and chlorides rather high. Increase in permanent hardness probably due to sulphates in sewage. A very impure water showing evidence of recent animal pollution.

(E) Water From Pond Receiving Sewage

A turbid brown unpleasant smelling water. F and S and alb ammonia and $O_2$ absorbed all very high. Nitrites present, nitrates and chlorides very high. Permanent hardness probably due to sulphate from sewage. A very bad water showing marked evidence of recent animal and vegetable pollution

(F) Water from well with Bad /surface Protection

F and S ammonia high, alb ammonia and $O_2$ absorbed very high. Nitrites nil but nitrates rather high. Chlorides high (figure for this district 20.00) temporary and permanent hardness high. A poor well water almost certainly contaminated by surface washings.

## Water Quality Standards

Prevention of pollution of drinking water, though ideal, is beyond achievement even with the best of efforts. Hence to minimize all the known health hazards, governments or appropriate authorities have adopted specific drinking water standards. These standards are the exposure limits for bacterial, viral, chemical and physical agents. The WHO in 1996 has published guidelines for drinking water quality. The standards of water quality are, however, by no means static; these are constantly under review in the light of new knowledge.

### Microbiological Pollutants

These are the standards relating to the presence of bacteria and viruses in drinking water.

### Standards of Bacterial Quality

Treated Water

Ideally, all samples taken from the distribution system should be free from coliform organisms. In practice this standards is not always attainable and the following standard for water collected in the distribution system is therefore recommended throughout any year, 95 percent of samples should not contain coliform organisms in 100 ml; no sample should contain *E. coli* in 100 ml and a coliform organism should not be detected in 100 ml of any consecutive samples.

Individual or Small Community Supplies

The standards outlined above may not be attainable in the case of waters from wells and springs. In these waters, the coliform count should be less than 10 per 100 ml. Persistent failure to achieve this particularly if *E. coli* is repeatedly found calls for rejection of water supply.

### Standards of Viral Quality

As stated earlier, water free of faecal coliform need not necessarily be free of viruses. Enteroviruses, reoviruses and adeno-virus have all been detected in water. As per

Table - 6 : Toxic Chemical Sustances

| Substance | Upper limit of concentration (mg/1) |
|---|---|
| Arsenic | 0.05 |
| Cadmium | 0.005 |
| Cyanide | 0.05 |
| Lead | 0.05 |
| Mercury | 0.001 |
| Selenium | 0.01 |

WHO standards not more than one plaque forming unit (PFU) per liter of water is considered potable. There should also be complete absence of enteropathogenic viruses and faecal bacteriophages.

### Toxic Chemical Substances

The presence of the following substances in excess of the concentrations shown against each should constitute grounds for rejection of the water (Table 6).

Table - 7 : Desired Levels

| Substances | Highest desired level |
|---|---|
| Substances causing discoloration | 5 units |
| Substances causing odour | Unobjectionable |
| Substances causing tastes | Unobjectionable |
| PH range | 7.0 - 8.5 |
| Total solids | 500mg/1 |
| Total hardness | 2mEq/1 |
| Iron | 0.1 mg/1 |
| Manganese | 0.05 mg/1 |
| Copper | 0.05 mg/1 |
| Zinc | 5.0 mg/1 |
| Calcium | 75 mg/1 |
| Magnesium | 30 mg/1 |
| Sulphate | 200 mg/1 |
| Chloride | 200 mg/1 |
| Phenolic Substances | 0.001 mg/1 |

**Specific Chemical Substances.**

Fluorides

Optimum recommended concentration is 1 ppm (0.5 to 0.8 ppm in India).

Nitrates

The ingestion of water containing nitrates in excess of 45 mg/ L may give rise to methhaemoglobinaemia in infants.

Polynuclear Aromatic Hydrocarbons

Some of these are know to be carcinogenic. Their concentration, in general should not exceed 0.2 g / L.

**Substances Affecting the Acceptability of Water.**

Turbidity of water is caused by the presence of suspended matter which interferes with the passage of scattering and absorbing light rays, and thus giving the water a non-transparent, milky appearance. Turbidity may result from soil erosion, algal growth or animal debris carried by surface run off. Colour may be imparted by substances leached from decomposed organic matter, leaves or soil such as peat.

The following criteria have been suggested: -

Turbidity should be less than 5 NTU and before chlorination should be < 1 NTU

**Radioactive Substances**

There is an increasing hazard of pollution of water supplies by radioactive substances. The radioactivity of water is measured in picocuries per liter (pCi/l). The WHO has proposed the following limits of radioactivity as acceptable: -

Gross alpha activity 3 pCi/l.

Gross beta activity 30 pCi/l.

## Detection of Poison in Drinking Water

Water is the most vital source of all kinds of life on this planet. There is every possibility of sabotage of the drinking water source by the enemy/militants. It must be ensured that water is free from poisons before it is declared potable. Testing of poison in drinking water requires elaborate laboratory facilities, which are not possible in remote areas. A set of Kit has been developed by DRDE Gwalior and marketed by Hindustan Metal Industries, Nai Sarak, Gwalior-1(MP) keeping in view the above requirement and facilitated testing of most commonly present poisons, sulphur mustard, nerve agent and microbial contaminations.

**Description**

The kit is housed in aluminium container having shoulder strap to carry for field use. The kit is provided with the reagents/material, sufficient for testing poisons 50 times. Each of the consumable reagents/material are quite stable and are replenishable. The Field kit for the detection of poisoning in drinking water. (WPDK) test are specific and can be performed systematically within 30 minutes, excluding the test for microbial contamination which takes 18 hours alone.

**Warning**

The following points should be considered before performing the tests :-

(a) The sample of water should not be chlorinated. If chlorinated, water can be dechlorinated by adding sodium thiosulphate.

(b) Water sample should be made clear by filtering if turbidity is observed.

(c) pH of water sample should be close to 7.

(d) Deionised water may be used in lieu of distilled water. The deioniosed water can be prepared by shaking the water (50 ml) with four scoopful of resin from bottle No (3) for 5 minutes, supernatant of which can be used.

Table - 8 : Poisons in drinking water

| Poisons | Detection units mg/L |
|---|---|
| Nerve agents | 0.01 |
| Sulphur mustard | 2.0 |
| Cyanide | 0.05 |
| Mercury | 0.5 |
| Arsenic | 0.2 |
| Lead | 0.001 |
| Manganese | 0.2 |
| Copper | 1.5 |
| Microbial contamination | 1-3 coliforms per 100ml |

**Field Kit for the Detection of Poisons in Drinking Water (WPDK)**

Specification

(a) **Size :** L.317 mm. W. 270. mm. H. 100mm.

(b) **Capacity :** 50 tests for each poison and 5 test each for nerve agents and microbial contaminants

(c) **Poisons and their Detection Limit**

Procedure of detection

Nerve agents

(a) Take the sample of water more than half in the small glass bottle (24)

(b) Break the ampoule, big followed by small by means of clean glass plunger(25)

**Observation**

(a) The colour of the water sample will turn blue, wait for 5-8 minutes

(b) The blue colour will disappear. It shows that the sample under test is free from Nerve agents.

(c) If the blue colour of the water does not disappear even in 10 minutes. It shows the presence of Nerve agents.

Sulphur Mustard

(a) Open the cap of chemical heater assembly (19) and take out the metallic part.

(b) Add approximately 30 drops of distilled water/deionised water in the plastic container of the chemical heater assembly then add one crushed tablet (20) and put the metallic part in it.

(c) Place one mustard test paper (18) over the pre-heated metallic platform of the heater.

(d) Add 1-2 drops of catalyst solution (22)

(e) Add slowly 10 drops of water sample drop by drop and wait for 2 minutes.

(f) Add 1 drop of reagent No (21)

**Observation**

(a) Appearance of purple blue colour will indicate the presence of sulphur mustard.

(b) Intensity of colour will vary from light blue to purple blue depending upon the concentration of Sulphur mustard.

Cyanide

(a) Take 15 drops approximately of distilled water/deionised water in test tube.

(b) Add one tablet each of (11) and (4) together.

(c) Shake the test tube till it makes suspension, then add two drops of suspension on the filter paper (17).

(d) Now take 100 ml sample of water in a polythene bottle (14) add to it one tablet (12) and add one scoopful of (2).

(e) Quickly put the paper from step (iii) upside down directly on the mouth of the polythene bottle, prepared as step (iv)

(f) Wait for 5 minutes.

**Caution**

Cork of the plastic bottle may be put over the filter paper in order to minimise the escape of gas evolved through the sides of filter paper.

**Observation**

A distinct bluish green colour will appear on the filter paper indicating the presence of Cyanide.

Mercury

(a) Take a mercury test paper (16).

(b) Add slowly fifteen drops of water sample by means of droper on the centre of the paper allowing the drop to be soaked completely before adding the next drop.

(c) After adding all the drops, wait for 2 minutes.

**Observation**

(a) Appearance of brick red/orange colour will indicate the presence of Mercury.

(b) For better visibility see colour against white back ground.

(c) Any other colour has no significance.

**Arsenic**

(a) Take a filter paper (17) and add two drops of reagent (13).

(b) Now take 100 ml water sample in a polythene bottle (15) and add one tablet(5).

(c) Add one scoopful of (2).

(d) Quickly put the above fitter paper to which the reagent is already added, directly on the mouth of the polythene bottle, facing the water.

(e) Wait for 10 minutes.

**Observation**

Pink / voilet stain will appear on the filter paper facing the water indicating the presence of Arsenic. Yellow stain has no significance.

Lead

(a) Take 100ml of the sample of water in the polythene bottle (15). Add one scoopful of (No 1). After 5 minutes shake the bottle gently up and down for two minutes, then allow to settle the resin, reject the supernatant liquid. Add another 100 ml sample and repeat as above till one litre of sample extracted.

(b) Take the extracted resin on a filter paper to remove excess water. Transfer the resin thus dried in the test tube.

(c) Add 15 drops approximately distilled/deionised water in the test tube, crush and add one tablet each of (6) and (7) together in the test tube.

(d) Shake vigorously for 5-10 minutes. The solution will become turbid.

(e) Add five drops of turbid solution on a fresh filter paper (17)

(f) Take 5-6 crystals of (8) in another test tube and add 30 drops distilled/deionised water to make solution. Add 5 drops of this solution over the filter paper where turbid solution has already been added.

**Observation**

A distinct dark violet stain will develop to indicate the presence of Lead.

Manganese

(a) Put one tablet (9) on filter paper (17)

(b) Add 10 drops of water sample very slowly by means of dropper

(c) Wait for two minutes.

**Observation**

A distinct bluish green colour will appear on the filter paper indicates the presence of Manganese in water.

Copper

(a) Put one tablet (10) on a filter paper (17).

(b) Add slowly 10 drops sample of water on the tablet

(c) Wait for two minutes

**Observation**

A olive green colour will appear on the filter paper indicating the presence of Copper.

Microbiological Contaminations

(a) Take a bottle (23) unscrew it and immediately fill the sample of water up to the mark

(b) Shake the bottle for one minute.

(c) Keep the bottle at room temperature preferably at 30°C for 18 hours

**Observation**

After 18 hours see the colour of water, if it turns jet black it confirms the heavy biological contamination and if it is less means less contamination. Temperature will play an important role in the development of colour if sample of water is contaminated.

## The International Drinking Water Supply and Sanitation Decade 1981-1990(1, 2)

The 'Decade' was launched at a special meeting of the United Nations General Assembly on 10 November 1980 following the recommendation of the UN Water Conference at Mar del Plata in 1977. The priority given by the above conference to the provision of safe water supply and sanitation was influenced by the joint report of WHO and World Bank which showed that in I975 some I230 million people were still without safe water supplies and I350 million people had lack of adequate sanitation facilities. Among the rural populations of developing countries, only 22 percent had access to reasonable safe water and only 15 per cent had facilities for excreta disposal. The Mar del Plata action plan also urged the individual countries to establish goals for 1990, which match the global target of the Decade.

### Target of the Decade (1991-2000)

The targets were fixed by the Indian Government for the decade

100% urban and rural supply

50% urban sanitation

25% rural sanitation

The Guinea worm eradication programme was linked with this decade. In 1986 the National drinking water Mission (NDWM) popularly unknown as Technical Mission was launched in order to provide scientific and cost effective content to the centrally sponsored Accelerate Rural water supply programme. In 1987 the National Water Policy was announced that has given high priority to drinking water.

### Tenth Five Year Plan (2002-2007)

Broad Terms of Reference

Develop a perspective on demand and supply for the next two decades say, by 2021 taking into account the present status and the ground realities.

Evolve a long-term strategy for provision and Operation & Maintenance of drinking water supply and sanitation facilities, which should be contributory to the process of economic development in a sustainable framework.

To formulate objectives, policies, strategies and methodology for the Tenth Five Year Plan, suggest modifications, if any, in the existing schemes, formulate new programmes, designed to address the specific problems in the water supply and sanitation sector.

Recommend viable and efficient policy options with particular reference to financing, development of compatible institutions and planning systems in a decentralised set up.

Analyse the pattern of financial flow in the Central and State Government's Budgets in the recent Five Year Plans and suggest proposals for changes/enhancement in the allocation process of Central and State budgetary resources for this sector.

To review the current status of operation and maintenance of rural water supply and sanitation schemes and suggest policies, strategies ways and means for effective operation and maintenance of the assets created including transfer of responsibilities to PRIs during the Tenth Plan.

To make a critical review of the achievements, roles and involvement of the International and other External Support Agencies like the WHO, UNICEF, UNDI World Bank and bilateral donors and define their future roles keeping in view the national policies, objectives and priorities.

The chairman of the Steering Committee for drinking water supply and sanitation (Rural and urban) has been empowered by Govt of India to constitute Sub-Groups and co-opt other member(s) as deemed necessary.

### World Water Day 2005: "Water for Life". Start of the International Decade for Action 2005-2015

The United Nations General Assembly at its 58th session in 2003 proclaimed the years 2005 to 2015 as the International Decade for Action, and called upon the relevant United Nations bodies, specialized agencies, regional commissions and other organisations to deliver a

coordinated response to make “Water for Life” a “decade for action”.

The Water for Life decade sets the world's goals on “a greater focus on water-related issues, while striving to ensure the participation of women in water-related development efforts, and further cooperation at all levels to achieve water-related goals of the Millennium Declaration, Johannesburg Plan of Implementation of the World Summit for Sustainable Development and Agenda 21.”

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# Management of Biomedical Waste

Col PS Chawla

## Introduction

Healthcare settings or hospitals are institutions intended to provide medical treatment and care for the ill or the injured. Contrarily, today most of them are increasingly turning out to be potential centres for spreading diseases due to improper biomedical waste management. Its magnitude can be gauged by the fact that in the metropolitan city of Mumbai alone, there are at least 15000 biomedical waste generators. Biomedical waste has been a growing concern because of the awareness in public regarding HIV AIDS and Hepatitis B as a result of exposure to discarded needles, syringes and other medical waste from municipal garbage bins and disposal sites. At the waste dump sites there are several rag pickers trying to salvage any discarded material to sell them and make a living. These rag pickers are exposed to the risk of injuries from contaminated needles and other sharp objects (1). Proper management of biomedical waste is a statutory requirement as per Biomedical waste (management and handling) rules 1998, under sec 6,8, and 25 of the environment protection act, 1986, of the Govt of India(2). The Gazette notification of the Ministry of environment and forests, Govt of India dated 20 Jul 98 lays down the rules in detail. It shall be the duty of the occupier of an institution (Person who has control over the institution and/or premises) generating biomedical waste (including a hospital, nursing home, clinic, dispensary, veterinary institution, animal house, pathology laboratory, blood bank.) to ensure that such waste is handled without any adverse effect to human health and environment.

General hospital hygiene is a pre-requisite for good medical waste management. It will be useless in terms of prevention of nosocomial infections to start improving hospital waste management if the hospital does not have a reliable supply of safe water and basic sanitation facilities accessible to hospital personnel, patients and visitors. Most hospitals in India lack these basic amenities. It is vital that the whole hospital be kept clean and in a satisfactory state of hygiene to prevent spread of infection from patient to patient, patient to health care providers and health care providers to patients. In terms of prevention of spread of infection outside the hospital, careful management of waste from the point of generation to safe disposal is of paramount importance (3, 4).

## Definition of Bio Medical Waste

As per Gazette Notification, 'Bio Medical Waste' means any waste, which is generated during the diagnosis, treatment or immunization of human being or animals or in research activities pertaining thereto or in the production or testing

Table - 1 : Biomedical waste (management & handling rules)

| Category | Type of Waste | Treatment & Disposal Option |
|---|---|---|
| **Category 1** | Human Anatomical Waste (Human tissues, Organs, body parts) | Incineration/deep burial |
| **Category 2** | Animal waste (Animal tissues, organs, body parts, carcasses, bleeding parts, fluid, blood and experimental animals used in research and waste generated by veterinary hospitals). | Incineration/deep burial |
| **Category 3** | Microbiology and Bio-technology waste (waste from laboratory cultures, stocks or specimens of micro-organisms, live or attenuated vaccines human and animal cell culture used in research and industrial laboratories, waste from biological production, toxins, dishes and devices used to transfer cultures) | Local Autoclaving / Microwaving / Incineration |
| **Category 4** | Waste Sharps (Needles, syringes, scalpels, blades, glass etc, that are capable of causing puncture and cuts. This includes both used and unused sharps) | Disinfection (Chemical)/Autoclaving/ Microwaving and mutilation/Shredding |
| **Category 5** | Discarded Medicines and Cytotoxic Drugs (Waste comprising of outdated, contaminated and discarded drugs and medicines) | Incineration/Destruction and disposal in land fills |
| **Category 6** | Soiled Waste (Items contaminated with blood and body fluids including cotton, dressings, soiled plaster, linens, bedding, other materials contaminated with blood) | Incineration/Autoclaving/ Microwaving |
| **Category 7** | Solid Waste (Waste generated from disposable items other than the waste sharps such as tubing, catheters, IV sets, etc.) | Disinfection by chemical treatment/Autoclaving/ Microwaving and Mutilation/Shredding |
| **Category 8** | Liquid waste (Waste generated from laboratory and washing, cleaning , house keeping and disinfecting activities. | Disinfection by chemical treatment and discharge into drains. |
| **Category 9** | Incineration ash (Ash from incineration of any Bio-medical waste) | Disposal in municipal land fills |
| **Category 10** | Chemical Waste (Chemicals used in biological production, | Chemical treatment & discharge into drains |

Source : (1)

of biologicals including categories mentioned in Table - 1.

### Bio Medical Waste Management Planning in the Armed Forces

All health care establishments have to formulate their Bio Medical Waste Management plan as per their needs based on the guidelines given below. Comprehensive instructions on the subject of handling and management of biomedical waste (BMW) have been issued by the office of the DGAFMS and all medical officers should familiarize themselves with the same (4). Simple handbook on the subject, developed by National AIDS Control Organisation (5) and Armed Forces AIDS Control Organisation (6, 7) are also available.

### Organisation Structure

At the highest level, an advisory committee for Biomedical Waste management in the Armed Forces, has been constituted under the DGAFMS. It has representatives from Ministry of Defence, DsGMS from the three services, E-in-C's branch and from other branches.

Similarly at the service HQ, Command HQ and lower fmn HQs, a nodal officer is designated to assist the senior medical staff officer in implementation of Biomedical Waste Management rules.

Commanding Officer of the Hospital and other health care establishments will be responsible for the implementation of the various provisions under the Rules in his establishment. His functions will be :

(a) To make an application for authorization in Form I to the prescribed authority.

(b) To submit Annual Report in Form II by 31 Jan each year.

(c) To report any accident in his establishment in Form III.

(d) To appoint a BMW Management Committee.

(e) Procure all consumables required for the system, including through LP under existing procedures, if the central supply does not materialize.

### BMW Management Committee of the Hospital

The Committee will be constituted as under wherever posted :

(a) Registrar/Senior Registrar - O/IC

(b) Specialist Pathology

(c) Principal Matron

(d) QM/Adm Officer

(e) OC SHO/ Specialist in PSM

(f) JCO I/C sanitation (Equivalent in Navy and Air Force),

(g) Senior most safaiwala / safaiwali

Functions of BMW Management Committee

The committee will formulate a SOP covering the following aspects :

(a) Segregation of the waste at source

(b) Collection storage, labeling, transportation of the waste to the site of treatment and final disposal.

(c) Make an inventory of waste; weight wise and category wise.

(d) Maintain a record of generation, collection, reception, storage, transport, treatment, disposal, handling by using appropriate forms and make the same available for inspection by the prescribed authority.

(e) Increasing the awareness of the rules amongst all pers and bring about an Attitudinal and Behavioral change among the HCE staff for observance of universal precautions and practices on BMW.

(f) Ensure use of protective clothing.

(g) Ensure education of the Health staff and the handlers by holding courses at least twice a year.

(h) To identify, procure, supply the quantity of consumables such as coloured containers, bags, trolleys, syringes and needle destroyers, face masks, caps, protective eye shields, aprons, gumboots, disinfectants etc. for proper management of the waste through central sources or locally, if the former system is disrupted, as per existing procedures.

## Principles of Infection control

The infections acquired in health care setting can be greatly minimised by observing some simple precautions. The broad principles of infection control include the following (6, 7) :

### (a) Infection Control Measures

(i) Each institution should establish an appropriate infection control policy (ICP) and programme. A mechanism should be set up for planning, implementing and monitoring the evaluations of ICP and programmes.

(ii) Hand washing is the most simple and cost effective measure and must be encouraged.

(iii) Disinfectants should be prepared and used according to the guidelines.

### (b) Patients Admission

A patient should not be admitted into a hospital unless it is absolutely necessary and he/she should be discharged as early as possible to reduce the risk of infection.

### (c) Hygienic Environment

Health care facilities should be kept clean and void of virulent organisms by proper house keeping. Cleaning of premises and room floors with water and detergent is recommended. Cleaning with a disinfectant is usually not necessary unless there is spillage with potential infectious material. Architectural design of a health care facility should permit good ventilation. Proper waste disposal, water treatment, disinfection and sterilization of equipment can reduce the risk of infection among patients, health care workers and community. To minimize the spread of infection, it is important that hospitals/health centres and the surroundings remain clean and no waste is spilled anywhere outside or inside

the hospital premises. A clean hospital has positive effects on its patients and its personnel too.

**(d) Monitoring of Infectious Agents**

Microorganisms responsible for infections in health care settings may originate from patients, the environment or health care workers. These sources of infection are to be identified and specific measures must be taken appropriately to prevent their spread.

**(e) Waste Reduction and Reuse**

There is a growing trend in health care settings to provide or use disposable materials in all aspects of work. Some are quite necessary for proper infection control and worker and patient safety. Hospitals should select a mixture of disposable and reusable material depending upon their situation, e.g. General Wards and OPD can use mostly reusable items but casualty departments may incorporate more of the disposable items. More waste means more expense on waste disposal. Reuse not only reduces disposal cost but also reduces procurement cost for medical items (2,3).

## Steps in Waste Management

In brief, the following steps should be followed for waste management. Medical Officers may refer to standard texts for more detailed information (3, 5-9) :

**(a) Waste Survey**

Waste survey is an important component of the waste management scheme. A survey helps in evaluating both the type and quantity of waste generated in the hospital. A survey aims to :

(i) Differentiate the types of waste.

(ii) Quantify the waste generated.

(iii) Determine the points of generation and the type of waste generated at each point.

(iv) Determine the level of generation and disinfection within the hospital.

(v) To find out the type of disposal carried out; and get familiar with the personnel at all levels.

**With this information, it will be easy to :**

(i) Provide specific receptacles for different wastes at different levels of output.

(ii) Determine the type of disinfection needed and the point at which it should be carried out in the waste stream.

(iii) Use the information in hospital specific training.

**(b) Waste Categories**

The Ministry of Environment and Forests has classified hospital waste, which is notified in the Bio-medical Waste (Management and Handling Rules). The categories of bio-medical waste and their treatment & disposal options are appended in Table - 1.

**(c) Segregation and Safe Storage**

(i) Segregation at source and safe storage is the key to whole hospital waste management process Segregation should be carried out at the point of generation, to keep general waste from becoming infectious. If the infectious waste, which forms a small part of hospital waste, is mixed with the other hospital waste, the entire waste will have to be treated as infectious waste which is an expensive option.

(ii) Thus, by segregation, a hospital can :

- Reduce total treatment cost.
- Reduce the impacts of this waste on the community.
- Reduce the chances of infecting health care workers.

(iii) It is essential that all sharps (whether infected or not), infected waste not containing sharps, chemicals and pharmaceuticals other than cytotoxic drugs, and other hazardous wastes are segregated by medical / paramedical personnel and kept separately in readily identifiable, preferably colour coded containers. Radioactive waste, cytotoxic drugs and high pressure containers require special handling and disposal channels.

**(d) Colour Coding and Containers for Disposal of Bio-medical Waste**

Ministry of Environment and Forests has notified the types of containers and their colour codes for storage of different categories of hospital waste as appended in Table - 2.

**(e) Choice of Bins or Receptacles**

(i) Hospital managers may prefer to use plastic or metal bins for waste.

(ii) If reusable containers are to be used, considerable thought should be given to methods of cleaning and disinfecting them. The containers should be smooth and well rounded from inside to allow effective and complete cleaning.

(iii) The size and number of receptacles should be appropriate to the amount of waste produced in the hospital sites.

**(f) Handling and Treatment**

The term treatment, refers to processes that modify the waste in some way before it is taken to its final resting place. Treatment is mainly required to disinfect or decontaminate by chemical disinfection of waste right at source, so that this is no longer the source of pathogenic organisms. After such treatment, the residue can be handled, transported, stored and disposed off safely. The following should be kept in mind while dealing with infectious waste :

(i) Infectious waste must be separated at the point of generation itself.

(ii) Bins with lids lined with polythene bags, or with inner chamber bucket should be used.

(iii) The bins and bags should also be labeled with the biohazard symbol.

Table - 2 : Colour coding for disposal of biomedical waste

| Colour | Type of Container | Waste Category | Treatment Option |
|---|---|---|---|
| Yellow | Plastic bags | Human & animal wastes, Microbial and Bio-technological wastes and soiled wastes (Category 1,2,3, and 6) | Incineration/deep burial. |
| Red | Disinfected container/ Plastic bag | Microbiological and Bio-technological wastes, soiled wastes, solid waste (Category-3,6 and 7) | Autoclaving/ Microwaving/ Chemical treatment. |
| Blue/ White transparent Destruction | Plastic bag/ Puncture proof container | Waste sharps and solid waste (Category 4& 7) | Autoclaving / Microwaving / Chemical treatment, and shredding. |
| Black | Plastic bag | Discarded medicines, Cytotoxic drugs, Incineration Ash and Chemical Wastes (Category 5,9 & 10 [solids]) | Disposal in secured landfills. |
| Green | Plastic Container | General waste such as office waste, food waste & garden waste etc. | Disposed in secured landfills. |

(iv) Personnel involved in infectious waste handling should be provided with suitable protective wear and should be properly trained.

(v) Polythene bags placed in the bins have to be changed with each shift or when they are 3/4th full. They should be sealed/tied at the top whenever the waste is being transported within or outside the hospital.

(vi) Infectious waste needs to be destroyed or disinfected by the recommended methods of disinfection / destruction of the biologically infectious waste such as autoclaving, microwaving and incineration.

**(g) Handling of Disposable Items**

(i) Disposable items like the gloves, syringes, IV bottles, catheters etc. have to be shredded, cut or mutilated. This ensures that they are not recycled/reused.

(ii) Extreme care has to be taken while handling the needles, syringes and blood bags.

(iii) Disposable items should be dipped in an effective chemical disinfectant for a sufficient time or autoclaved or microwaved so that they are disinfected properly.

**(h) Chemical Disinfection**

Chemical disinfection has wide application in small health care facilities. A good disinfectant is bleach. For chemically treating the waste, an optimum concentration of bleach has to be prepared. The concentration prescribed by WHO is 10 gm of bleach in 1 litre of water. However, it must be noticed that medical waste that has been chemically disinfected should continue to be treated as hazardous, unless careful bacteriological testing has shown disinfection to be complete. The bleach solution should be prepared at the beginning of the shift. At the end of the shift or after the bin is full and the waste has been treated with suitable chemical disinfectant, it has to be disposed off. The various chemical disinfectants commonly used are shown in Table - 3.

**(j) Sharps**

Major portion of the sharps are the needles, which can be cut by a needle cutter and contained in a bleaching powder solution or autoclaved and/or shredded or destroyed by a needle destroyer. Precautions in handling sharps are :

(i) All the health workers employed in/outside the hospital must be vaccinated against Hepatitis B.

(ii) All the health care workers should put on heavy duty gloves while dealing with infectious waste specially sharps.

(iii) Sharps should not be left casually on counter tops, food trays or beds as grievous injuries can result.

(iv) Recapping needles should be discouraged. In situations when recapping is unavoidable, the single hand method should be utilized.

**(k) Liquid Waste**

The liquid pathological waste should be treated with a chemical disinfectant. The solution should then be treated with a reagent to neutralize it. This can be flushed into the sewer system.

**(l) Radioactive Medical Waste**

Hospitals providing Nuclear Medicine for diagnosis or treatment of diseases have not only to check for radiation but also to ensure that instruments are properly maintained, proper protective wear is provided, not only to the physicians and other employees of the hospital, but also to the patients.

**(m) General Waste**

(i) The general office waste comprising of the waste papers can be clubbed with other recyclable materials.

(ii) According to the quantity of waste, kitchen waste

Table - 3 : Chemical disinfectants - Chlorine releasing compounds

| Available Chlorine Condition | "Clean" Condition | "Dirty" |
|---|---|---|
| Required Chlorine | 0.1 %, 1g/Litre | 0.5%, 5g/Litre |
| Sodium hypochlorite solution 5% available chlorine | 20 ml/litre | 100 ml/litre |
| Calcium hypochlorite 70% available chlorine | 1.4 gm/litre | 7.0 gm/litre |
| (NaOCl Powder) Sodium dischlorosocyanurate | 1.7 gm/litre | 8.5 gm/litre |
| (NaOCl Tablets) Sodium dischlorosocyanurate | 1 tablet/litre | 4 tablets/litre |

Non-chlorine releasing compounds (used for disinfection of Items which are adversely affected upon by chlorine).

| Name of Disinfectant | Required concentration | Contact period | Used for disinfection of |
|---|---|---|---|
| Ethanol | 70% | 3-5 min | Smooth metal surfaces, table tops, incubators, thermometers |
| Alkaline Glutaraldehyde etc. | 2% | 30 min | Ambu bags, suction tubes/bottles, laryngoscopes, endotracheal tubes, catheters |
| Formaldehyde/Formalin etc. | 3 - 4% | 30 min | Furniture, rooms, walls, blankets, beds, books |
| Savlon | 1% | 30 min | Cheatle forceps. |
| Dettol (chloroxylenol) | 5% | 15 min | Instruments & plastic equipment |

can be utilized in many different ways. In large hospitals, technologies like bio- digestion (vermicomposting) can be installed. In smaller establishments, kitchen waste can be composted.

(iii) Non-biodegradable waste can be disposed off in municipal bins

**(n) Disposal of Biodegradable Waste**

The biodegradable waste is comparatively easy to handle. It should be disposed off after its biodegradation which can be accomplished by Bio-digestion (using bacteria or earth worms or by Pit composting. After complete decomposition it can be used as a biofertlizer.

**(o) Chemical Hazardous Waste**

Hospital also generates a wide range of chemical hazardous waste, which may be segregated and properly managed. Chemical hazardous waste may include : solvents, chemotherapy waste, formaldehyde waste, radioactive waste, heavy metals like mercury used in instruments, other toxins and corrosives and waste anaesthetic gases. Minimization of the waste, careful segregation of these wastes and safe disposal of that waste, which cannot be recycled, is very necessary.

**(p) On-site Transportation**

Segregated waste has to be transported within the facility from the point of generation to the final waste disposal site. All bags should be fastened and small trolleys can be used in large facilities. Hazardous waste, even after decontamination, should never be transported with general municipal waste.

## Technologies for Waste Treatment (2, 4).

Some of the technologies, which are being promoted in India are :

**(a) Autoclave**

An autoclave is an instrument, which uses steam at high temperature to kill all microbes. There are two types of autoclaves :

**(i) Gravity Displacement Autoclaves**

In this system, the air within the autoclave is pushed out by entering steam. This process has a problem. There may be air pockets left within the waste, which is being autoclaved. This reduces the temperature of the waste and therefore reduces the efficiency of the system.

**(ii) Pre-vacuum Autoclaves**

Once the waste is put into the autoclave, a vacuum is created within the autoclave (all the air from the chamber is removed). Steam, which enters the chamber, is able to penetrate the entire waste. Absence of air pockets ensures that high temperature is achieved within the waste, rendering it harmless (Fig-1).

**(b) Microwave**

A microwave system uses high frequency waves. These waves cause the molecules within the waste material to vibrate. This generates heat from within the matter itself. The heat generated is high enough to ensure that all microbes are killed (Fig-2).

**(c) Chemical Disinfection**

(i) Chemical disinfection is cost effective and does not require large investments. In this form of disinfection, a chemical is used to destroy the pathogens.

(ii) Not all medical waste should be treated in this way. Only plastic, rubber and metals should be disinfected. It is not advisable to chemically disinfect cloth based medical waste because it is difficult to handle wet waste and it also adds to the weight and volume of the waste.

**(d) Incineration**

Incineration is the process of burning the solids at very high temperature in a furnace. The temperature in these furnaces is usually high enough to burn even the metals. The furnace is connected to a cline so that the smoke does not pollute the surrounding environment (Fig. - 3). The incineration area must be out of bounds for everyone except those working there.

**(e) Hydroclave**

Hydroclaving is a steam sterilization technology. Hydroclave is a double walled container, in which steam is injected into the outer jacket to heat the inner chamber containing the waste. Moisture contained in the waste evaporates as steam and builds up the requisite steam pressure which sterilizes the waste. The waste material gets dehydrated and reduced in volume

**(f) Plasma Torch Techniques**

The waste is pyrolysed (heated without air) at temperatures beyond 115°C, producing combustible gases and vitreous or glass like rock substance by deploying plasma technology. The residue is suitable for concrete and asphalt construction and the gases may serve as a source of energy.

**(g) Medical Waste Sterilization Unit**

Recommended for garrisons having large hospital bed strengths such as Pune & Delhi.

**(h) Secured landfill**

## Disposal of Disposable Material

| Technologies for treatment of Biomedical Waste | |
|---|---|
| 1. Autoclave | 2. Microwave |
| 3. Hydroclave | 4. Chemical disinfection |
| 5. Incineration | 6. Plasma torch technique |
| 7. Medical waste sterilization unit | |
| 8. Secured landfill | |

The following measures should be taken for disposal of the biomedical waste :-

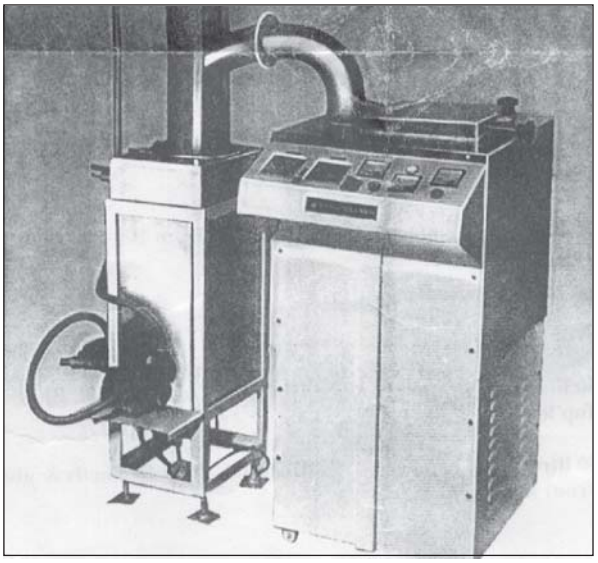
(a) Awareness of the danger of acquiring HIV infection while handling blood and blood contaminated material has resulted in sudden increase in the usage of pre-sterilized disposable material. In most of the hospitals, disposable needles are reused after boiling. This practice must be discontinued immediately.

(b) There is a definite problem of disposal of the disposable material used for injection and for other skin piercing invasive procedures in the hospitals. Further, there is a high possibility that unscrupulous persons may start re-cycling the

Fig - 1 : Autoclave

Fig - 2 : Microwave

Fig - 3 : Incinerator



disposable material resulting in their reuse without even proper sterilization.

(c) Thus, it is recommended that the disposable material should be given high priority by ensuring its destruction and eliminating reuse. Therefore, the following procedure is recommended:

(i) All the disposable material after use has to be accounted for like any other reusable material. This can be achieved by discarding the disposable material in a plastic/metal container and sealing this in the presence of a responsible person. The plastic container for piercing instruments like needles, etc. should be puncture resistant. Plastic breadboxes are suitable for this purpose. Other non-piercing material can be discarded in plastic bags.

(ii) The plastic material such as I.V bottles, I.V sets and syringes can be shredded with a shredder.

Fig - 4 : Biohazard symbol

**Biohazard Symbol**

The biohazard symbol to be used as labels on all containers and vehicles meant for storage / transportation of waste is shown in fig. 4.

**Conclusion**

Consequent to the Gazette Notification, it is now mandatory for all health care facilities to have sound Bio-medical waste management and handling facilities as per prescribed standards and schedules. It may not be possible to achieve all the standards in one go. The aim should be to make improvements and gradually move towards a sustainable system in order to achieve a healthier environment, mind and body.It is time that our service hospitals, who are eminently known for their high standards of hygiene, good maintenance and excellent administration, should take a lead in this vital area of health care. It is also of utmost importance that consideration be given to safe laboratory practices (10, 11). In the Armed Forces, a sound beginning has been made. Large scale research projects have been undertaken on this subject (12, 13) and detailed guidelines (7, 8), as well as administrative instructions (5) have been issued. It now devolves on all Medical, Dental and Nursing Officers and paramedical personnel to ensure the implementation of the guidelines. The Govt of India, through an amendment to the Gazette Notification of July 1998, issued on 17 sept 2003, appointed the DGAFMS as the prescribed authority for enforcing the provisions of the rules for all establishments under the Min of Defence. Medical Officers are therefore advised to go through, in detail, the Gazette Notification (2), as well as the amendment (14).

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Gp Capt S Mukherji & Maj (Mrs) R Mukherji

# Housing

Housing and shelter is a basic human need. However a 'house' means more than a roof over one's head: It means to have a home, a place which protects privacy, contributes to physical and psychological well-being, and supports the development and social integration of its inhabitants a central place for human life (1,2).

### The WHO approach to housing and healthy housing

'Housing' is a comprehensive concept taking into consideration a variety of factors contributing to the quality of housing and housing environment. The Habitat declaration, Istanbul (1996), defines the characteristics of an 'adequate shelter' as "Adequate shelter means more than a roof over one's head. It also means adequate privacy, adequate space, physical accessibility, adequate security, security of tenure, structural stability and durability, adequate lighting, heating and ventilation; adequate basic infrastructure, such as water supply, sanitation and waste-management facilities; suitable environmental quality and health related factors; and adequate and accessible location with regard to work and basic facilities….."(2).

Housing is a complex construct that cannot be represented merely by the physical structure of the home. The WHO understanding of 'housing' is, therefore, based on a four-layer model of housing, taking into consideration the physical structure of the dwelling as well as the meaning of home (for a family and each individual), and the external dimension of the immediate housing environment, and the community with all neighbours (3).

There is considerable evidence that housing conditions do affect health status. Nevertheless, we are still left with the question, "what is healthy housing?"


Housing is the conjunction of the dwelling, the home, the immediate environment and the community. The role of public health is to provide the circumstances under which people can be healthy (4).

## Housing as a determinant of health

An increasing body of evidence has associated housing quality with morbidity from infectious diseases, chronic ailments, injuries, poor nutrition and mental disorders. Some of the health effects of housing are summarized below:

### Infectious diseases

Poor housing standards and lack of basic hygiene facilities like lack of safe drinking water, lack of water for maintaining personal hygiene, inefficient or absent waste disposal systems, easy entry of diseases vectors and rodents, have long been associated with spread of infectious diseases. Overcrowding and poor ventilation are associated with the spread of respiratory diseases and tuberculosis.

### Chronic diseases

While inadequate housing conditions and infectious diseases have long been associated, epidemiological studies in more recent years have shown the relationship between improper/ substandard housing conditions and risk of chronic ailments. For example damp, cold and mould infested houses are associated with asthma, allergies and other chronic respiratory diseases. Houses with entry for mites, roaches, respiratory viruses, moulds have been linked to respiratory diseases.

Living in cold houses has been associated with a generalized lower health status and increased utilization of health services. Recent studies have shown that deviation of indoor ambient temperature beyond a relatively narrow range may be associated with increased risk of cardiovascular diseases. Exposure to toxic substances found in homes can result in chronic health problems. Exposure to ETS (environmental tobacco smoke) and its myriad ill effects are well documented. Volatile organic compounds (VOC) emitted by numerous household cleaning and disinfectant agents, floor coverings etc may be associated with several adverse health effects including asthma and Sick Building Syndrome. Some of the VOCs are known carcinogens. The relationship between lead exposure and neurodevelopment abnormalities is well established, now additional evidence suggests an association with hypertension (5).

### Injuries

Unintentional home injuries are a serious health problem. Dwelling design and maintenance is an important factor related to such injuries. Houses contain physical dangers like gas, electrical fittings, steps, stairs, balconies, breakable glass window panes, unprotected upper storey windows, low railings etc, which pose imminent risks for domestic accidents.

### Mental health

Data gathered from the WHO LARES (Large Analysis and Review of European housing and health Status) shows that people are significantly more depressed and more

Table - 1 : Sources and health hazards of indoor pollutants

| Pollutant | Sources/types | Health Hazard |
|---|---|---|
| Respirable particles | Tobacco smoke, smoke, stoves, biomass fuel etc | Respiratory tract disorders |
| Carbon monoxide, Nitrogen dioxide, Sulfur dioxide, Carbon dioxide | Combustion | Respiratory tract disorders |
| Volatile organic compounds | Cleaning materials, solvents Types: Formaldehyde, benzene, toluene | Asthma, allergies, mucosal irritation, carcinogens |
| Radon and daughters | Building material | Carcinogens |
| Asbestos | Insulation, fireproofing | Asbestosis, Carcinogens |
| Biological hazards | Bacteria( Legionella, Mycobacterium), viruses and fungi (moulds),pests (cockroaches, mites ,bedbugs, rats) | Airborne infections, asthma, infections |

anxious when they live in a dwelling that is overcrowded, has inadequate ventilation, does not offer adequate protection from noise, dampness, moulds etc. (2). Studies have demonstrated a consistent association between mental disorders and urban living conditions. Though alcoholism, vandalism, adolescent delinquency, schizophrenia etc, may not be caused by bad housing alone, and are symptoms of more complex social pathology, it is also accepted that stressful housing conditions can aggravate pre-existing psychiatric pathologies. Finally, indoor exposure to toxic compounds (i.e. heavy metals, solvents) may lead to neuropsychiatry disorders.

### Neighborhood health effects

Besides the conditions of the housing unit, the immediate neighborhood is also documented to have health effects on the inhabitants. These include increased rates of intentional injuries, poor birth outcomes, cardiovascular diseases, STD, depression, physical inactivity and obesity. Several features of the neighborhood may contribute towards ill health. The air quality may be poor due to proximity to major highways or roads, improper waste disposal in the neighborhood, absence of green spaces and walking areas may promote physical inactivity and obesity. Several social dimensions of neighborhoods also affect the health of the inhabitants (6).

### Built environment and health

The built environment encompasses all buildings, spaces and products that are created or modified by people. It includes our homes, schools, workplaces, parks, industrial areas, farms and roads. The built environment not only impacts indoor and outdoor physical environments (e.g., climatic conditions, indoor and outdoor air quality), but it also affects social environment and subsequently our physical health and quality of life. Recent research has explored the effect of built environment on physical activity, asthma, obesity, cardiovascular diseases, lung cancer mortality and mental health. These complex diseases are attributable to an interaction of genetic and environmental influences and many of the later can be directly connected to the built environment.

### Housing in special situations

The criteria of healthy housing have been laid down by several agencies and are updated form time to time. Housing and health: 'APHA-CDC Recommended Minimum Housing standards' sets the specific standards as related to basic facilities and equipment. The 'WHO Health principles of Housing' throws light on the wide range of behavioral factors that can influence health in relation to housing conditions. In India certain standards have been laid down, and have been enunciated in the recent document on Indira Aawas Yojana for housing for the poor. However none of these standards are legally enforceable, and can only be used as guidelines (2,3, 7).

### Housing in urban slums

In the last few decades with increasing urbanization, there has been a great increase in the number of people staying in peri-urban or urban areas in slums or shanties. These dwelling are not only highly substandard but they often lack basic sanitation, access to clean water supplies, medical care and other basic services. The proportion of people residing in such situations ranges from 20 to 80 percent in most cities through out developing nations like in South, South-east and South-west Asia, Africa and Latin America.

### Housing for the displaced populations

Short-term shelter in existing buildings

In many situations, people may independently seek shelter in buildings such as schools, community centers, offices, sports facilities, and even railway carriages and wagons. Such buildings are often also used for organized short-term evacuation centres. The evacuation centre should be as close as possible to the neighborhood or rural community concerned, but far enough from the disaster site to avoid secondary hazards. Buildings should be thoroughly inspected for structural damage. They

should have running water and toilets. Military barracks or school buildings are usually better equipped for large numbers of people. It is important that these accommodations are only used for a short period, and that they are cleaned and maintained intensively, to avoid a rapid deterioration in environmental health conditions.

As per guidelines on temporary shelters (8) : People sleeping on beds or mats should have a minimum of 3.5 $m^2$ of floor area or 10$m^3$ of air space. Beds or mats should be separated by a minimum distance of 0.75 metres. Smoking and the use of cooking fires in the shelter should be strongly discouraged.

To avoid very high temperatures in hot climates, buildings can be modified to increase shade, ventilation and thermal capacity. Buildings should have emergency exits and fire escapes; the flues of stoves / *bukharis* used for space heating should extend outside the building. Clear instructions on fire hazards and safety practices should be made and group of volunteers from among the survivors should be taught about the possible fire hazards and trained in the use of fire-fighting equipment.

Access to sufficient water for drinking, cooking, and personal and domestic hygiene should be provided. One wash basin should be provided for every 10 people or 45 metres of wash-bench for every 100 people; there should be separate benches for men and women, and waste receptacles at each bench. One shower head is needed for every 50 people in temperate climates and one for every 30 people in hot climates. Floors must be disinfected daily.

Arrangements must be made for human waste disposal. Water-flushed toilets may be available in existing buildings if the water supply has not been interrupted. Outside latrines should be located within 50 metres of the building, but at least 20 metres away from the kitchen, dining hall and water supply.

One refuse bin of capacity 50-100 litres should be provided for every 12-15 people. The bins should have tightly fitting lids. Special arrangements for the collection of refuse may be needed if the normal collection service is interrupted.

If existing buildings are not available

One possibility is to use tents or makeshift shelters made of plastic sheets, tarpaulins, or local materials, such as palm thatch, in a secure location where water, sanitation and food can be provided. The site should be free of vector habitats for diseases like malaria (8).

The topography of the land should permit easy drainage and the site should be located above flood level. Rocky, impermeable soil should be avoided. Land covered with excessive vegetation can harbor insects, rodents, reptiles, etc., and should be avoided or cleared. Ideally, the site should have a slope of 24% for good drainage, but not more than 10% to avoid erosion and the need for expensive earth-moving for roads and building construction.

Areas adjacent to commercial and industrial zones, exposed to noise, odours and air pollution should be avoided. Areas sufficiently close to blocks or rows of shelters should be identified for sanitation and waste management. The residential area of the camp should face the prevailing wind to avoid odours from latrines. Temporary camps for refugees should hold no more than 10000-12000 people, or should be subdivided into independent units of no more than 1000 people.

Drainage ditches should be dug around the tents or other shelters and along the sides of roads, especially if there is a danger of flooding. Care should be taken to lead water away from shelters, latrines, health centres, and stores. Persistent areas of stagnant water that are difficult to drain can be backfilled, or covered with polystyrene balls or a thin layer of oil, to control insects. Water points should also have adequate drainage to avoid mud.

Shelters should be arranged in rows or in clusters of 10-12 on both sides of a road at least 10 metres wide to permit easy traffic flow and access by ambulances or firefighting vehicles. In tented areas, there should be at least 2 metres between the edge of the road and the tent pegs. Shelters should be spaced 8 metres apart so that people can pass freely between them without being obstructed by pegs and ropes. A separation greater than 8 metres may lead to open-air defecation and should be avoided.

Shelters may be tents or prefabricated units, or may be built out of plastic sheeting together with timber, stone and thatch. Where plastic sheeting is used, it is common to provide one piece, 4 metres by 6-7 metres, per household.

No one should have to walk more than 500 metres to a water point, and there should be at least one water point for every 250 people.

Latrines or other facilities for excreta disposal should be provided (at least one toilet per 20 people), and gradually improved as time and resources allow.

Separate accommodation is necessary for unaccompanied children, with provision for adults (welfare staff and/or community volunteers) to stay with them; there should be at least one adult per shelter or room. These children may be very disoriented and frightened, and may also have special nutritional needs. The shelters should be situated near the nutritional rehabilitation centre and field hospital, and as far from sources of secondary hazards, noise and contamination as possible.

In conflict and famine related disasters, many people may be suffering from malnutrition and debilitation when they arrive, so specialized services such as intensive or therapeutic feeding may be needed. Intensive feeding or nutrition rehabilitation units should be provided with up to 15-30 litres of potable water per bed per day. Also, special care needs to be given to latrines and other waste-disposal facilities used by parents, children and staff. Means for hand-washing by all staff and parents concerned with child feeding are also important.

## Housing in the Armed Forces

Housing in the Armed Forces has its special considerations for the reason that the forces tend to be frequently on the move and may require to leave one area to occupy another or may at times have to reside in inhospitable terrains for very prolonged periods.

Quartering of the service personnel should be analyzed with respect to permanent accommodation in family stations and accommodation in field areas. While guidelines and recommendations on standards of housing may be adhered to for the living accommodation in peace / family areas, the same may not be possible during operations/ exercise locations. During operations/ exercise/ move etc, priority is given to safety of troops. Improvisations for comfort only follow after ascertaining the safety from the operational point of view. Often, due to operational requirements troops have to stay in compromised living conditions.

**Temporary accommodation for troops**

Accommodations for troops when they move out of their military camps usually include the following: Bivouacs, trenches, dug outs, bunkers and tents. While most of them are meant as a temporary measure, however at times, troops may have to occupy these for months on end.

Bivouac

A bivouac is a temporary, overnight shelter used during emergency, when troops are on the move / in an operational area. These provide very scanty shelter, usually in the form of a ground sheet stretched overhead.

Trenches, Dugouts, Bunkers

These are defensive fortifications. Bunkers are mostly below the ground. In certain areas massive bunker complexes were built to house strategic infrastructure as well as troops and stores. There are several types of bunkers like the trench bunker, pillbox bunker, industrial bunker and personal shelter bunker. The basic plan of a bunker is to provide a structure that can withstand physical compression. A bunker should deflect blast waves from explosions to prevent internal injuries to people sheltering in the bunkers. In the present scenario of nuclear warfare, the bunkers must also provide radiation protection. Technical expertise is provided by the Corps of Engineers during construction of these bunkers. However, factors which influence the health of the troops, like ventilation, protection from heat, cold, wind, snow etc, must be given due consideration. Prolonged occupation and maintenance of sanitation in bunkers, trenches and dug outs present difficult problems and are tiring for the physical and mental health of the troops.

Fig - 1 : TEFS (Tent Extendable Frame Supported

Tented Camps

Tented camps are usually of a temporary nature, but due to tactical, administrative, logistic and economic reasons, they may be protracted over longer durations. Various improvisations may have to be introduced to decrease the discomfort and health hazards to the troops. Ventilation, overcrowding are problems commonly associated with tented accommodation. Presently, use of TEFS (tent extendable frame supported) is common in the Armed Forces. After first appearing during the Second World War, these tents have through the years evolved into Extendible Modular types that have become widely acknowledged the world over as the most practical alternative shelters in times of unrest. Furthermore, Extendible Frame Supported Tents can today adapt many special requirements such as vehicle maintenance, field kitchens and mobile hospitals to the original standard modular tents. As far as possible, only authorized strength of persons should use the tents, four persons in the four man tent and two men in the two man tent. Modular shelters, fibre glass huts and various other prefabricated shelters are now in use. However, in all such shelters, problems of overcrowding and improper ventilation continue to worry the medical authorities. Risk of carbon monoxide poisoning and fire hazard are relevant concerns in high altitude living arrangements.

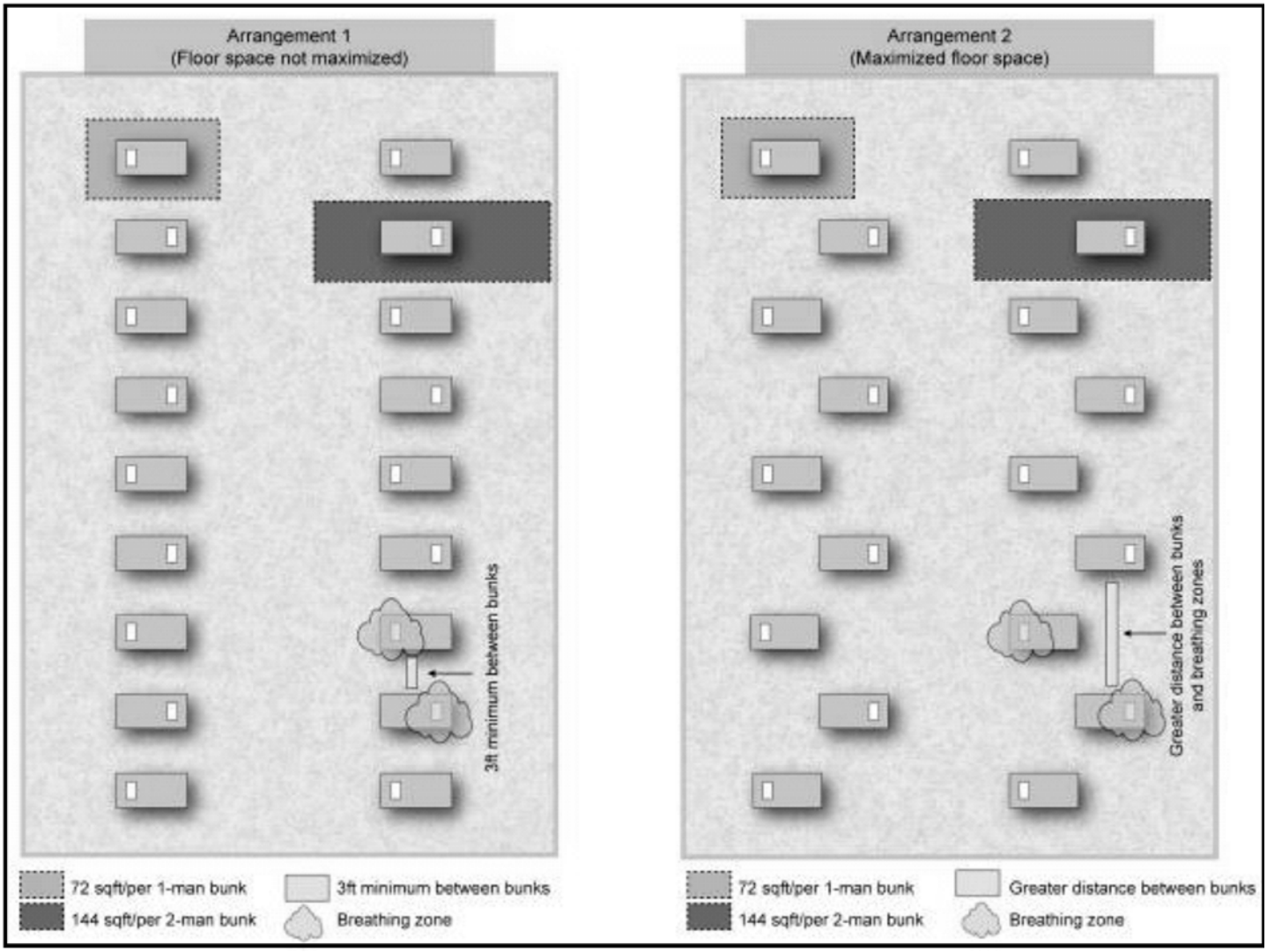
**Permanent Accommodation**

In cantonments, garrison stations and in peacetime, accommodation for single men is provided in permanent barracks. The primary consideration here is 'the health and comfort of troops' and this outweighs any other consideration. In general, married accommodation available for troops falls short of requirement. The commanding officer should ensure equitable allotment of such accommodation at his disposal so as to permit the personnel to bring their families by turn. Due to the shortage of married accommodation in most of the military stations, outliving or living under own arrangements (or CILQ) is usually resorted to, to enable the soldier to live with his family. The commanding officer of the unit is responsible for ascertaining that the hygiene, sanitation and other aspects of the accommodation proposed to be used by the service personnel is satisfactory, and periodic checks are also ensured by the unit rep to ascertain the living conditions from time to time. Scales of accommodation for the various ranks in the Armed Forces is given in Appendix (10).

Minimum prescribed standards

The housing for single men in the Armed Forces is unique in that a large number of people share the accommodation and are in close contact for a large period of time. Prevention of infections and diseases in such setting prompts the requirement for prescribing certain standards for 'healthy living space'. These standards may also prove to be useful in other circumstances where people may have to live in close contact like refugee camps, prisons, correctional centers, boarding schools,

Fig - 2 : Method for optimising floor space utilisation




tourists or pilgrim's camps etc. It may be in barrack, hut, bunker, basha or tent; principles applicable to one are applicable to all types of accommodation.

### Per person space requirement

The space allowed per individual in a barrack is a minimum 2 metres of linear wall space, 5 metre² of floor area and 18 metre$^3$ of air space with the exclusion of any height above 3.6 metre. The distance between centers of two adjacent beds / bunks should not be less than 1.8 metres, but during exigencies of service, these scales may have to be reduced after a medical review. The US Army in its technical bulletin on non-vaccine recommendations for prevention of acute infectious respiratory diseases among army personnel staying in close quarters has recommended 72 feet$^2$ of floor space per person with at least 3 feet between adjacent beds to minimize disease agent transmission. In all forms of accommodation, whether permanent, temporary or even in tents, this minimum space should be ensured. At times, overcrowding in the barracks becomes inevitable, as is usually seen in some regimental centers. Given below in an illustration of a method of optimizing floor space utilization, while allowing maximum space between the beds (Fig. 2).

### Ventilation standards

Various standards of ventilation have been prescribed by different workers. Ventilation is usually measured in cubic space, air change or floor space. The accepted standards are 1000 to 1200 feet$^3$ cubic space per person and 50 to 100 feet$^2$ floor space per person. However more subjectively, it is usually said that at 0300hrs in the morning, if no musty or unpleasant odors are perceived inside the barrack/ room, the ventilation is satisfactory. For ensuring adequate ventilation, the total window space should not be less than 1/10th of the total floor space and cross ventilation should be maintained.

### Temperature and Humidity

Though temperature and humidity are both perceived to be matters of personal comfort, both these factors are associated with health symptoms. High humidity can support the growth of fungus, moulds, mites etc. The

Occupational Safety and Health Administration (OSHA) recommend maintenance of indoor temperatures in the range of 68-76°F and humidity levels of 20-60%. However, these are only recommendations and not guidelines.

### Housing and public health

The notion of housing as a public health issue is not new. Attention has been directed towards housing and related facilities in response to outbreak of infectious diseases from time to time (e.g. Cholera in New York City in 1830s). In the early 1800s the relation between housing conditions and health was recognized among public health practitioners in the United States and Europe and several corrective reforms towards healthier housing facilities were also initiated. The eight essential components of primary health care as outlined by the Alma Ata Declaration included basic sanitation and thus encompass the housing conditions of the people. Current public health efforts to improve housing conditions include a focus on the basic and established aspects of health and housing as well as new strategies based on emerging issue and newer research. The WHO has a health and housing program and carried out periodic surveys aimed at comprehensive understanding of health and housing. In India the National Family Health Survey collects data on the housing condition of people. The data from NFHS-3 (2005-06) shows that only about 26% of rural India live in pucca houses, with only 28% having access to piped drinking water and 26% have access to toilet facilities (11).

### Housing and the government policy

Housing is a State subject but the Union Govt. is responsible for the formulation of policy with regard to programmes and approaches for effective implementation of the social housing schemes, particularly those pertaining to weaker sections of the society. The National Housing Policy is enunciated in the Five Year Plan and the State Govts implement the schemes in accordance with the plan priorities and local requirements.

In tune with the policy of the Government, a National Policy on Housing, taking into account the development on national and international scene on Shelter Sector has

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## Appendix

| Provisioning of accommodation for married personnel | | |
|---|---|---|
| (a) | **Officers** | |
| | Major and above | 100 % |
| | Captains | 80% |
| | Lieuts & below | 33% |
| (b) | **JCOs** | 100% |
| (c) | **OR** | 35% or more depending on trade |

**Scales of accommodation**

(a) **Single Living Accommodation for Service Officers and Nursing Officers**

| Category | Plinth area (Sq,m) | | |
|---|---|---|---|
| | Main unit of accn | Servant Qtrs | Garages |
| Major and equivalent ranks and above | 60.40 | 18.58 | 20.90 |
| Captain and equivalent ranks | 51.10 | 18.58 | 20.90 |
| Lieutenants and equivalent ranks | 51.10 | 18.58 | 4.20 |
| (b) **Single Living Accommodation for JCOs** | 37.20 | - | 4.20 |
| (c) **Single Living Accommodation for Havs/OR** | | | |
| (i) Living accn per Hav | 10.00 | | |
| (ii) Living accn per OR | 5.00 | | |
| (iii) Common room | 0.25 per man | | |
| (iv) Study room | 0.25 per man | | |
| (v) Store room | 0.25 per man | | |
| (vi) Verandah | 2.40 m wide | | |
| (d) **Sanitary Blocks to Barracks** | | | |
| (i) WC/latrine | 16.67% of authorized strength | | |
| (ii) Bath rooms | 10% of authorized strength | | |
| (iii) Wash hand basins | 16.67% of authorized strength | | |
| (iv) Urinals | 4% of authorized strength | | |

e) **Married Accommodation for Service Officers and Nursing Officers**

| Category | Plinth area (Sq,m) | | |
|---|---|---|---|
| | Main unit of accn | Servant Qtrs | Garages |
| Major Gen & above and equivalent mandatory | 139.35 | 22.30 | 20.90 |
| Major to Brig and equivalent recommended | 139.35 | 22.30 | 20.90 |
| Captain and equivalent ranks | 83.61 | 22.30 | 20.90 |
| Lieutenants and equivalent ranks | - | - | 4.20 |

Note

1. Maj Gen & above and equivalent holding Command appointment only are also auth 23.23 Sq,m plinth area for attached office and 19.98 Sq,m for office of ADC.
2. Brig and equivalent holding Command appointment only are also auth 16.26 Sq,m plinth area for attached office

(f) **Married Accommodation for Separated Families of Service Officers and Nursing Officers**

| Category | Plinth area (Sq,m) | | |
|---|---|---|---|
| | Main unit of accn | Servant Qtrs | Garages |
| Major Gen and above and equivalent | 139.35 | 16.72 | 20.90 |
| Major to Brig and equivalent | 83.61 | 16.72 | 20.90 |
| Captain and below and equivalent ranks | 83.61 | 16.72 | 20.90 |
| Lieutenants and equivalent ranks | - | - | 4.20 |

**(Details of Scales of accommodation for Defence services are given in reference No 10).**

Lt Col VK Agrawal

# Environmental Sanitation

## Introduction

Environment, according to the present day concept, is no longer restricted to the traditional field of physical and biotic realms comprising visible, tangible and the inanimate aspects of man's surroundings but also encompasses the sociocultural setting fashioned by him. The physical environment comprises on one hand the natural factors like the topography, atmosphere, water, soil, climate, light, radiation and on the other hand the artificial human innovations, such as housing, clothing and air-conditioning created for his adaptation to the natural environment. The biological environment means the universe of living things, which surround him. The living things are the plants, animals, rodents, insects, microbes, helminths, viruses and so on. Social environment is represented by people, their activities, interrelations, culture, traditions, customs, habits, beliefs and standard of living.

Man, in his endeavour to support his biological, cultural and technical needs, is constantly altering the environment and also creating new environments, which are often inconsistent for healthful living. The environmental problems faced by man today are due to the widening gap between the technical developments and the abilities of his institutions to adapt to them. Development and population growth are much more rapid now than they were a century ago; and in many of the countries now undergoing development, the tropical, climatological and ecological characteristics add further difficulties. In addition to the creation of artificial human innovations and efficient management of air and water pollution, the control of physical environment includes safe disposal of human, animal, plastic and electronic wastes.

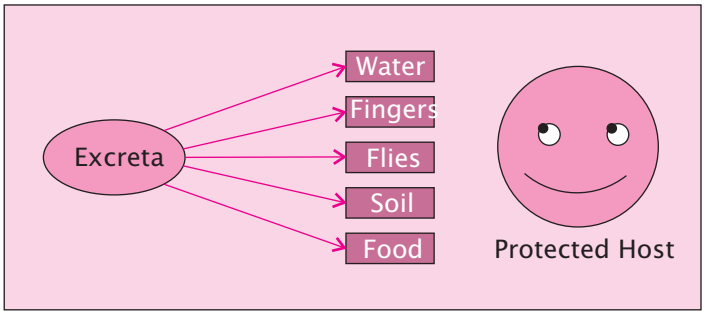
"Sanitation" refers to all conditions that affect health, especially with regard to dirt and infection and specifically to the drainage and disposal of sewage and refuse from houses (The Concise Oxford Dictionary). At its first meeting in 1950, the WHO Expert Committee on Environmental Sanitation defined environmental sanitation as including the control of community water supplies, excreta and wastewater disposal, refuse disposal, vectors of disease, housing conditions, food supplies and handling, atmospheric conditions, and the safety of the working environment. Environmental problems have since grown in complexity, especially with the advent of radiation and chemical hazards. Meanwhile, the world's needs for basic sanitation services (i.e., drinking-water supply, excreta and wastewater disposal) have greatly increased as a result of rapid population growth and higher expectations. This led to the designation by the United Nations of the International Drinking Water Supply and Sanitation Decade (1981-1990).

> Environmental sanitation deals with control of Physical environment (safe water supply, waste disposal, and housing) for prevention of diseases.

### Sanitation Barrier

The sanitation control which aims at interruption of transmission cycle of the disease agent from the reservoir to the new host can be achieved at several levels such as segregation of excreta and wastes, protection of water supply, protection of food and drinks, control of flies and the practice of personal hygienic measures. The most effective measure out of all these would be segregation of excreta and arrangement for its proper disposal so that the disease agents do not get a chance to reach the new host. The sanitation barrier (Fig. 1) in the simplest way can be provided by a sanitary latrine and a disposal pit.

Fig - 1 : Sanitation Barrier




### Waste

Waste is an unwanted or discarded material which may not be of any use to an individual who is throwing it but it may be of use to someone who may reuse it or recycle it. **Built of industrial waste and thrown-away items, the Rock Garden in the city of Chandigarh is perhaps the world's most poignant and salient statement of the possibility of finding beauty in the unexpected and accidental.** In India a number of people eg rag pickers and Kabadiwalas are earning their livelihood by retrieving articles from waste and they should be effectively utilized in waste management.

### Significance of Waste Disposal

Poor sanitation is known to increase the risk of morbidity and mortality from diarrhea among children. Several studies have found a high correlation between childhood morbidity and availability of sanitation services. It has been estimated that 1.7 million deaths each year, or 3.1% of all deaths are attributable to inadequate access to water, sanitation and hygiene[1]. Waste collection and disposal assume significance primarily on two fronts-public health and socio-economic. The Governments across the globe have understood the need for providing improved sanitation and have committed themselves at the "Millennium Declaration" to undertake measures to provide sanitation services particularly to the urban poor population [Millennium Development Goal-7; Target-11;

Indicator-31][2]. The significance of waste disposal is further discussed below :

(a) Public Health Aspects

Human excreta are the principal source of pathogenic organisms, which are transmitted through the various channels stated already. Diseases of special significance such as the enteric group of infections including cholera, typhoid, dysentery, diarrhoeal diseases and viral infections are the leading causes of death in developing countries, which comprise more than two-third of the world's population. Food crop contamination through insanitary irrigation practices and soil contamination by helminths including ascaris, enterobius and hook worm result in many morbid conditions. Breeding of *Culex fatigans* in standing pools of wastewater causing widespread filariasis is a serious hazard.

(b) Socio-economic Aspects

The socio-economic benefits of waste disposal are difficult to measure in quantitative terms. A lack of adequate sanitation measures means perpetual discomfort, fight against diseases, a sense of being unwell and consequently loss of productivity and mounting cost of health care for the community.

Improper disposal of biodegradable waste can spread diseases and pollute the environment, while waste management in environment friendly manner will not only prevent diseases but will give bio-fertilizer and methane gas for

**Waste Disposal versus Management**

Disposal means to get rid off. Since waste is not considered useful it is tried to be disposed by easiest mean or without wasting any money or time. People require to be educated regarding the usefulness of waste as well as the hazards associated with improper disposal of waste. Term waste disposal should be replaced by the term waste management so that the waste can be managed in a manner that money spent on handling / treatment is recovered (for example disposal of human excreta / animal excreta / biodegradable kitchen waste by biogas plant gives biogas for cooking purpose as well as manure for agricultural purposes).

**Classification of wastes**

For convenience of disposal, wastes may be grouped as under:

(a) Human excreta - faeces and urine.
(b) Animal excreta -cattle and horse dung.
(c) Dry refuse and garbage-household, municipal, and agricultural.
(d) Liquid wastes-household sullage.
(e) Dead animals, carcasses and offal of slaughtered animals.
(f) Electronic waste
(g) Biomedical waste

**Principles of Waste Management**

Following points needs to be considered :

Local bodies should adopt all the three approaches (Service, education and legislative) for efficient

(a)People to be educated to generate minimum waste.
(b)People to be educated to recycle or reuse packing material.
(c) Waste to be disposed in environment friendly manner.
(d) Waste to be disposed in a manner to retrieve biogas and manure.

**Integrated Approach for Waste Management**

Waste to be managed by a integrated approach by providing services to the people in terms of toilets, urinals or public bins etc., by educating the people regarding hazards of improper disposal of waste and enforcing legislation if people do not comply with rules and regulation.

**General Principles of Waste Management in the Armed Forces**

The methods of waste management in armed forces to be employed depend on the length of stay in any particular place. For convenience, Armed Forces camps are grouped as permanent, semi permanent and temporary camps. Permanent camps are occupied for a year or longer; they include cantonments, garrisons, base camps, large camps on the Comn Z, and so on; semi permanent camps are occupied for less than a year and more than six days. Temporary camps are occupied for six days or less. This grouping serves as a guide only and no hard and fast rules can be laid to distinguish the various kinds of camps. Moreover it should always be kept in mind that a particular camp can be required to be occupied for a more prolonged period than initially expected. Thus a temporary camp can become a permanent camp, and a semi permanent camp can become a permanent camp, garrison or even a cantonment. Generally in permanent camps, cantonments and in garrison stations where water carriage system of faeces disposal or other efficient systems of conservancy, sullage and refuse disposal exist, latrines and other sanitary conveniences are usually located from the point of view of users' convenience. In semipermanent and temporary camps, latrines and refuse disposal should be concentrated in a well defined circumscribed sanitary disposal area so as to facilitate efficient supervision of the working, even at the expense of the convenience of the users to some extent. However, the latrines should be as close as possible to men's living quarters, commensurate with the need for efficient supervision and working. The sanitary area should be clean and tidy; on the leeward side of the camp; away from the water supply points and cook houses; protected from rains and allotted according to the existing scale to units and subunits.

Responsibilities

The local Commander is responsible for the health and comfort of his men. Maintenance of the latrines and all other sanitary installations and appliances, detection and rectification of sanitary defects, and obedience of orders regarding sanitation are, therefore important responsibilities of the unit administration. The unit sanitary squad should carry out all these duties under the

supervision of the unit hygiene and sanitation officer. The officer should make a routine inspection at least once a day. Advising the local Commander on matters of health of the troops, prevention of ill health, and healthy living and working conditions is the responsibility of the medical officer. These duties should, therefore, oblige him to visit from time to time the latrine areas and unit lines and observe the state of unit sanitation and hygiene and make recommendations to improve them. He is also responsible to train and guide the unit hygiene and sanitation officer and the sanitary squad. For this purpose he can get assistance from the sanitary staff of the medical organization and the technical staff officer at the formation HQ

## Disposal of Human Excreta

A detailed description of all these methods of excreta disposal, which is in practice in different parts of the world, is beyond the scope of this manual. Only those ones, which are popular in the Armed Forces establishments in India, will hereafter be briefly discussed. Standard textbooks should be consulted for details (3, 4). Reference No 4 is generally accepted as a standard referral by MES authorities also. Disposal of excreta Can be divided in four groups

(a) **Temporary camp:** Shallow trench latrine, sanitary latrine based on improvised and removable Indian type sanitary water closet, incinerator latrine

(b) **Semi-permanent camp :** Deep trench latrine, Improvised deep trench latrine, dug well latrine, ventilation improved pit latrine ,Pour flush water seal latrine

(c) **Permanent camp :** Sewerage system, Combination of septic tank and soakage pit/subsoil irrigation, oxidation pond, biolatrine, Aqua farming

(d ) **High altitude:** Temperature controlled bio-digester

### Temporary camps

(a) Shallow Trench Latrines

STL has a problem of smell and fly breeding which can be overcome by educating the users to cover the excreta after defaecation

These are used strictly as a temporary measure only when the deep trench latrines cannot be constructed. Each trench is 90 cm long, 30 cm wide and 60 cm deep. Trenches are dug in parallel with an interval of at least 60 cm in between two trenches (Fig. - 2). The earth removed should be neatly piled at its head end. The trench is used by squatting astride it, with a foot on either side and not both feet on the same side. After defaecation the excreta must be covered by earth with a scoop. Fly breeding occurs if this is neglected. The latrine area must be policed by a member of the unit sanitary squad to ensure that each user carries out these instructions. After 24 hours, faeces should be covered with a 3 cm layer of slaked lime and trenches should be filled with earth. A new row of trenches is immediately dug in front of the previous day's row. While leaving the camp, the earth should be well rammed down, the whole area and the ground up to 1 m all round sprayed with the insecticides and the area suitably marked 'L' so as to indicate the ground as unusable by any unit camping thereafter.

(b) Sanitary latrine based on improvised and removable Indian type sanitary water closet

Although STL are easy to construct as well as are not costly but are hardly used by the troops due to smell and fly nuisance. By fitting a plastic or stainless steel Indian type of water closet on metallic sheet enforced wooden platform which can be placed on a trench and subsequently removed, a sanitary latrine can be constructed which will be aesthetic also and not have the problem of smell, fly breeding and non- utilization .

(c) Incinerator Latrine

It may be used in sandy desert, loamy or arid lands by small detachments for short periods. A shallow trench with dimension as given in Fig. - 3 is dug. Ghee tin 'A' has its bottom perforated top removed and corners cut and the sides bent outwards so as to receive the bottom of tin 'B'. The tin 'B' with its top and bottom removed is then placed in position projecting 15 cm above the ground level. The remainder of the trench is filled up to the level of the base of tin 'B' with stones Tin 'C' with its bottom perforated and the top 15 cm of its side adjacent to tin 'B' cut way is then placed in position. The top 15 cm of the side of tin 'B' adjacent to tin 'C' is cut and bent over to grasp the cut side of tin 'C. A fly proofed wooden seat battened with strips of wood on its under surface is then placed in position so as to fit tightly over the tins BC. Faeces fall into tin AB and urine into 'C' to soak into the small soakpit beneath. The seat must be kept clean. The faeces are burnt twice a day by pouring a small quantity of mixture of petrol, kerosene and sump oil and igniting after removing the seat. This latrine lasts for a fortnight for ten men. When the contents are 15 cm from the top, the seat is removed and the final burning is carried out. A sandbag soaked in oil is placed on top, the flap of tin 'B' is bent backwards and the remainder of tin 'B' is then filled with sand/earth and well packed. No flies can either enter

Fig - 2 Shallow Trench Latrine

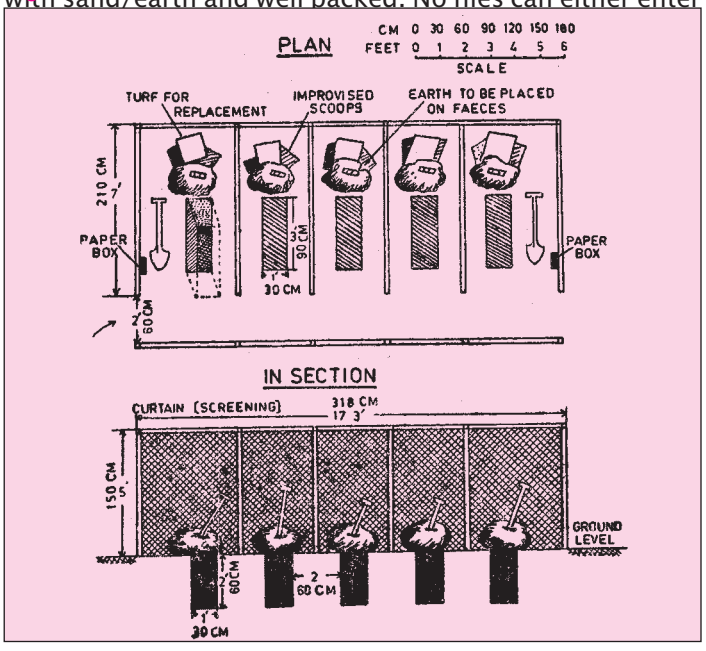
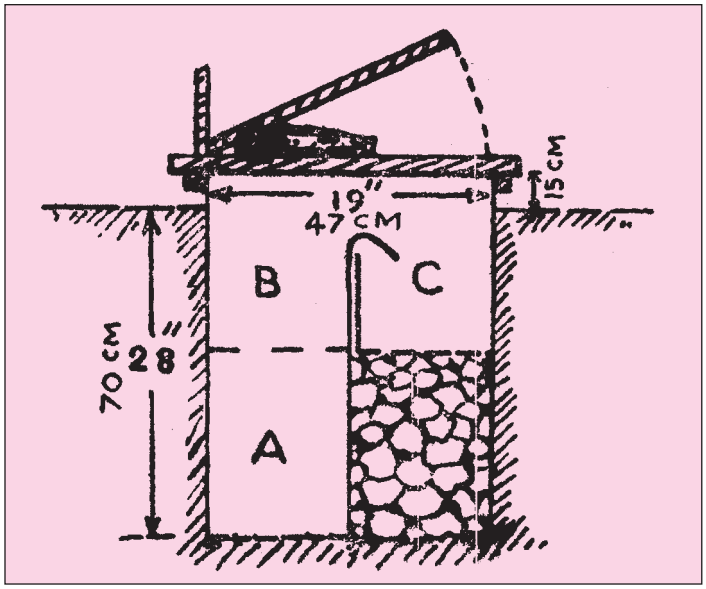


Fig - 3 : Incinerator Latrine




**Semipermanent camps**

In semi permanent camp human excreta can be disposed by deep trench latrine, improvised deep trench latrine, sanplat latrine, ventilation improved pit latrine, pour flush water seal latrine. Normally 5 seats per latrine are constructed at the scale of 10 percent of the strength of unit/subunit.

**Construction details of Deep Trench Latrine**

Broad details of the construction of DTL and its maintenance are given hereunder step by step. Unit sanitary personnel should be trained in proper construction and maintenance of the DTL with understanding of the rationale (Fig. - 4).

(a) The standard trench is 1 m wide, at least 2½ m deep and 3 m in length, or of the length of the superstructure available. If any danger of sides collapsing is envisaged, they should be riveted with bamboos, sandbags or wire netting. If sandbags are used the width should be 1.3 m. It should not reach the subsoil water level for chances of contamination of subsoil water level. If the subsoil water level is high, an increased depth may be obtained by building a mud bank upto one meter high all around the trench. This bank is riveted on both its internal and external faces with interlaced bamboo.

(b) The ground upto one metre around the trench is then dug to a depth of 10 cm and the loosened earth is removed. Strips of oil-soaked sacking, each 1½ m wide, are then spread over this dugout area with the inner edges hanging down to 15 cm over the sides of the trench and secured in position with small wooden pegs. The outer edges are sunk into the ground along the outer edge of the dugout area.

(c) Required numbers of joists (4 or 5) are placed over the trench, overlapping its edges by 60 cm to support the superstructure.

(d) The fly proof wooden superstructure made as described below is then placed over the joists so as to overlap the edges of the trench by 10 cm.

(e) The squatting type of superstructure should be flat as a table top, made of tongued and grooved timber, and its under surface completely covered by a double thickness of oiled sacking snugly tucked to the wood, except at the lidded squatting apertures.

(f) Each aperture should be 36X25 cm, with a distance of 30 cm from the next one and fitted with a hinged lid.

(g) The lid should overlap the aperture by 5 cm all round. It should be covered on the under surface with a double layer of oiled sacking. A device for opening without touching it with hands should be provided.

(h) The loose soil removed from around the trench is then mixed with heavy oil, replaced in the dug-out area around the trench on the top of the sacking and joists, and rammed down to form a hard impervious layer. Flies likely to hatch out inside the trench are trapped beneath the sacking while trying to reach the surface after emergence from their pupal cases.

(j) A flytrap may be constructed at one end of the trench.

(k) A shallow drain with a soakpit at its end to stop storm water from entering the trench is made all round the latrine.

(l) An overhead shelter must be provided as protection against rain and the sun. Partitions should be interposed between seats.

(m) Maintenance should be carried out as under :

(i) The superstructure must be maintained fly proof by replacing all wrapped lids, by caulking all cracks with oiled sacking and by replacing all torn sacking.

(ii) The lids must always be kept closed when the latrine is not in use.

(iii) It is unnecessary and even harmful to throw any disinfectant into the trench.

(iv) Oiling of superstructure or seats is unnecessary; they should be scrubbed daily and washed and always kept dry.

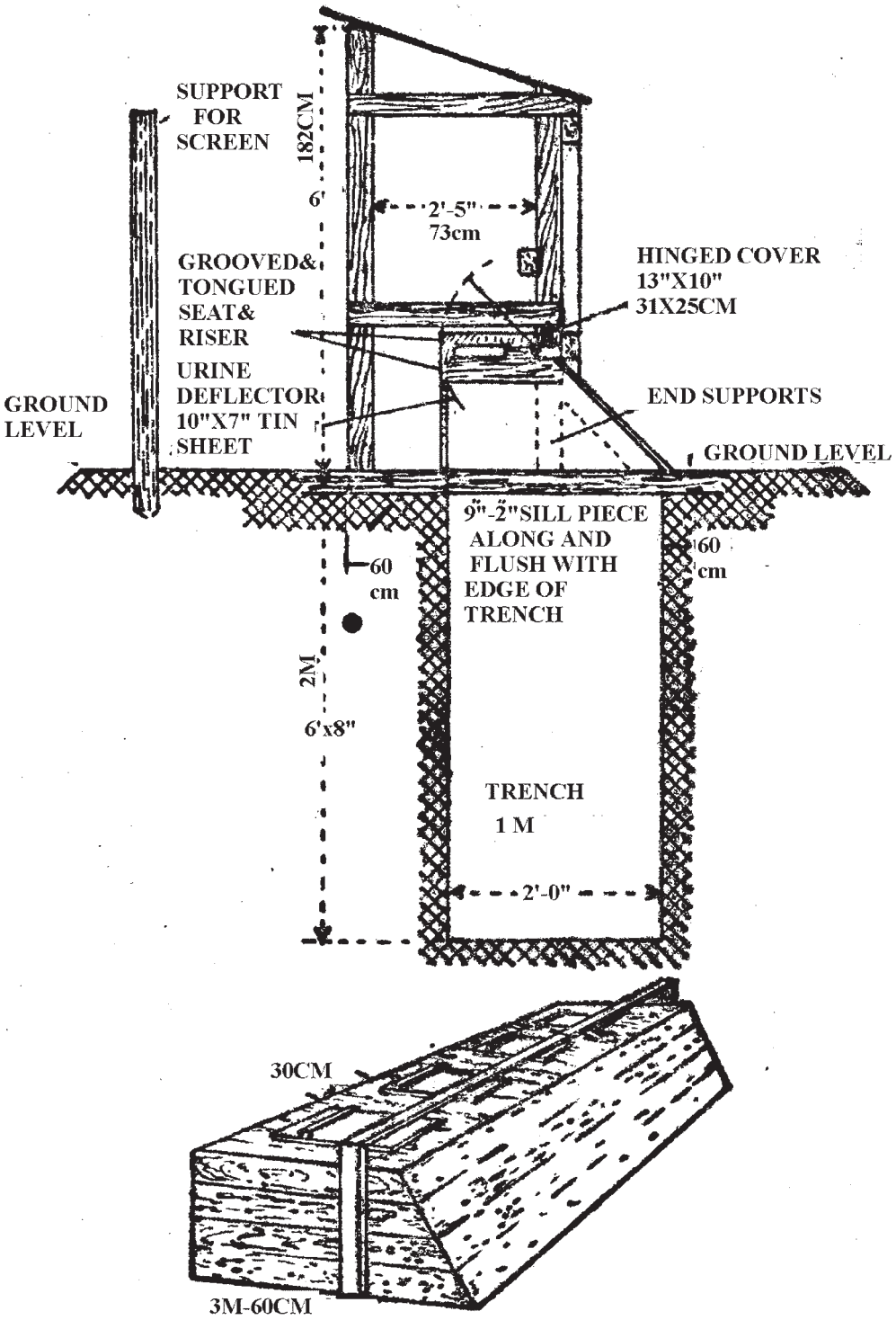
(v) Tins, bottles or other extraneous matter must not be thrown in.

(vi) Insecticide spray should be carried out on a fixed day once a week on the superstructures and 2 m all around the latrine.

**Improvised Deep Trench Latrine (IDTL)**

An improvisation of DTL may be carried out by placing the seats fitted with modified water closets, a meter and half in front of the long edge of the trench. The excreta are flushed through sewage pipes into the trench with small quantity of water. This type of latrine, therefore, is more hygienic and acceptable. It is similar in principle to the hand flushed water seal latrine evolved by the Planning, Research and Action Institute (PRAI) of the Ministry of Health, Government of India. The water seal performs two important functions. It prevents access to flies by sealing off the night soil and escape of foul gases. This type of latrine, therefore, is more hygienic and acceptable. For a

Fig - 4 : Deep trench latrine




**By Modifying DTL by incorporating water closet and water seal, problem of fly breeding and smell of DTL can be overcome.**

detailed description and functioning of the PRAI and RCA types of latrines, which have been found highly suitable for the rural masses in this country, standard textbooks may be consulted (4-9) Construction details for improvised DTL are as follows (10) :

(a) Trench

It is 1 meter wide, at least 2.5 meters deep and 3 meters long. The dimensions may vary depending on the type of soil / terrain and the level of subsoil water. The trench has to be covered with a superstructure that should overlap the trench all around up to 10 cm.

(b) Superstructure

Instead of the recommended wooden superstructure, the superstructure is made of a metallic sheet (iron / tin) of appropriate thickness which will be more hardy and long lasting. It has no apertures / lids so that there is no scope of lids getting broken / missing to cause fly breeding. A pipe of sufficient height for vent of gases is fitted at one corner of the trench.

(c) Water closets

Along the length of the IDTL on both sides, 3 to 5 Indian type water closet seats of plastic / fiber glass / chinaware are fitted. The seats should be put about 1.5 meters away from the edge on both the sides of the trench. This will lead to doubling of the number of seats available for each IDTL.

(d) Water seal

The WCs are fitted with a water seal (bend pipe) which is connected to a pipe leading into the trench.

(e) Water for flushing

Small quantity of water (2.5 to 3 liters) is sufficient to flush the WCs after each use. Water can be stored near the IDTL in a plastic tank.

(f) Shelter

A shelter with interposed partitions between the WCs using canvas / tarpaulin to provide privacy and protection from rain and sun.

(g) Storm water drain

A storm water drain dug all around the IDTL with a soakage pit at one end prevents rainwater from entering the IDTL.

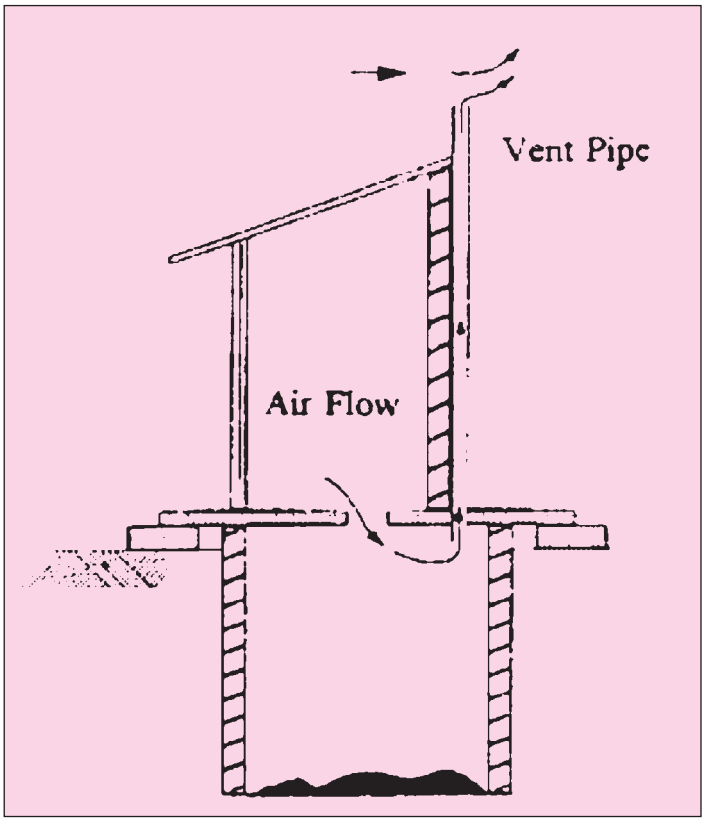
**Sanplat**

The sanplat (11, 12) is the cheapest and most basic pit latrine. It is a small concrete platform (usually 60cm or smaller), laid on top of logs or other supporting material traditionally used to cover the pit. The purpose of the sanplat is to provide a sanitary (san) platform (plat) which can be easily cleaned to limit the presence of helminths such as hookworm. Once the pit is full, the sanplat can easily be moved. However, the sanplat design does not overcome problems with odours or flies and may not be acceptable to some community members. The sanplat is best used when there is very little money for improving sanitation and where odours and flies will be tolerated.

**The VIP latrine**

The VIP (ventilated improved pit) latrine is designed (13, 14) to overcome some of the problems with traditional latrine designs, but it is more expensive than a sanplat. It has a vent pipe from the pit to above the roof of the building. When air flows across the top of the vent pipe, air is drawn up the pipe from the pit and fresh air is drawn into the pit from the building. Offensive odours from the pit thus pass through the vent pipe and do not enter the building. The location of VIP latrines is important: unless a clear flow of air is maintained across the top of the vent, the ventilation system may not be effective. VIP latrines should therefore be located away from trees or high buildings that may limit air flow. A dark vent pipe also helps the air to rise. The top of the pipe is usually covered with mosquito meshing. If the inside of the building is kept partially dark, the flies will be attracted to light at the top of the pipe, where they will get trapped and die.

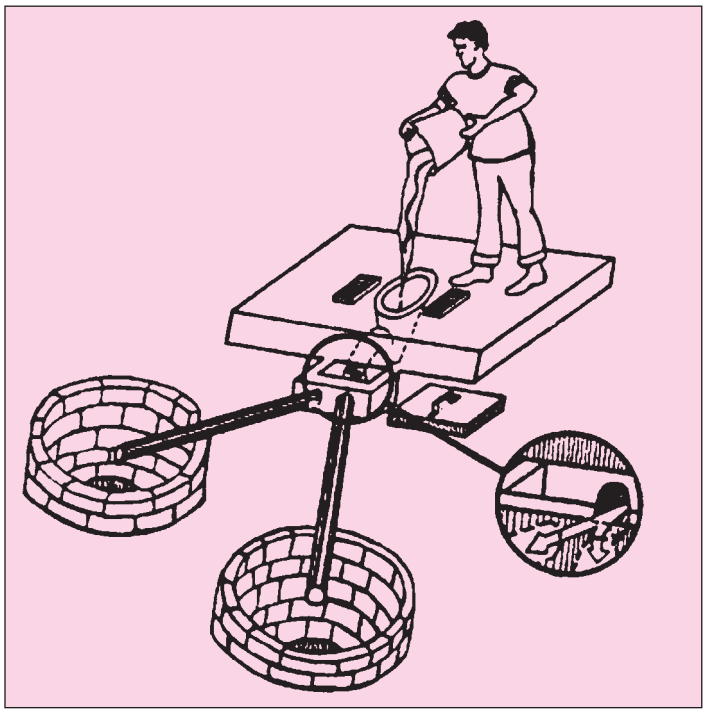
Fig - 5 : VIP Latrine




**Pourflush Latrine**

A pourflush latrine is a type of pit latrine where small volumes of water (commonly 13 litres) are used to flush faeces into the pit. They are most appropriate where people use water to clean themselves after defecating and where people have access to reliable water supplies close to the home. Solid waste should not be disposed of into pourflush latrines, as this could block the pipe and even cause it to break. A pourflush latrine has a small collection pan set in a slab. Wastes are disposed of through a section of pipe bent into a U shape (a U-bend) to maintain a water seal for reducing odour problems. A vent pipe may also be added to the pit to help with fly and odour problems. The

Fig - 6 : Double Pit Pourflush Latrine



pit of a pourflush latrine may be located directly beneath the slab or set to one side, but offset pits may require more water to prevent blockages. The pit is usually connected to a soak-pit to allow liquids to infiltrate the soil, leaving solid waste to decompose.

**Permanent Camp**

The method of excreta disposal in a permanent camp depends on the existence of sewerage system. The final treatment and disposal can be accomplished in sewage treatment plant, combination of septic tanks and subsoil irrigation/soakage pit, oxidation ponds and biolatrine. Broad principles of all these systems are given in subsequent paragraphs.

**Water Carriage System**

In this system human excreta and waste water from residential, commercial and areas are carried away by a network of underground pipes called sewers to the place of ultimate disposal. This is the method of choice for urban areas having piped water supply (15). There are two types of sewerage system, the combined and the separate systems. The combined system carries both sewage and storm water. In the separate system surface water is not admitted into the sewers. The latter is the system of choice. Although, first time the sewers in this country were laid in 1867, at Calcutta, till recently not more than 20 percent of the urban areas are estimated to have such facilities. The main problems are lack of funds, piped water supply, skilled manpower and low priority accorded to its construction. Importance of sewerage system was realized during floods at Mumbai in 2005 when heavy rain in Mumbai caused floods due to choked sewerage system leading to heavy economic losses and outbreak of Leptospirosis subsequently (16).

Components of Water Carriage System

It consists of house hold sanitary fittings, house sewers, street sewers and sewer appurtenances: -

**(a) Household Sanitary Fittings**

These include water closets, urinals, washbasins, bathtubs along with their plumbing systems.

**(b) Soil Pipes**

These are pipelines, which carry excreta from the water closets to the house drain. They are fitted with outlet ventilators for the escape of foul gases and hence are placed outside along rear walls of the houses and are carried above the roof tops.

**(c) House Drain**

It is an underground iron or stoneware pipe usually of 10 cm diameter and is laid in the courtyard 15 cm below the ground level on a bed of cement concrete mix with sufficient gradient towards the public sewer. It carries away the discharges from the household sanitary fittings to the street sewers.

**(d) Public Sewer**

It is a network of underground pipelines varying in diameter from 22 cm to 3 m for carriage of sewage from domestic, industrial and commercial areas to the place of final disposal. While laying the pipelines sufficient gradient is to be ensured for self- cleansing velocity of sewage. This velocity varies from 60 cm to 90 cm per second.

**(e) Sewer Appurtenances**

These are manholes and traps installed in the sewerage system: -

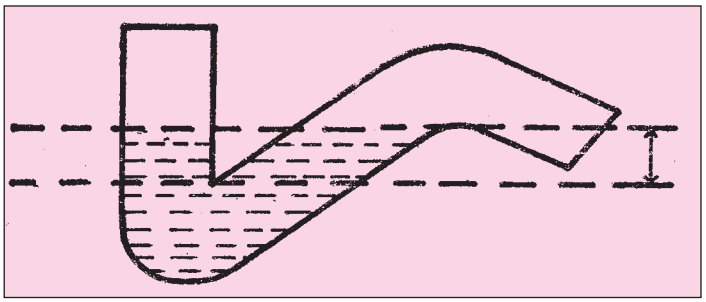
(i) Manholes

These are opening built in the sewers for the purposes of repairs and cleaning. They are placed wherever there is change in the direction of sewers, at the junction of two or more sewers and at a distance of 100 meters in the long, straight run of the sewers. Workers entering manholes are liable to gas poisoning and asphyxiation unless due precautions are taken.

(ii) Traps

These are devices designed to prevent the entry of foul gases inside the house and to remove sand, grit, grease etc. from sewage. Traps are placed at three points under the water closet, at the junction of the house drain and the street sewer and where the surface water enters the sewers. There are several designs of traps. The simplest one is a bentpipe containing water as a seal (Fig. - 7). The water seal in a trap is the distance between the highest

Fig - 7 : Water seal



level of water in the trap and the lowest point of the trap's concave upper surface.

## Composition of Sewage

It contains 99.9 percent water and 0.1 percent solids, which are partly organic and partly inorganic. Sewage is teeming with living organisms, some of which may be pathogenic. The strength of the sewage may be expressed in terms of biochemical oxygen demand, chemical oxygen demand and suspended solids.

### (a) BOD( Biochemical Oxygen Demand)

It is defined as the amount of oxygen absorbed by a sample of sewage during a specified period, generally 5 days at a specified temperature, usually 20°C for aerobic digestion. This is the most important test carried out on sewage. A sewage with a BOD value of 300 mg/l (300 ppm) or above is termed strong while that of 100 mg/l (100 ppm) or below is termed weak.

### (b) Chemical Oxygen Demand (COD)

The COD is the amount of oxygen required to oxidize the organic matter by use of dichromate in an acid solution and to convert it to carbon dioxide and water. The value of COD is always higher than that of BOD because many organic substances can be oxidized chemically but cannot be oxidized biologically. Commonly, BOD is used to test the strength of untreated and treated municipal and biodegradable industrial wastewaters. COD is used to test the strength of wastewater that is either not biodegradable or contains compounds that inhibit activities of microorganisms.

### (c) Suspended Solids

If the amount of suspended solids is 100 mg/L or more, it is termed strong.

## Sewage Purification

The aim of sewage treatment is to convert an offensive and potentially dangerous mixture into an inoffensive effluent and sludge which can be disposed off safely and without causing nuisance into rivers, into the sea, or on land and should even be capable of being reused to replenish non-potable water supplies and to provide water useful for agriculture in suitable circumstances and with due safeguard. The conversion of the complex organic matter in the sewage to simpler substances takes place by two processes, viz .aerobic and anaerobic. The aerobic method requires a continuous supply of free dissolved oxygen for the aerobic microorganisms to breakdown the organic matter into simpler substances such as carbon dioxide, ammonia, water, nitrite, nitrate, sulphate etc. The anaerobic process is highly effective where the sewage is highly concentrated and contains plenty of solids. Hence, this method is usually gainfully used for digestion of sludge in sewage works. The end products of anerobic decomposition are methane, ammonia, carbon dioxide, hydrogen etc.

### Sewage Treatment Plant

The main processes comprise of physical treatment to remove solids from the liquid and biological treatment brought about by aerobic and anaerobic bacteria. While the physical treatment is often referred as primary treatment, the biological treatment process is called secondary treatment. Treatment rendered in addition to the conventional secondary treatment for improving further the quality of effluent is termed 'tertiary treatment' or advanced waste treatment process. The sludge is also given treatment for stabilization and dewatering. Chemical treatment by the addition of coagulants may be used to assist sedimentation and sludge treatment. Flow diagram of a modern sewage treatment plant is show in (Fig. - 8).

Primary Treatment

Fig - 8 : Flow diagram of a modern sewage treatment plant

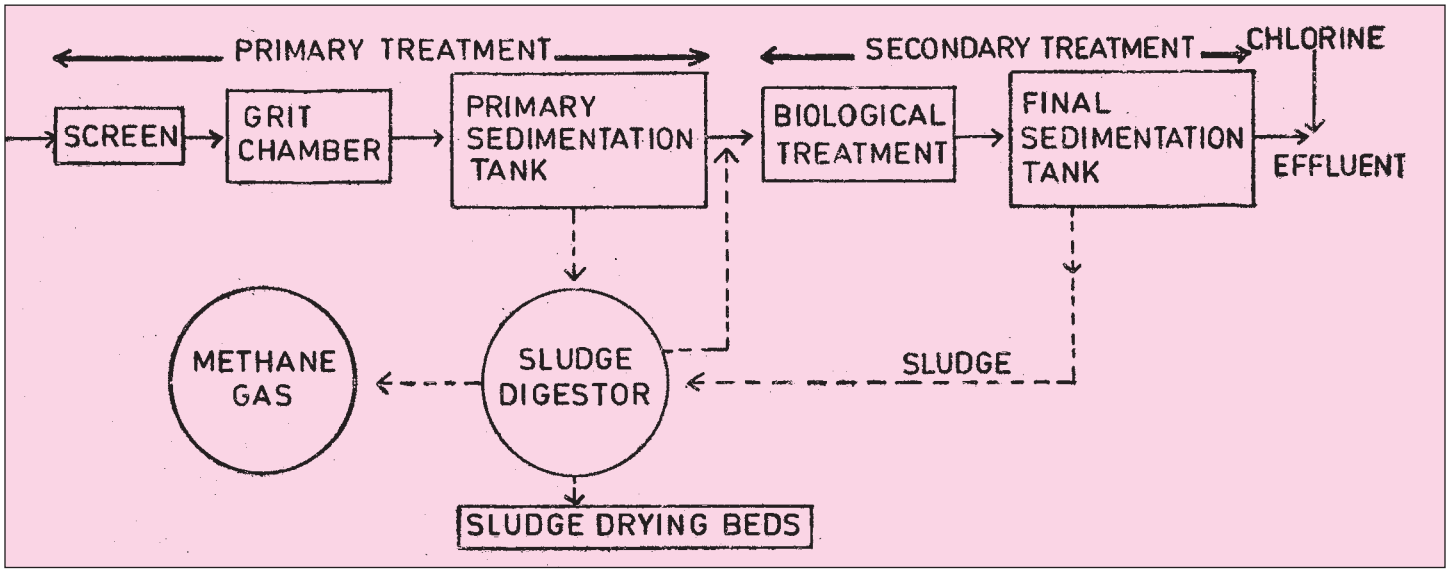
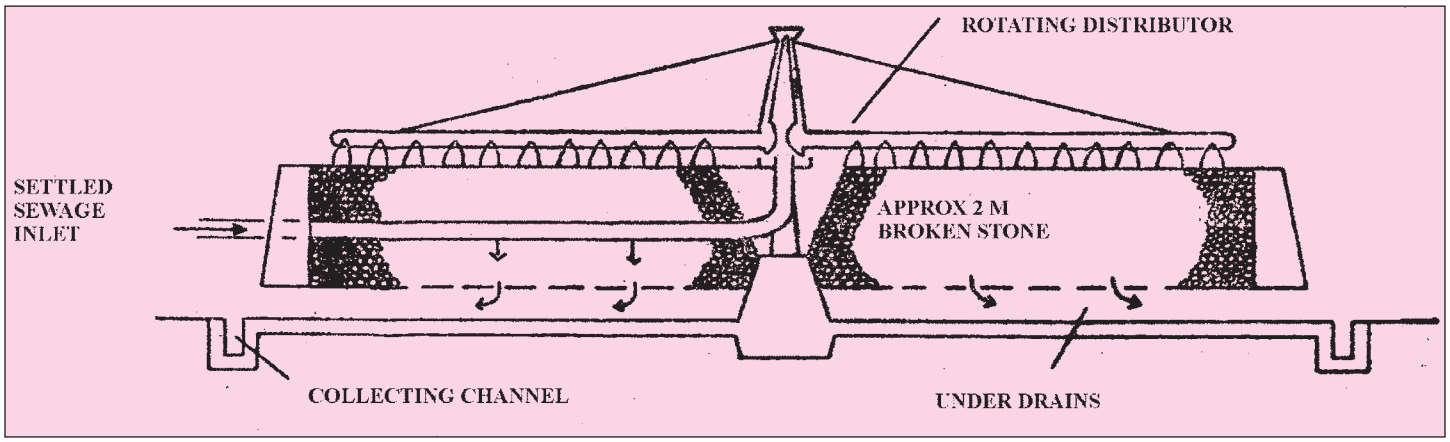


Fig - 9 : Diagrammatic section of a percolating filter for biological treatment of sewage




**(a) Screening**

It is the first step in the sewage treatment for removing the larger solids. The raw sewage is passed through bar-screens with openings of 8 to 10 cm between the bars placed across the inflow channels. The screenings can be manually raked from the screens and buried.

**(b) Grit Removal**

Combined sewerage systems carry grit from roads or other debris from general sullage and fine granular inorganic material. This material which otherwise causes heavy wear in pumps and tends to settle out and cause difficulty in later treatment processes must be removed in grit chambers and channels. The sewage is allowed to flow in a channel at a controlled velocity of about 30 cm/s, which is slow enough for the heavy non-organic solids to settle down but fast enough to carry the lighter organic solids forward. The grit is removed periodically, washed free of organic matter and dumped on waste land for reclamation or to fill excavations and quarries without causing nuisance.

**(c) Sedimentation**

It is the third step to remove as much of the organic solids as possible from the liquid sewage. The same principles as these for the treatment of water are employed. Sedimentation tanks may be rectangular with a horizontal flow, hopper-shaped with vertical flow, or circular with radial centrifugal flow. Slow moving paddles to encourage flocculation of solids and increased settling velocities may be incorporated. The sewage is retained in sedimentation tanks for 4 to 12 hours. The process removes 50-60 percent of the suspended solids and about 40 percent of the BOD of the sewage. The settled sludge is removed by mechanical scrapers to hoppers from which it is drawn off either continuously or at frequent intervals to prevent it from becoming septic. The sewage is then treated biologically.

Secondary Treatment

The secondary or biological treatment of sewage essentially involves the oxidation of suspended and dissolved organic matter by aerobic bacteria. Carbonaceous matter is converted to carbon dioxide and water, and nitrogenous material to ammonia, nitrites, and nitrates. Fungi, algae, ciliate protozoa, insects and worms supplement the bacterial digestion. The main processes employed for biological treatment are as under:-

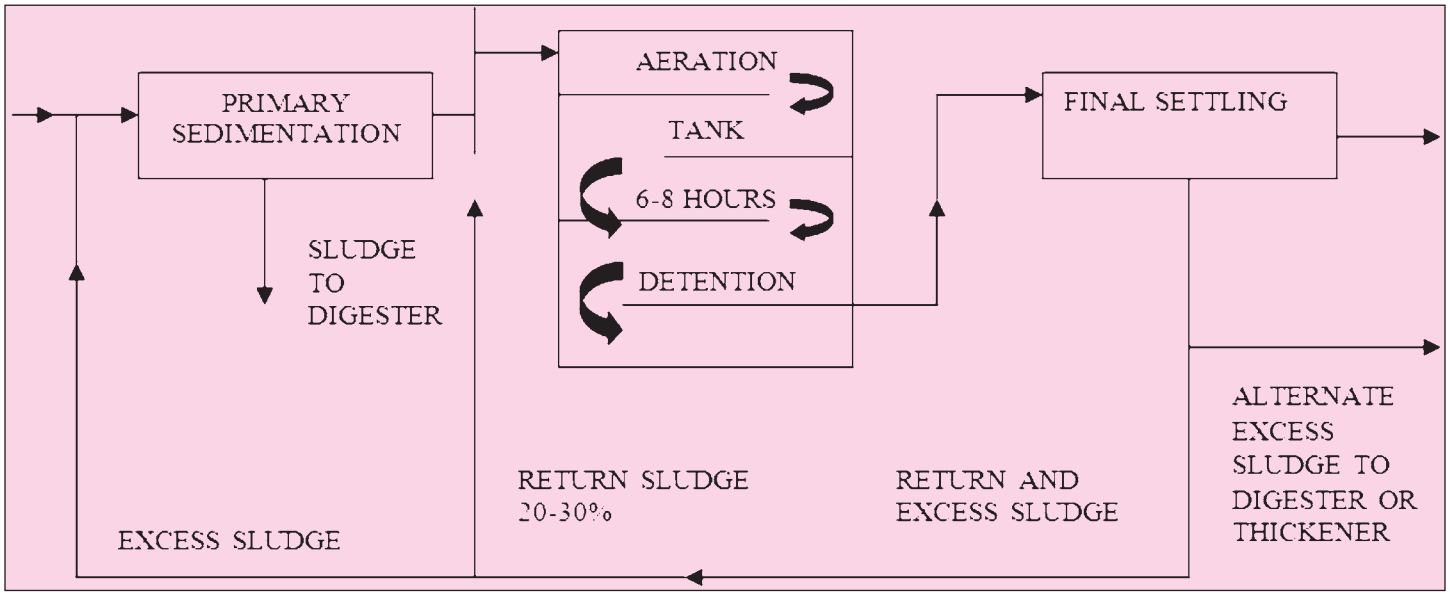
**(a) Percolating or Trickling Filters (Fig. 9)**

These consist of beds 1½ to 2 m in depth, made of stone, cinders, slag, or brick pieces, other impervious material generally from 3 to 8 cm in size over which effluent from primary sedimentation tanks brought in through a central pipe is intermittently percolated. The beds are usually circular with rotating distributors, or rectangular with horizontally gliding distributors and sometimes irregular in shape with fixed spraying nozzles. A slimy 'zoogleal' film of aerobic bacteria and other organisms develops on the surface of the stones. In trickling downward through the bed, the sewage donates its organic content to the vital zoogeal film for its nutrition and in return receives soluble organic salts produced by oxidation. Access of air through the filter is essential for the zoogleal fauna to oxidize the organic matter. Percolation is followed by final settling in humus tanks to remove the particles of the zoogleal matter and innocuous debris. The humus is separately disposed off or can be returned to the primary sedimentation tanks from which it is removed for treatment with primary sludge as described below. A competent percolating filter plant reduces the BOD of the raw sewage by 85 to 95 percent. A higher rate of treatment can be achieved by returning some of the filtered effluent to mix with the influent and reapplying it on to the filter, or by 'alternating double filtration', in which the sewage passes through two filters in series, their orders being reversed daily. Deep enclosed filters aerated by forced draught can also treat sewage at two or three times the normal rate while maintaining a high quality effluent

**(b) Activated Sludge Process**

In this process of biological treatment of sewage, the high BOD of the raw sewage from the primary sedimentation tank is satisfied by aerating it after intimately mixing with some of the sludge collected from the final sedimentation tank. The sludge from the final tank is called 'activated sludge' as it contains the active aerobic bacteria. The mixture is called 'mixed liquor'. In the presence of ample oxygen the aerobic bacteria utilize the unstable oxygen

Fig - 10 : Conventional activated sludge process




demanding solids in the raw sewage such as food materials and convert them into stabilized, odourless compounds having nil or very little oxygen demand. The process requires air supply and thorough mixing which brings about an intimate contact of the organic solids with oxygen and aerobic bacteria. First the effluent from the primary sedimentation tank is mixed for an hour or two with the activated sludge returned from the final sedimentation tank to form the 'mixed liquor', then the oxygenation of the mixed liquor is carried out by 4 to 6 hours aeration by one or more of the methods described below. The plant consists of a long channel or of a series of chambers through which the sewage passes while aeration proceeds. The aeration is followed by settling in tanks. The sludge is removed and the clear purified final effluent flows out for safe discharge. Most of the sludge is returned to be mixed with the sewage from the primary settling tanks as described above. Thus there is a continuous circulation of activated sludge carrying aerobic bacteria and protozoa, which are kept active by the constant replenishment of organic food and oxygen (Fig. 10). The common methods of aeration employed in the activated sludge process are :-

(i) Diffused Air System

Compressed air is blown through porous plates, domes or pipes fixed at the bottom of aeration channels.

(ii) Simplex Surface Aeration

Motor driven propellers are used to mix and break up the sewage into fine spray, bring it in contact with air and induce circulation in hopper-bottomed chambers.

Sludge Treatment

The sludge from primary or final sedimentation tanks contains 90 to 95 percent water. This high water content needs to be reduced for converting the sludge to a solid condition in which it may be used or disposed of harmlessly. Possible methods of dealing with sludge of which one or more or even all may be utilized in any given situation are shown in Fig. 10. The most profitable sludge treatment is anaerobic digestion. The sludge is pumped daily into enclosed digestion tanks in which anaerobic fermentation proceeds with the production of gas comprising about 70 percent methane and 30 percent carbon dioxide. This sludge gas is a valuable fuel to supply all power needs for pumping, air compression, electricity generation, and heating on the activated sludge plants. The gas may also be compressed and used as vehicle fuel. For most effective digestion and gas production, the digestors are heated to about 32° C. Digestion converts much of the organic solids to gas and soluble matter, and so reduces the quantity of solids to be handled eventually. Digested sludge is a black liquid with a tarry odour and is more amenable to subsequent de-watering than undigested sludge. Apart from digestion, the main object of sludge treatment is to de-water it so that it can be handled as relatively compact, moist solid rather than as a much greater volume of liquid with a low solid content. The following processes are used for de-watering the sludge and may be applied to either raw or digested sludge.

**(a) Air Drying**

Liquid sludge, after digestion, is placed on sand beds for air drying. Percolation into the sand and evaporation are the chief processes involved in the dewatering process. Air drying requires dry, relatively warm weather for greatest efficiency, and some plants have a greenhouse-like structure to shelter the sand beds. The semisolid sludge, which is left, is lifted manually or mechanically. Dried sludge in most cases is used as a soil conditioner; sometimes it is used as a fertilizer because of its 2 percent nitrogen and 1 percent phosphorus content.

**(b) Lagooning**

Sludge is stored in open basin, a few metres deep to allow settlement of solids. Clarified liquid may be drawn off,

and.the solids are eventually dug out.

**(c) Filter pressing**

In this, moisture is squeezed out through a filter cloth by mechanical pressure.

**(d) Vacuum Filtration**

Water is extracted by applying a vacuum to the inside of a filter drum, rotating partially submerged in a trough of the sludge.

Sewage sludge contains useful nitrogen and phosphorus, and although rather deficient in potassium, it forms a moderately good fertilizer. Undigested primary sludge and undigested activated sludge are easier to apply to land, and their humus content improves the soil. In suitable circumstances sewage sludge may be composted with municipal refuse. Where sludge cannot be used either as a fertilizer or for composting, or, in a few cases, for recovery of byproducts, it is usually tipped for land reclamation, dumped at sea, or incinerated.

Disposal of Effluent

The effluent after treatment is usually discharged on land or into bodies of water :

**(a) Disposal on Land**

If suitable land is available the effluent can be used gainfully for irrigation purposes. Over the past 20 years, there has been a considerable revival of interest in the use of wastewater for crop irrigation in arid and semiarid regions as a result of the scarcity of alternative water supplies and the need to increase food production. Reuse of treated effluent for the irrigation of crops and urban 'green spaces' (such as parks and golf courses) has expanded significantly in many countries. The viability of organisms in the soil or on crops irrigated by wastewater depends on the type of organism and its resistance to environmental factors such as climatic conditions, soil moisture, and the amount of protection provided by crops. Enteric viruses appear to be particularly persistent under natural conditions. Sewage farming or spread of treated effluent on farms is still used in many countries, particularly those having low rainfall and high temperatures. In wetter, cooler climates, the area of land required may become prohibitive. Enteric viruses have been found in raw sewage in concentrations of 1-10 per ml in various countries. Limited studies have shown that ingestion of 1 TCID of poliovirus can cause infection in man, but it is not known as to what percentage of persons would become infected with such a low dose or what size of infective dose would be needed for other enteric viruses. Only if water has been treated to such a degree that essentially all ammonia and nearly all residual organic matter has been removed, is it possible to achieve the free chlorine concentration of 0.5 mg/L for one hour recommended by WHO for effective inactivation of enteric viruses. It has been reported from India that hookworm and other enteric infections are much commoner among workers on sewage farms than among the farming population in general. The local custom of walking barefoot is a major contributing factor in the spread of some of these diseases.

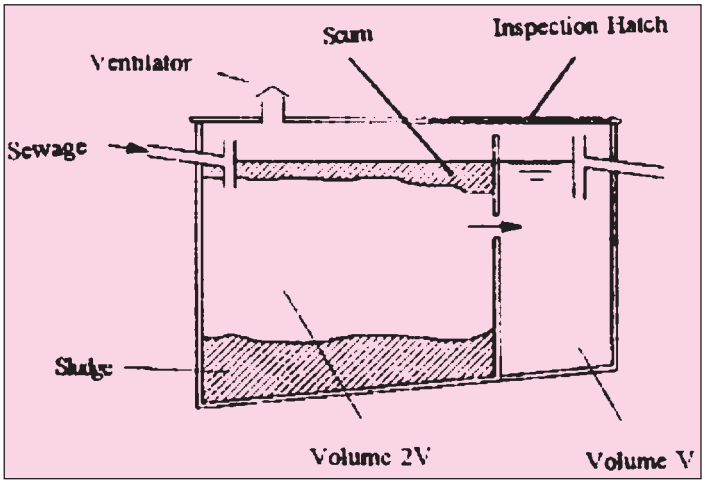
**(b) Disposal by Dilution**

Discharging the effluent into bodies of water such as rivers, streams, lakes and sea for the purpose of dilution as well as oxidation of the impurities by the dissolved oxygen in water is termed "disposal by dilution". The BOD content of the effluent and diluting capacity of the bodies of water are the important considerations. The BOD standards of effluent laid down by different countries, in particular, is towards lower values as newer chemicals which are increasingly discharged into the sewerage system may not be removed adequately by biological treatment. Consequently, the effluent may contain toxic substances, which may be harmful to man either directly or indirectly through the aquatic flora and fauna. In UK, the effluent standards have been raised to 10 mg/L each of BOD and 30 mg/L of suspended solids, laid down in 1908, by the Royal Commission. Even the present standards are not considered very satisfactory. In times of drought, the water supply source for Agra, consists almost entirely of partially treated sewage from New Delhi, 190 km away. The inadequacy of traditional methods of water treatment may perhaps be indicated by the outbreaks of infectious hepatitis in New Delhi, in 1955-56, when there were 30,000 cases, and in 1958. At the time of the outbreak, drought conditions prevailed, and the water abstracted from the river was estimated to contain about 50% of sullage water. When rivers contain a high proportion of effluents, the production of water from them should be regarded as analogous to the direct recovery of water from a sewage or industrial effluent, and safeguards appropriate to this situation should be imposed. Some rivers carry such a high proportion of treated and untreated wastewater that their use as a water source can be considered as essentially wastewater reuse.

## Septic Tank System

The efficiency of a septic tank system is certainly inferior to the sewage works but the former is fairly satisfactory for disposal of excreta and liquid wastes from individual houses, groups of houses and institutions having adequate piped water supply but lacking the facilities of a public sewerage system. It is much cheaper, quicker and easier to provide and maintain than sewage works. Hence it is often favoured in the Armed Forces permanent camps.

Fig - 11 : Septic Tank



Septic tanks are commonly used for individual households in low density residential areas.

**(a) Construction**

It consists of an underground concrete tank usually double chambered. A tank with more than two chambers is expensive and has no additional advantage. Even a single chambered tank has been found satisfactory for a small installation. The latrines should preferably be grouped together with one or more tanks placed close to a group. The sewers leading from the latrines to the tanks should have manholes at every 100 m and at every change of direction. Two or more medium sized tanks arranged in parallel instead of one large tank are preferable as these facilitate removal of sludge without disturbing the functioning of the system. The capacity of the tank should be at the scale of 13 /12 users with a minimum size of 3mx3m. The length of the tank should be a minimum air space of 30 cm above the liquid level. The septic tank is covered by a concrete slab with a manhole in it. The aeration chamber should be ventilated by one or more shafts, the opening of which should be screened with wire gauze. The inlet and exit pipes to the tank should be trapped. Agricultural drains are laid from the exit pipe at a suitable fall in a herring-bone pattern, 30 to 60 cm below the surface of the soil. The length of the agricultural drains per user should be 60 cm. Alternatively the effluent may be disposed into a soakwell. Septic tanks are commonly used for individual households in low density residential areas. The guiding principles in designing a septic tank are :-

(i) Provide sufficient retention time for the sewage in the tank to allow separation of solids and stabilization of liquid;

(ii) To provide stable, quiescent, hydraulic conditions for efficient settlement and floatation of solids.

(iii) To ensure that the tank is large enough to store accumulated sludge and scum

(iv) To ensure that no blockages are likely to occur and that there is adequate ventilation of gases.

**(b) Functioning**

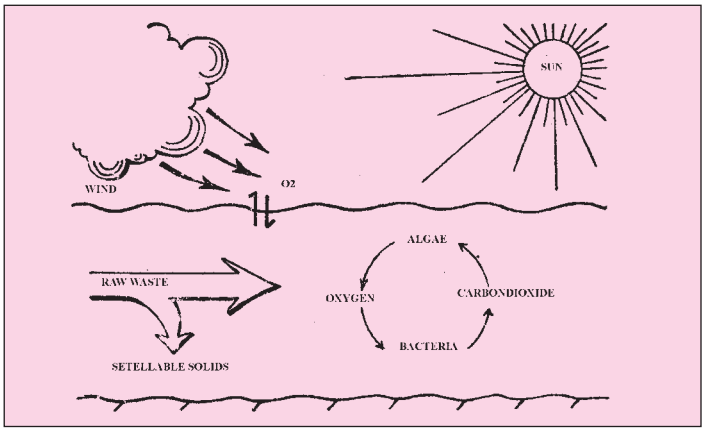
The action in a septic tank is by the biological process of anaerobic and aerobic digestion. The crude sewage on entry to the anaerobic chamber is allowed to stand for 2 to 3 days and is acted upon by the anaerobic micro-organisms. A colloidal solution is formed which is only partially digested and hence has an offensive smell. The complete oxidation and mineralization of the colloidal matter is carried out by the aerobic micro-organisms in the aerobic chamber and or in the agricultural drains. Though most of the pathogens, after having undergone aerobic treatment, die but the cysts and ova of the intestinal parasites survive. The effluent, however, loses most of its offensive smell. The minerals are absorbed from the soil by the plants. Many of the problems of septic tanks arise because inadequate consideration is given to the disposal of the tank effluent. A principal aim of septic tank design is to achieve hydraulically, quiescent conditions within the tank to assist the settlement by gravity of heavy solid particles. Large surges of flow entering the tank may cause a temporarily high concentration of suspended solids in the effluent owing to disturbance of the solids, which have already settled out. Grease, oil and other light materials float up, forming a layer of scum, which can become quite hard. The liquid moves through the tank sandwiched between the scum and sludge. The use of ordinary household soap in normal amounts is unlikely to affect the digestion process of a septic tank. The wastewater to septic tanks may be waste from toilets only, or may also include sullage. After desludging, the effective liquid retention time is greater because liquid then occupies the regions previously full of sludge and scum. The shape and size of septic tank should be such that there is achievement of even distribution of flow so that there are no dead areas and no "short-circuiting", i.e., the incoming flow shooting through the tank in less than the designed retention time. Surges and turbulence reduce the efficiency of settlement and can cause large amounts of solid matter to be carried out in the tank effluent.

**(c) Maintenance**

The operation and maintenance of a septic tank is simple. To commission a septic tank it has to be first filled with water and then seeded with a bucketful of sludge from another tank or a DTL. Not less than 25 L of water per day per user must enter the tank. Use of soap water and chemicals should be avoided. Sludge from the tank is to be bailed out once in a year or two. The tank cover or roof, which usually consists of one or more concrete slabs, must be strong enough to withstand any load that will be imposed. Removable cover slabs should be provided over the inlet and outlet. Circular covers, rather than rectangular ones, have the advantage that they cannot fall into the tank when removed. Routine inspection is necessary to check whether desludging is needed, and to ensure that there are no blockages at the inlet or outlet. A simple rule is to desludge when solids occupy between one-half and two-thirds of the total depth between the water level and bottom of the water tank. The most satisfactory method of sludge removal is by vacuum cleaner.

## Oxidation Pond

Fig - 12 : Oxidation Pond



Also known as the "Redox Pond, Sewage Lagoon and Waste Stablisation Pond", Oxidation pond is the cheapest method. It is an open shallow pool upto 5 feet deep with an inlet and outlet. The presence algae, bacteria decomposing organic matter and sunlight are mandatory for the functioning of oxidation pond. Bacteria oxidises sewage to carbon dioxide, ammonia and water. The algae, with the help of sunlight utilises carbon dioxide, water and other organic substances for their growth. Algae releases oxygen during photosynthesis, which is used by bacteria. So the pond works as a aerobic system during the sunlight hours, in night hours, the pond works anaerobically too, especially the lower layers. The effluent can be used for farming or can be discharged into rivers after suitable treatment. If the pond runs well, it is an accepted method for sewage disposal in small communities.

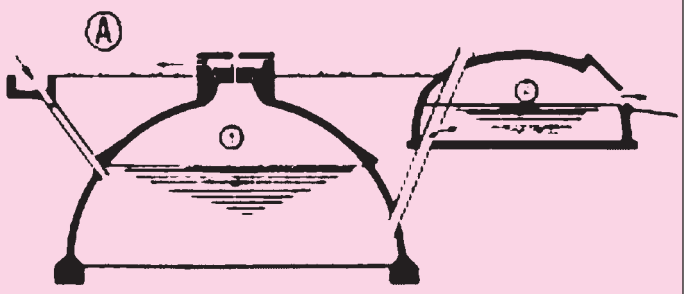
### Oxidation Ditch/Aerated Lagoon (17)

This process makes use of mechanical rotors for extended aeration and thus minimizes the requirement of land area. The land requirement in this method is barely one tenth of oxidation pond (Fig. 12).In primary sedimentation, a reduction of 30-40% in the number of coliforms is obtained, while in most full biological treatment processes the reduction is between 90% and 95%. Stabilization ponds with a 30-day retention period have shown reductions from 99% to 99.9%. Most vegetative bacterial pathogens appear to be removed in the same proportion as coliforms. Certain helminthic eggs may be effectively removed by primary sedimentation and even more effectively by stabilization pond treatment of 5-7 days duration; viruses are less effectively removed. Coagulation and filtration remove 98 to 99.9% of viruses. High standards (< 100 coliforms / 100 ml in 80% of samples) can often be obtained after complete biological stabilization, followed by heavy and carefully controlled chlorination (15-20 mg/l of chlorine with contact periods of 1-2 hours). The treatment was also effective in inactivating amoebic cysts. When treating a sewage of normal characteristics, the overall reduction of BOD and suspended solids to be expected from a conventional combination of primary and secondary treatment will be 85-95%. In a properly designed and operated pond, well over 90% of the polluting matter (in terms of its BOD) can be removed and the number of microorganisms much reduced. Ponds have the advantage of providing a fairly high degree of treatment at a relatively low cost, with little call for equipment or skilled operators.

### Biolatrine (Biogas plant)

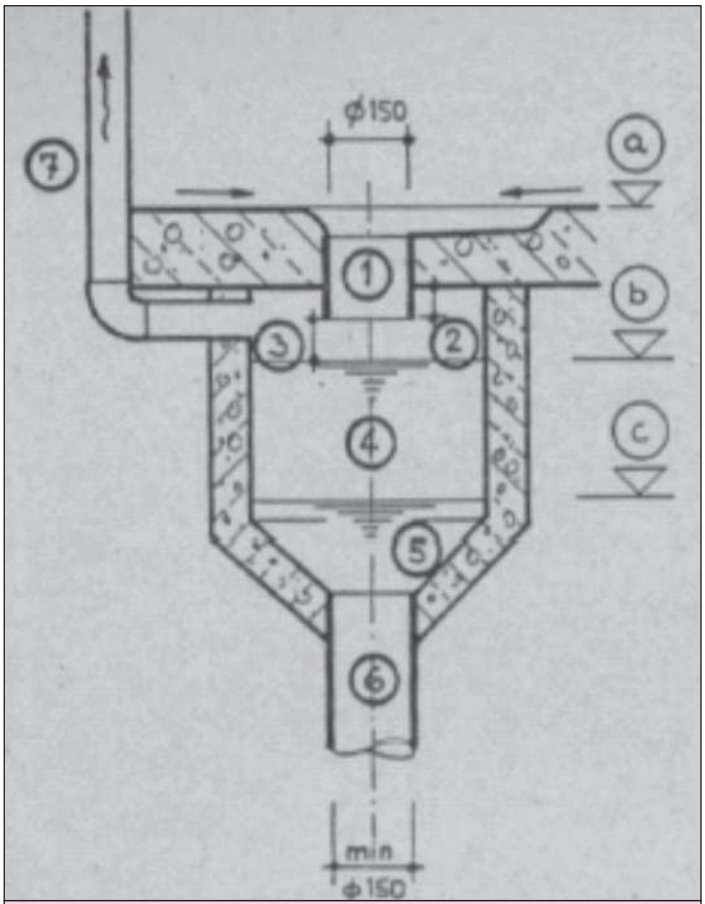
The biolatrine is in principle the centre part of a sanitary biogas unit for safe human faeces disposal, degrading the excreta anaerobically, thus producing biogas and digested substrate that may be utilized as fertilizer (18 - 20). The main focus is however mostly on sanitary aspects, i.e. clean toilets with low maintenance demand, rather than a high gas productivity. The soil conditions should however allow effluent and slurry absorption so as to prevent a disposal problem. Biolatrines are designed as integrated fixed-dome biogas plants (see Fig. 13), where up to 6 latrines can be installed around a dome. The main advantage of biolatrines is that they are generally run without water (except for the start-up phase), i.e. also not in connection with flush toilets, thus substantially

Fig - 13 : Fixed dome biogas plant




1) Digester 2) Expansion chamber

Fig - 14 : Construction details of toilets for a biolatrine




a) toilet floor b) highest and (c) lowest slurry level; (1) inlet pipe; (2) bottom of rim of inlet pipe; (3) inlet piece always above highest slurry level; (4) feeding chamber; (6) down pipe; (7)vent pipe.

reducing water demand and related costs. The urine will provide sufficient liquid for the substrate to be able to flow. The toilet chamber is connected to a vent pipe corresponding to those of the VIP latrine. For the main design criteria of the toilet, see Fig.14. Due to a required minimum flow rate, a biolatrine may only be an appropriate solution if at least 25 people are connected to its use. The excreta of 25 people will produce an average of about 1 $m^3$ of biogas per day (40 l per person and day), representing the approximate cooking energy demand of one household. Speaking of institutions with 500 or more attendants (depending on the type of institution and the mean time people spend at the location), the produced biogas may supply sufficient energy for a canteen. Application may occur for institutions like schools, prisons, religious centres, or for public facilities like markets. In Ralegaon Siddhi (Ahemednagar) Maharashtra community latrines has been connected to biogas plant. Biogas produced is being distributed to houses for cooking purposes .

## Aquaculture

Acting on the principle that sewage is not just waste water but also a source of nutrients, an experimental plant in operation since 1994 treats sewage with aquatic weeds and fish. One million litres of primary treated sewage a day, sits first in ponds containing duckweed, then in ponds stocked with carp and prawns. After five days, water quality has improved to the point where it may be used for agriculture, although not for drinking.Although faecal coliforms were found to be present in the system and in the guts and gills of fish fed on sewage, none were found in fish muscle. The sale of fish fattened in the sewage ponds for 8 to 12 months almost offsets the operating cost of the plant, leaving a net cost of 15 000 rupees a year, about US$385. The plant, which covers half a hectare, is run by two men.

The Aquaculture Sewage Treatment Plant (ASTP) cost 1.5 million rupees (US$38 000) to build, compared with 5 million to 6 million rupees (US$128 000 to US$154 000) for a standard Indian sewage treatment plant and 10 million rupees (US$256 000) for a comparable Western plant. The plant, located in Cuttack, Orissa, eastern India, is the brainchild of the Central Institute of Freshwater Aquaculture (CIFA), founded in 1986 with FAO's assistance. Cuttack, a city of 700 000, would need a plant with 60 times the capacity of the experimental station to treat its daily sewage output, currently untreated. A National Workshop on Sewage Treatment through Aquaculture, held in 1997 at CIFA, endorsed the plant design and recommended that more state governments adopt it (21).

## Management of Human Excreta at High Altitude areas

The problem of waste disposal, especially the faecal matter in high altitude and snow bound areas is rather complicated due to extreme cold temperatures causing difficulty in maintaining suitable thermal environment at which microorganisms effecting degradation can survive, multiply and remain active. A number of trials are in progress to find a suitable solution to this problem. In non-glacier regions the waste is collected and used as fertiliser in the field. Incineration and chemical treatment of human waste has also been attempted to overcome the problem. However, all these methods are either unhygienic or not practically viable alternatives.

Biological treatment is an attractive approach for solving the problem, but decreased metabolic activities of the micro-organisms, freezing of the substrate, non-availability of conventional energy sources and hilly terrains are some of the hurdles which need to be solved to make the process practically possible. DRDO has developed an innovative technology for disposal of human waste in eco-friendly manner at high altitude locations where temperature drops to -40°C or lower. The process culminates into treated effluent, which is free from pathogens and is also environmental friendly. During waste treatment, inflammable biogas (methane) is generated as a byproduct, which can be used for various energy intensive activities like cooking, water and room heating (22).

Fig - 15 : Temperature controlled Biodigester

The technology has two major components, low temperature active inoculum and temperature-controlled biodigester.A consortium of anaerobic bacteria has been formulated and adopted to work at temperature as low as 5°C. This acts as inoculum (seed) and converts the organic wastes into methane and carbon dioxide. The anaerobic process inactivates the pathogens responsible for water-borne diseases. Biodigester serves as reaction vessel for biomethanation and provides the anaerobic conditions and required temperature for the bacteria. The optimum temperature is maintained by microbial heat.

**Summary of Disposal of Human Excreta**

(a) **Temporary camp:** Shallow trench latrine, sanitary latrine based on improvised and removable Indian type sanitary water closet, incinerator latrine

(b) **Semi permanent camp:** Deep trench latrine, Improvised deep trench latrine, dug well latrine, ventilation improved pit latrine, Pour flush water seal latrine

(c) **Permanent camp:** Sewerage system, Combination of septic tank and soakage pit/subsoil irrigation, oxidation pond, biolatrine, treating sewage by aquaculture

**Salient Features**

Suitable for subzero temperature of Himalayan region as well as glaciers

(a) No dependence on the limited and costly conventional

energy sources

(b) Easy to transport and install in hilly terrains

(c) Maintenance free, continuous biological process

(d) Eliminates the pathogens

(e) Generates odourless and inflammable biogas which can be used for cooking

## Disposal of urine

### Permanent Camp

In a permanent camp having water carriage system, porcelain, cement or masonry urinals connected to the sewers should be insisted upon. If water carriage system does not exist, the urinals should be drained to a covered soakage pit.

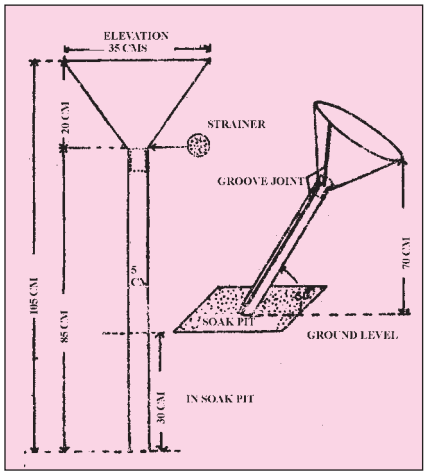
### Semi-permanent Camp

In a semi-permanent camp the standard type of funnel urinal or porcelain urinal connected to a covered soakage pit should always be used for disposal of urine.

### Temporary Camp

In a temporary camp improvised tin urinal placed over soakage pit may be used. A ghee tin with perforated bottom and half buried in a soakpit is the simplest of these types. A trench half a meter broad, 4 to 5 m long, dug down to 15 cm to 18 cm filled with brickbats or stones may be used in camps on the line of march. At the time of closing of the camps, the trenches should be filled with earth and layer of slaked lime spread over these.

Fig - 16 : Funnel Urinal




Funnel Urinal

The standard one can be made out of three ghee tins. The entire length of the urinal is 105 cm, of which the shaft is 85 cm and the funnel top in its central axis is 20 cm. The diameter of the funnel top is 35 cm, which tapers gradually to 5 cm where it joins the shaft. The outer surface of the entire urinal and the inner surface of the shaft should be treated with coaltar. The inner surface of the funnel may be painted white for easy visibility at night. A strainer of 5 cm diameter and made of a perforated tinplate is soldered inside at the junction of the funnel with the shaft. The urinal should be installed over the soakage pit so that 30 cm of the shaft is buried. That will leave 55 cm of the shaft and the funnel top above the ground. The urinal should be fixed inclined in such a way that the user can stand just outside the soakage pit. This is ensured by placing the shaft at an angle of 25° to 30° with the vertical axis. The edge of the funnel should not be less than 60 cm nor more than 75 cm above the ground. Naphthalene balls should be left in the funnel to minimize bad odour. A hessian cloth enclosure will ensure privacy.

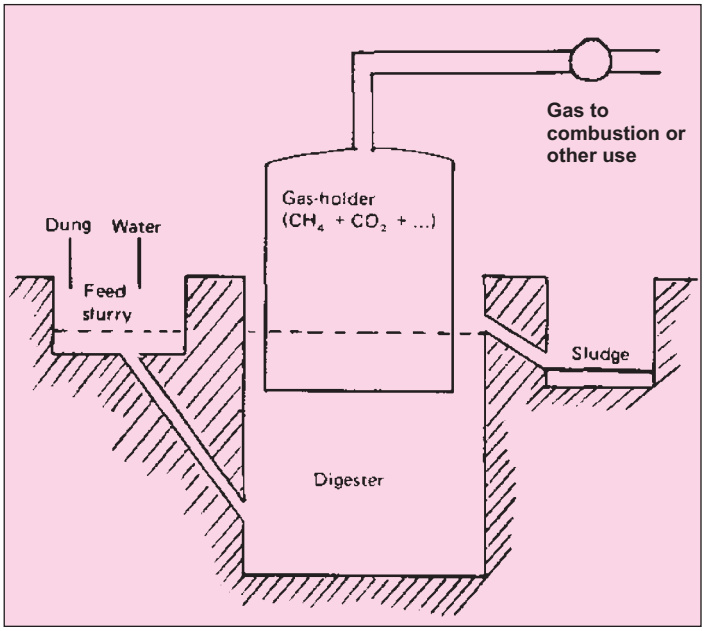
## Management of Animal Excreta

Animal excreta carry enormous potential of fly breeding and it should be managed by disposing in biogas plants (popularly known as gobar gas plants), sanitary land fill or composting (Disposal along with biodegradable solid waste).

### (a) Disposal in Biogas Plant (Gobar Gas Plant)

In view of the increasing energy crisis, this method is gaining rapid popularity, particularly in countries having large cattle population. In this method the dung gets converted into good quality manure under hygienic conditions and there is also generous liberation of biogas energy. This can be used as fuel in the kitchen, for running engines, lighting and other purposes. A biogas plant is cheap, simple in construction, easy to handle and can be made locally from indigenous materials. The digester is partly an underground masonry tank with an incomplete partition in the middle. It has an inlet and an outlet pipe. Dung mixed with water in equal proportion is put inside through the inlet. In the plant, excreta are often mixed with straw or other vegetable waste, and equal quantities of water added to make a slurry which is fed to the inlet side of the chamber. Effluent slurry is removed after a retention time of 30-50 days. Biogas production is greater at higher temperatures. At 300°C the rate of generation of gas is about twice that at 250°C and little gas is produced if the temperature is below 150°C. A few hookworm eggs survive and there is high survival of roundworm eggs. Many pathogens including schistosoma eggs are killed (Fig. 17).

Fig - 17 : Bio-gas plant




### (b) Composting

There are carried out in the same manner as for and often in conjunction with solid waste and night soil.

## Solid waste management

### Composition

Solid waste includes all unwanted or discarded material of domestic, street, commercial, industrial and agricultural origin. It consists of garbage and swill from cook houses and dining halls; house and street rubbish like waste papers, rags, glass pieces, ferrous and nonferrous metals, plastics, dried leaves, pieces of wood, ferrous and nonferrous metals, plastics, ashes, cinders, brick bats and commercial and industrial wastes of all types. Generally, wastes of animal and vegetable origin are very attractive to flies, cockroaches, rodents and other pests and therefore must be disposed off hygienically, as early as possible. Solid waste should be managed according to **Municipal Solid Wastes (Management and Handling) Rules 2000 (23) described in subsequent paragraph.**

### Collection

Suitable receptacles are to be provided at convenient places for collection of all rubbish awaiting disposal. Metal, fly proof receptacles, big enough to hold 24 hours collection, must be provided for storage of garbage and swill in the cook houses and dining halls. General camp refuse and house refuse other than garbage which is not so attractive to flies may be collected separately. In a permanent camp sanitary bins made of G I sheet are usually provided. In other types of camps receptacles having well fitted lids may be improvised from empty cresol drums, oil drums and ghee tins.

### Management of Solid waste

The recognized methods of disposal of solid wastes are dumping, burial, sanitary land-fill, incineration, composting, biogas plant, EM technology and salvaging. The choice of a particular method is governed by factors such as type of camp, cost, availability of land and labour.

Dumping

In this method waste is simply dumped in low lying areas. As the waste is kept lying loose it creates nuisance, pollutes the surrounding water and soil and encourages breeding of flies, rodents and other pests. Dumping, as a method of waste disposal, should be avoided. Dumping can be used to disposed demolition material in low lying areas.

Controlled Tipping (Sanitary Land-fill)

This is a satisfactory method if suitable land is available. This method is popular with local bodies and cantonments. It differs from dumping in that the material is placed in trenches or other prepared areas adequately compacted and covered with earth. Hence it minimizes the problem of offensive odour, unsightly appearance, pollution of the surrounding soil and water, and pest and vermin infestation. The site selected should be away from the habitation. A hollow low lying ground or an abandoned quarry or a swampy area is generally selected; otherwise broad trenches are dug on flat low lying ground. Long trenches are usually dug out, each having a depth of 2 to 3 m and breadth of 3 to 10 m. Filling of waste is to take place from the farthest end. At the end of the day's work it is covered with earth and compacted well. The method of controlled tipping has been revolutionized by mechanization. The bulldozer achieves the tasks of spreading, compacting and leveling the top. After this operation the top is covered with clinkers or sweet earth and fast growing shrubs may be planted. Pollution of surface and groundwater is minimized by lining and contouring the fill, compacting and planting the cover, selecting proper soil, diverting upland drainage, and placing wastes in sites not subject to flooding or high groundwater levels. Gases are generated in landfills through anaerobic decomposition of organic solid waste. If a significant amount of methane is present, it may be explosive; proper venting eliminates this problem.

Composting

It is usually employed for the combined disposal of solid wastes, stable litter, night soil and sludge. It entails proper preliminary construction, higher initial expenditure, running cost, efficient organization and supervision. The organic matter in this method breaks down under microbial action into relatively stable humus like substance called compost, which has considerable manurial value. The principal by-products are carbon dioxide, water and heat. The heat produced during composting rises to 60ºC or higher which is retained over a period of several weeks. The following methods of composting are now a days used- Bangalore method, mechanical method and vermicomposting. The first is an anaerobic method while the second is an aerobic one.

**(a) Bangalore Method (Hot Fermentation Process)**

This method of anaerobic composting was evolved under the auspices of The Indian Council of Agricultural Research at the Indian Institute of Science, Bangalore and hence termed Bangalore method. Long trenches are dug each having a depth of 1 m and breadth of 1.5 to 2.5 m. Depths greater than 1 m are not recommended because of slow decomposition. First a layer of refuse 15 cm thick is spread at the bottom. Over it, a layer of night soil of 5 cm thickness is added. The alternate layers of refuse and nightsoil are added in the proportion 15 cm and 5 cm respectively till the heap rises 30 cm above the ground level. The top layer of refuse should be at least 25 cm thickness. The heap is then covered with excavated earth. If properly laid; a man's leg will not sink when walking over it. Within 7 days considerable heat is generated in the mass. The heat persists for 2 to 3 weeks. At the end of 4 to 6.months the mass is ready to be taken out as manure. During decomposition of faeces and urine, the following processes take place :-

(i) Complex organic compounds such as proteins and urea are broken down into simpler and stable forms.

(ii) Gases such as ammonia, methane, carbon dioxide and nitrogen are produced and released into the atmosphere.

(iii) Soluble material is produced which may leach into the underlying or surrounding soil or be washed away by flushing water or ground water.

(iv) Pathogens are destroyed because they are unable

to survive in the environment of the decomposing soil.

**(b) Mechanical Composting**

In this method compost is manufactured on a large scale out of the raw materials within a very short time. The refuse first undergoes a process of mechanical sorting for items like rags, bones, metal pieces and glass which otherwise are likely to interfere with grinding operation. The entire mass is then pulverized in mechanically operated pulverizing equipment. The pulverized refuse is then mixed with night soil, sewage or sludge in a rotating machine and incubated under controlled temperature, pH, carbon-nitrogen ratio and aeration. The final product compost is ready in 4 to 6 weeks time. This method of composting is in vogue in developed countries. A few of the Indian cities with population more than 3 lakhs are presently in the process of installing such plants. The wastes are degraded biologically to a humus with a total nitrogen, phosphorus, and potassium content of 1 to 3 percent, depending on the material being composted. Afterwards, the product is ready for curing, blending with additives, bagging, and marketing.

**(c) Vermicomposting**

It is an eco-friendly method of disposal of bio-degradable wastes from kitchen, dining places, etc. which mostly contain organic food wastes, peels , and serves the dual purpose of disposing off garbage and at the same time mustering the environment.

(i) Principles of process

- Proper aeration of organic material
- Inoculation of required bacteriae
- Spraying of fresh cow dung.
- Keeping pH around 7
- Maintaining moisture at 50%

(ii) Method

A rectangular bed of earth of suitable size bound by a brick wall 2-3 ft high will serve the purpose. A few hundred earthworms are introduced on which waste can be dumped and water sprinkled daily. Agriculturally useful compost is formed in 2-3 months which can be periodically removed.

(iii) Advantage

- End product is value added bio-fertiliser (Manure) and can be used in agriculture and organic farming.
- Process converts the project site into a green patch.
- Organic agriculture produce is a recurring output making the project sustainable and viable.
- The process does not generate methane gas nor contaminates ground water by leaching.
- The process enriches the organic matter in the soil with bacteria and deep burrowing earthworms.

## EM (Effective Microorganisms) Technology

First developed by Dr Teruo Higa in Japan, EM technology (24) is now in use in 30 countries. It essentially consists of the use of friendly micro organisms like phototropic bacteria, Actinomyces, Lactic acid bacteria and yeast contained in a stock solution (EM1 solution), which is diluted in rice wash water that has sugar added to it (EM 3 solution). This is added to kitchen waste in specially designed drums which converts the waste into compost, a process which helps plants grow better. Effective microorganisms (EM) solution is a living entity containing active microbes. It has no chemicals and no genetically engineered organisms. These microorganisms are extremely beneficial, eco friendly and totally harmless .EM is very economical and easy to use. EM solution can be classified into 2 categories:

(a) Original EM (EM 1) - shelf life of 6 months

(b) Extended EM (EM 2) - 30 days

**Advantages**

(a) EM helps suppress E coli bacteria from water along with other coliforms

(b) EM eats up sewage. After dying, they dissolve in the water so your drains are clean, odourless and drainpipes will never get clogged

(c) Contamination of drinking water through leaking pipes reduced

(c) Greatly improves earthworms in vermiculture

(d) Drain pipes last longer and better

(e) If EM is added everyday to the drainage system through sinks and toilets, then within a month or two you will see visible differences in septic tanks

## Portable Biogas Plant Introduction

Portable biogas plant developed by Appropriate Rural Technology Institute, Pune, Maharashtra, India (25) can also be used to manage biodegradable kitchen waste and left over food.

Fig - 18 : Portable Biogas Plant

**Construction**

The biogas plant consists of two cylindrical vessels telescoping into one another. The larger vessel, called the fermenter, has a total internal volume of about 500 lit. A drum having diameter of 85 cm and height of 85 cm would have the desired volume. The smaller vessel, which telescopes into the larger one, serves as the gas-holder. The diameter of the gas holder is about 2 cm smaller than that of the fermenter. The fermenter vessel is provided with appropriate inlet and outlet pipes for introducing the feedstock into it and for removal of spent slurry from it. The gas holder is provided with a gas tap, through which the gas is led to the burner. The size of the gas holder may vary between 500 litres and 1000 litres depending upon the requirements of the family. In a family eating mainly rice or noodles, a capacity of 500 litres is adequate, but in the case of families eating chapattees or rotis, which have to be made one after the other, the gas has to last longer, and therefore a larger capacity of gas holder and fermenter are required

**Advantage**

This system is much easier to operate than the dung based biogas plant, because of the relatively small quantities of feedstock and effluent slurry to be handled. The effluent slurry generated daily by the plant is just a couple of litres. It can be used as manure for plants growing around the house. The 500 litre biogas plant, mass produced from moulded plastic drums, would cost about Rs. 8000.

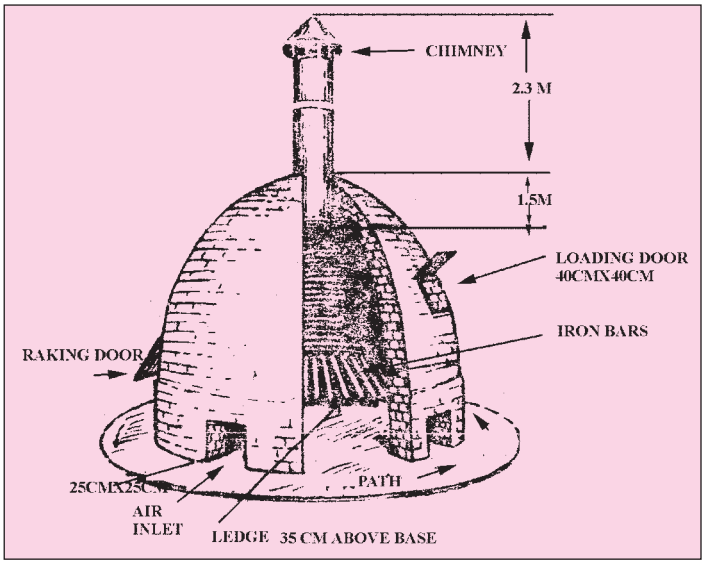
## Incineration

This is a hygienic method of waste disposal. Many developed countries use incinerators, which are complete with air pollution controls and heat recovery process. However, incineration is not considered very suitable in this country because the waste contains a high proportion of fine ash, which makes burning of refuse difficult. Besides it involves heavy initial cost on installation and recurring expenditure on fuel and maintenance. It also requires strict supervision and manpower management. With the present day energy crisis, incineration of community waste may be considered as loss to the country. However, incineration is still the best method for disposal of hospital waste. Incineration at times is resorted to in some of the Armed Forces permanent installations. The common types of incinerators used in the services are described follows: -

**(a) Beehive Incinerator**

The beehive incinerator is constructed preferably with fire bricks, over a concrete platform. The diameter of the incinerator up to the height of 1½ m is uniformly two metres. After this the construction tapers cone-fashion to half a metre in diameter at the apex. The total height of the incinerator is 2½ m up to the apex into which a chimney is fixed. This project out for 2 to 3 m and protrudes inside the incinerator for about ½ m. A circular ledge protruding inside is built in the wall about 35 cm above the base to support a grid-iron grill on which incineration takes place. Underneath the ledge there are four 25 cm square ventilating windows placed at equal intervals to provide cross ventilation. Above the ledge and the grid-iron grill, are 35 cm square taking windows. At the base of the tapering part of the incinerator a 40 cm square feeding window is provided with a chute protruding inside towards the centre of the incinerator. The feeding and the taking windows should have trap doors. Incinerators must

Fig - 19 : Closed beehive incinerator




be sited near the latrines and protected from the weather. A cement platform for drying and mixing faeces, camp refuse, animal manure and fuel and a water tight shed to store dry fuel are also necessary (Fig 19).

Working of the incinerator

The personnel must be skilled, properly trained and permanently employed. Adequate supply of readily combustible material such as dry camp refuse, dry leaves, paper, cinders or dried horse manure must be ensured. At least 15 kg of wood or coal each day will be needed in addition to the camp refuse. Coal or wood at the scale of 75 kg per 1000 men per day or an equivalent quantity of oil, may be necessary if camp refuse is not adequately available; a fire is first started with paper and other inflammable camp refuse. The faeces, manure and camp refuse are mixed to form sizeable lumps on the platform. When the fire has turned up brightly, the mixed mass is slowly tipped into the incinerator taking care not to overload the fire. Between the charges, camp refuse is added in small quantities to keep up the fire. The incinerator must be stoked carefully, otherwise the material will fall as a cake to the bottom of the fire. When the incinerator is working properly, all the smoke is consumed in the vault below the chimney. To keep the fire alive overnight, the air inlets should be blocked.

**(b) Modern Incinerators**

In incinerators of conventional design, refuse is burned on moving grates in refractory-lined chambers; combustible gases and the solids they carry are burned in secondary chambers. Combustion is 85 to 90 percent complete for the combustible materials. In addition to heat, the products of incineration include the normal primary products of combustion-carbon dioxide and water-as well

as oxides of sulphur and nitrogen and other gaseous pollutants; nongaseous products are fly ash and unburnt solid residue. Emissions of fly ash and other particles are often controlled by wet scrubbers, electrostatic precipitators, and bag filters.

### Resource Recovery

Numerous thermal processes, now in various stages of development, recover energy in one form or another from solid waste. These systems fall into two groups: combustion processes and pyrolysis processes. A number of companies burn in-plant wastes in conventional incinerators to produce steam. A few municipalities produce steam in incinerators in which the walls of the combustion chamber are lined with boiler tubes; the water circulated through the tubes absorbs heat generated in the combustion chamber and produces steam. Pyrolysis, also called destructive distillation, is the process of chemically decomposing solid wastes by heat in an oxygen-reduced atmosphere. This results in a gas stream containing primarily hydrogen, methane, carbon monoxide, carbon dioxide, and various other gases and inert ash, depending on the organic characteristics of the material being pyrolyzed.

### Burial

This is allowed in only temporary camps where incineration cannot be undertaken. Fly proof pits constructed exactly like an Otway's pit may be used for the purpose.

### Salvaging

This method of refuse disposal can be profitably used in metropolitan areas. Waste paper, polythene bags, wood pieces, glass pieces, tinkers, cigarette packets, tinfoils, rag and even the garbage and swill can be salvaged for economic gain before the unsuitable remnants are sent for disposal. The garbage and swill can be processed for use as chicken and hog feed. Rags and papers can be recycled. Metals both ferrous and non-ferrous, could be salvaged for gainful use. Today, recyclable materials are recovered from municipal refuse by a number of methods, including shredding, magnetic separation of metals, air classification that separates light and heavy fractions, screening, and washing. Another method of recovery is the wet pulping process: incoming refuse is mixed with water and ground into a slurry in the wet pulper, which resembles a large kitchen disposal unit. Large pieces of metal and other nonpulpable materials are pulled out by a magnetic device before the slurry from the pulper is loaded into a centrifuge called a liquid cyclone. Here the heavier noncombustibles, such as glass, metals, and ceramics, are separated out and sent on to a glass and metal-recovery system; other, lighter materials go to a paper-fiber-recovery system. The final residue is either incinerated or is used as landfill. In the developed nations, municipalities and private refuse-collection organizations require to keep bottles, cans, newspapers, cardboard, and other recyclable items separate from other waste. Special trucks pick up this waste and cart it to transfer stations or directly to recycling facilities, thus lessening the load at incinerators and landfills.

## Disposal of Liquid Waste

### Composition

(a) This includes waste water from bath rooms, ablution places, washing places, sullage from cook house and dining halls and industrial effluents. The main aims of liquid waste disposal are aesthetic considerations; prevention of water and soil pollution; prevention of water logging of grounds; prevention of mosquito, fly, and cockroach breeding; and protection of aquatic flora and fauna (26-28).

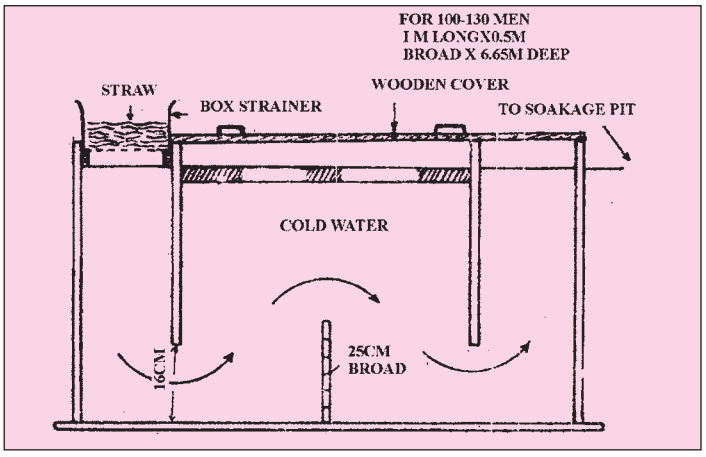
### Disposal

If water carriage system is existing, all liquid wastes can be conveniently discharged into the sewerage system. If this is not available, the most common method of disposal of these liquid wastes is into soakage pits or streams. The sullage from the cook houses and dining halls however, needs pretreatment before disposal due to its high fat content. Even with the most porous soil, fat, grease and soap form an impervious coating on the surface, which prevents percolation. When discharged into a stream untreated it can harm the aquatic flora and fauna by hampering oxidation. The simplest method of removal of grease from the sullage is by passing it through grease trap.

Cold Water Grease Trap

When warm waste water passes .into a sufficient quantity of cold water, the contained fat solidifies and rises to the surface and the clear water runs into soakage pits or into a stream. A cold water runs into soakage pits or into a

Fig - 20 : Cold water grease trap




stream. A cold water grease trap is used in semipermanent and permanent camps (Fig. 20 ). It is only useful for cookhouse sullage, but not for bathroom water because the soap does not float form scum. The construction and maintenance is as under:-

### (a) Construction

Grease traps for permanent camp should be made of cement concrete or masonry. while that for a semi-permanent camp may be made of wood. The quantity of water in a trap should be at least five times the peak-hour quantity of waste water entering it; otherwise the waste water will not be adequately cooled for the grease to

Fig - 21 : Strainer grease trap

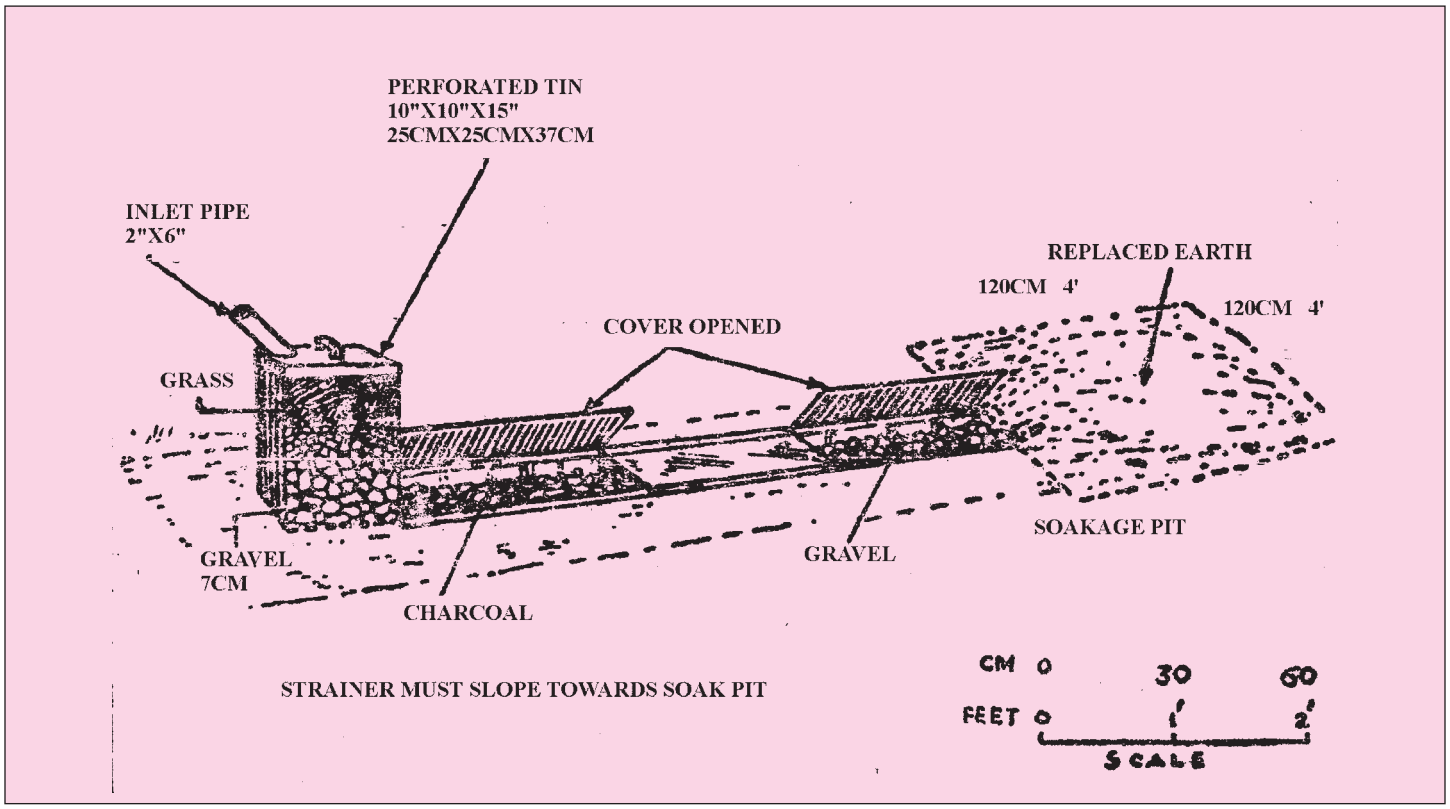
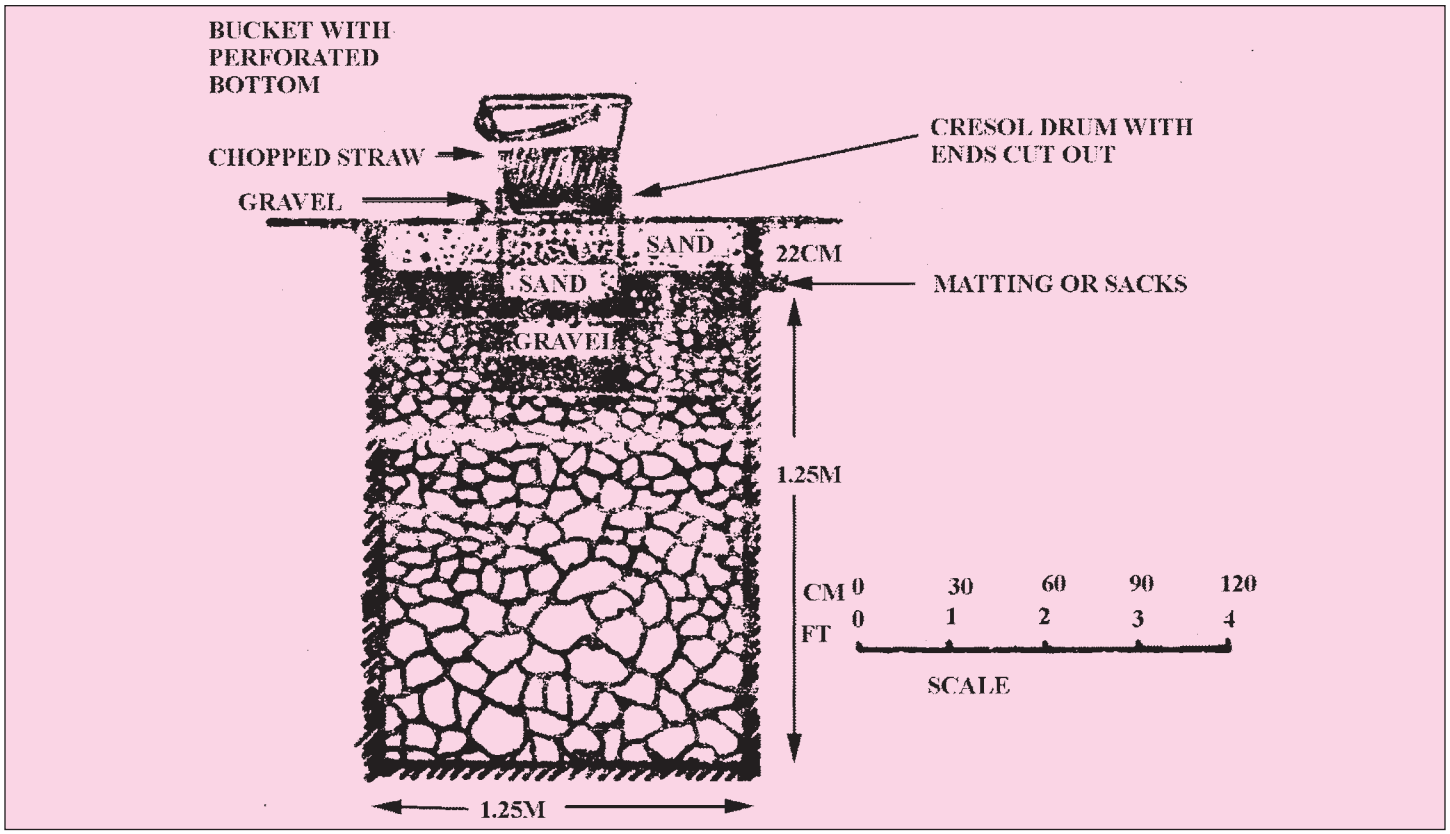



Fig - 22 : Soakage pit for kitchen sullage



solidify. The normal cookhouse waste water yield is about 3 L per head at the peak hour. Therefore, a trap for a coy cookhouse serving 100 to 130 men should be 1m long, 0.5 m broad and 0.65 m deep. This will hold about 300 L of cold water. The trap is divided into three compartments with two baffle plates placed at about 25 cm distance each from the entrance and exist. They are deficient for about 16 cm at the bottom, hanging in the trap without touching its floor. The middle compartment holds the scum of grease floating. A third baffle plate about 20 cm broad is fixed in the centre of this grease compartment resting vertically on the bottom of the trap to stop the sludge. A strainer made of galvanized iron or tin may be interposed between the inflow and the first compartment to hold back any gross pieces of garbage. The water entering the trap gravitates down due to force of flush and finding its way under the first baffle enters the second compartment wherein the cold water freezes the grease in it. The sludge accumulates at the middle baffle.

**(b) Maintenance**

Surface grease should be removed daily with a ladle and burnt in an incinerator. The grease trap should be emptied once a week, all sludge removed from the bottom and buried; and the sides, bottom and baffles scraped and scrubbed before refilling with cold water.

Strainer Grease Trap

These are used in temporary camps (Fig. 21). The standard type of strainer grease trap is made from ghee tin or cresol drum with perforated bottom. The tin is then filled from below upwards with 7 cm layer each of gravel, coarse sand and fine sand. Over this is placed a 15 cm thick layer of hay or straw. A shallow tin strainer is placed over this grease trap and the sullage water is led into this tin strainer. Percolating downwards the sullage water deposits grease on the straw and top layer of fine sand. A soakage pit is prepared, the strainer grease trap is fixed directly over its centre and waste water is led to it through drain from the outfall of water from the kitchen. The straw should be burnt daily. Sand and gravel need replacement twice or thrice a week and the greasy material is burnt or buried.

The effluent may be run into the existing drainage system, a septic tank or into a stream at point where It does not pollute any source of domestic water supply or into a soakage pit or soak well. The usual method of disposal in the Armed Forces units is to a soakage pit.

Soakage Pit

It is made by digging a 1.25 $m^3$ pit (Fig. 22). The pit is then filled with stones and brickbats in a graded fashion. The final top layer is made of coarse gravel or sand. The pit is then covered with bamboo matting except at the centre for fixing the strainer grease trap over the pit or over an area of required dimension to receive the channel from the cold water grease trap. Heavily oiled hessian cloth is put over the bamboo matting extending upto 0.5 m all around. The soakage pit functions by physical as well as biological process. The physical process involves soakage and evaporation. The biological process is due to action of the 'Zooglea' that grows on the surface of the stones and brickbats. The stones not only provide a surface for growth of the 'Zooglea' but also help in evaporation by providing a large surface area. Soakage pits are, however, liable to clogging even with the use of efficient mechanical traps as some grease and soap from sullage will be left in the effluent and form an impermeable coating on the walls and floor of the pit. Spare pits are thus to be kept in readiness. The water-logged pit is dug out scraped and left open for drying and subsequently rearranged. Weekly insecticidal spraying is to be carried out around the pits.

**Lagoon Pans**

These are suitable in a very dry climate where the soil is porous. The effluent is allowed to flow over the surface for percolation and evaporation. The ground is usually divided into seven areas called the 'lagoon pans'. Each pan receives one day's effluent in turn; the largest area is reserved for Sunday. A central channel with three parallel channels running across the central channel is cut. The effluent is diverted into these by rotation for filling up the required pan. The channel could also be modified in the pattern of 'herring bone' system for better functioning. Periodic scrapping of the pans and the channels is to be undertaken. Flowering or vegetable plants may be grown advantageously in the pan areas.

## Disposal of Dead Animals

Incineration is the best method of disposal of a carcass of animal died of an infection. It requires 40 kg of wood and 10 L of kerosene to ensure complete combustion of a mule in an efficient destructor. For an ordinary non-infectious carcass burial is suitable. A mule or horse carcass needs a 4 x 2 x 2 m pit. Before the carcass is placed in the pit its belly and intestines should be opened to permit the gases of decomposition to escape. Otherwise the belly swells enormously and often forces open the grave. Burial places should always be remote from any campsite or source of water supply. Charring can precede the burial. A pit is dug beside the disemboweled carcass. The viscera are buried. The carcass is then dragged over the buried viscera and blood saturated soil. 20 kg of dried grass or litter soaked with 2 L of kerosene oil is spread over the carcass and ignited. The aim is to sterilize the surface by charring and not to incinerate. The charring should be done early after the death of the animal so that the saprophytic organisms have no time to penetrate tissues. The exposed surface affords attraction to flies. A disinfectant fluid consisting of 1 part of coal tar-creosote-oil with 14 to 18 percent tar acids, and 5 parts kerosene prevents smell and fly breeding. This can be sprayed over the carcass or injected into its carotid artery. Ten liters per horse are necessary. A spray of five percent cresol is also used. Slaked lime should be sprinkled over the carcass, in the grave and over the area. Animals slaughtered for rations and found unfit for consumption should be disposed of on similar lines.

If it is not possible to incinerate the carcass of animal dead of anthrax or suspected anthrax, the carcass may be buried. It, however, must not be cut open. If it is necessary to take a sample of blood for bacteriological diagnosis, an ear is cut off and sent to the laboratory wrapped in gauze well soaked in 5 percent cresol solution and covered by

sacking. The blood or discharges of the animals should not contaminate the ground. All orifices should be plugged with gauze tow soaked in 5% percent cresol and the body wrapped in sacking similarly soaked. The carcass placed in the pit should be surrounded on all sides with quick lime. The byres should be disinfected with 5 percent cresol, using long handled brushes, and then treated with the freshly chlorinated lime wash. Overalls and gloves should be worn throughout the operation.

## E WASTE

'E-Waste' is a collective name for discarded electronics devices that enter the waste stream from various sources. E-Waste comprises of waste electronic goods, which are not fit for then originally intended use. These range from household electronic appliances such as televisions, VCDs, DVDs, radio/ stereo systems, refrigerators, personal computers, printers, washing machines, air conditioners, telephones, cell phones to medical equipments, ATM machines etc.

E-Waste contains several different substances and chemicals, many of which are toxic and are likely to create adverse impact on environment and health, if not handled properly. However, classification of E-Waste as hazardous or otherwise depends on the extent or presence of hazardous constituents in it. Of the entire E-Waste generated, computer waste poses significant environmental and health hazards. Rapid advances in information technology, with new and varied innovation in computers, have led to increasing product obsolescence.

### Generation of E-Waste:

**(a) Industrial sector**

Electronic control panels, electronic gadgets, old wireless handset, EPBX system, UPS, medical equipments, testing instruments etc. The E-Waste generated from automotive and aerospace industry includes control systems, communication system, instrumentation, navigation system, safety system, diagnostic system.

**(b) Commercial sector**

ATM machines, electronic banners, computers, public addressing system, inverter, printers, copiers, fax, scanner etc.

**(c) Residential sector**

Computer, TV, VCD, DVD, Stereo, Radio, Washing machines, refrigerator, microwave etc. The major quantity of electronic waste worldwide is PC (Personal Computer)

### Environmental and Occupational Impact of E-waste

Although it is hardly well known, E-Waste contains many toxic substances such as lead and cadmium in circuit boards; lead oxide and cadmium in monitor cathode ray tubes (CRTs) mercury in switches and flat screen monitors; cadmium in computer batteries; polychlorinated biphenyls (PCBs) in older capacitors and transformers; and brominated flame retardants on printed circuit boards, plastic casings, cables and polyvinyl chloride (PVC) cable insulation that release highly toxic dioxins and furans when burned to retrieve copper from the wires. Due to the hazards involved, disposing and recycling E-Waste has serious legal and environmental implications. The recycling of E-Waste has serious occupational and environmental implications, particularly when the recycling industry is often marginally profitable at best and often cannot afford to take the necessary precautions to protect the environment and worker health.

### International Scenario (Findings Stated in Report by BAN)

(a) 50 to 80% E-Waste collected are exported for recycling by US Export is legal in US

(b) Export is due to cheaper larbour and taxed standard in poor countries

(c) E-waste recycling and disposal in China, India and Pakistan are highly polluting

(d) China has banned import of E-Waste

(e) Lack of responsibility on the part of Federal Government and Electronic Industry, Consumers, recyclers and local governments towards viable and sustainable options for disposal of E-Waste

### Need for Assessment Study on E-Waste

(a) Assessment of current scenario : quantification characteristics, existing disposal practices, environment impacts etc.

(b) Projections for next 10 years regarding consumption and waste generation of electronic goods particularly PC & its accessories, fax, photocopiers etc.

(c) Regulatory mechanisms in other countries (OECD and Non-OECD) and comparison with Indian conditions particularly with regard to regulation of import

(d) Possibility of collection system and requirement of legal instruments.

A study carried out regarding E-Waste in Mumbai, revealed that the electronic scrap is managed through low end management alternatives such as product re-use, backyard recycling etc. The accured electronic wastes are dismantled and manually sorted to different fractions such as plastics, copper/ iron/ aluminum components, wires/ cables, cathode ray tubes, printed circuit boards etc. These components are then subjected to recycling. Since a major portion of the components of e-waste is recycled, the residual generated is insignificant. The process of dismantling and sorting is done by bare hands and only with the help of screwdrivers and hammers posing a serious threat to the health of the workers.

From the survey, the quantity of obsolete electronic products generated by the households in Mumbai for the coming years was estimated based on an assumption mentioned in the study. It was concluded that with the affordability and availability of the products the problem of E-Waste in terms of its quantity will likely increase in the near future.

The way this E-Waste recycling industry is proliferating in the backyards and shanties of scrap dealers in Mumbai,

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Lt Col R Kunwar

# Health Problems in Desert

### Introduction

The deserts are characterized by hot air temperatures, low humidity, hotter ground temperatures, high evaporation rates, lack of surface water, sparse vegetation and wide temperature ranges from day to night. Gigantic thunderheads, often moving at great speeds, may in a matter of minutes drop a half inch of rain on a locality, causing flash floods and instant erosion of the desert landscape.

Peculiar set of environmental conditions like these, increase stress on human physiology. Adaptation to such conditions by human body takes long. Inappropriate acclimatization and prolonged stay in desert causes deleterious effects on health & efficiency of individuals.

In India, the arid (desert) zone occupies nearly 12 percent of the total area sustaining a human population of over 19 million and live stock of over 23 million. The total area occupied includes 0.32 million sq. km. of hot desert mainly in Rajasthan, Gujarat and Haryana. Western Rajasthan, a part of the Thar desert, is covered by wind-blown sand and sand dunes. The five districts of Rajasthan, namely Ganganagar, Bikaner, Jaisalmer, Barmer and Jodhpur fall in this arid zone. The area suffers from extreme climate oscillations.

According to recent estimate 4.35 percent of Western Rajasthan has been affected by the process of desertification and another 76 percent is highly vulnerable to it. The human population in Rajasthan desert has increased from 3.42 million in 1901 to 10.84 million in 2001. The Indian desert is one of the most thickly populated deserts in the world. The population can be roughly divided into two major categories, namely, a diffuse and scattered population living in the hinterlands and a concentrated population living in the cities/towns. Working in desert area is beset with medical problems due to adverse environmental conditions and terrain (1).

### Desert Ecology and Human Physiology

The Indian arid zone is characterized by conditions of high aridity with low average annual rainfall ranging from 180 mm in Jaisalmer to 360 mm in Jodhpur. The rainfall is confined to the period from July to Sept.

The zone is also characterized by high temperature variation from less than Zero degree centigrade during nights in winter to more than 50°C in day time in summer. Relative humidity varies around 30% and sand storms are common during Apr-Jun. Vegetation is sparse with few trees in between. Full grown trees are still less though the ecology is changing fast. Drinking water scarcity compounds the problem.

### Zone of Thermoneutrality

The external temperature with which the homeostatic mechanism of thermo-regulation are not stressed and within which the resting heat production rate is at its minimum is called the zone of thermoneutrality. In a resting person this is 2°C on either side of 29°C depending on whether the person is clad or not. Deviation from this zone sets the homeostatic thermoregulatory mechanism in action. On the hotter side, the heat loss is increased while on the cooler side the heat conservation is stimulated. Body loses and gains heat by conduction, convection and radiation. By evaporation body only loses heat.

As the temperature rises beyond the thermoneutral zone, the immediate response is to cause vasodilatation in periphery to divert heat from core to periphery. As the temperature rises beyond 32.8°C vasodilatation alone cannot cause efficient cooling, hence body initiates sweating which is initially invisible but later on becomes visible and profuse. Approximately 6-8 ltr of sweat is produced after a spell of hard work in hot weather. One gram of sweat extracts out 537 calories of heat. Ultimately the loss of heat from body will depend on following factors: -

(a) Efficiency of body to produce adequate sweat.
(b) Efficiency of evaporation.

### Acclimatization in Desert

Over a longer period of stay in desert body achieves a more efficient mechanism of heat loss by setting in few physiological changes like :-

(a) Increased
  (i) Circulatory volume
  (ii) Cardiac output
  (iii) Aldosterone production
  (iv) Renal retention of sodium
  (v) Responsiveness of sweating
  (vi) Fluid requirement
(b) Decreased
  (i) Heart rate
  (ii) Volume of sweating

These changes constitute what is called acclimatization to heat and remain in place till the individual stays in desert area.

## Problems in Desert Area

### Water Supply

Only 3 percent of the ground water in Western Rajasthan conforms to normal standards of drinking water, i.e., containing less than 500 mg/L of total dissolved solids (TDS). As much as 42 percent of the water has a salinity, expressed in form of total chlorides, more than 600 mg/L. One percent of the ground water has a nitrate concentration of more than 50 mg/L, the maximum permissible limit laid down by the WHO. In some areas, the fluoride content of ground water is also high. However no

toxic elements are detected in the water of Western Rajasthan. It can thus be seen that this water deficit area has an acute problem of saline ground water, which is not potable and also hinders bathing, washing, and other community utility. Such a situation gives rise to a high incidence of gastrointestinal disease including viral hepatitis and skin diseases.

**Adverse Environmental Conditions**

During winter, there is a great drop of temperature after sunset which gives rise to the respiratory group of illnesses. During the day, especially during summer, high temperature accounts for a higher incidence of effects of heat like heat exhaustion, heat stroke and prickly heat. The sand and dusty environs lead to an increased incidence of foreign bodies in the eyes, conjunctivitis and trachoma. Desert sores are common and may develop from minor abrasions, and these heal slowly (2 – 4).

**Endemic Diseases**

Malaria, excremental diseases including viral hepatitis and skin diseases have a higher prevalence in desert areas.

**Local Fauna**

Desert areas are infested with poisonous snakes and scorpions. Cases of snake bites in summer and scorpion bites in winter are a common occurrence.

**Housing and Sanitation**

Sources of water in the desert areas are scarce and hence, people gather around such areas leading to overcrowding, unhealthy housing and fall in the standards of sanitation. There is a problem of waste water and sewage disposal in desert areas which may cause outbreaks of fly-borne and excremental diseases.

**Disposal of waste**

Disposal of dry and liquid waste is a problem in desert area due to caving in of the trenches/DTLs.

**Classification of Medical Problems in Desert**

There is no universally acceptable classification of medical problems in desert. These medical illnesses are also present in other parts of country but get exaggerated under desert conditions. Hence, a tentative classification is as under: -

(a) Illnesses due to high ambient temperature
  (i) Heat exhaustion
  (ii) Heat cramps
  (iii) Heat syncope
  (iv) Heat stroke

(b) Illnesses due to Solar Radiations exposure
  (i) Skin tanning
  (ii) Solar dermatitis
  (iii) Solar erythema (sun burn)
  (iv) Aging of skin
  (v) Rodent ulcer
  (vi) Cataract
  (vii) Retinal degenerative changes
  (viii) Pterygium
  (ix) Skin Cancers

(c) Illnesses due to dust
  (i) Chronic eye infections because of blocked / semiblocked eye punctum.
  (ii) Irritation of eyes
  (iii) Trachoma

(d) Miscellaneous
  (i) Prickly heat.
  (ii) Fluorosis
  (iii) Gastro- Intestinal illnesses
  (iv) Predisposition to urinary calculi.
  (v) Nitrates in water causing methaemoglobinaemia.
  (vi) Snake bite & scorpion bite.
  (vii) Eye injuries due to Acacia indica.
  (viii) Camel bites

## Preventive Measures

It is imperative that adequate preventive measures must be adopted to keep the wastage of adequate manpower due to sickness to a minimum. Guidelines to minimise the health hazards are given in the succeeding paragraphs.

**Water discipline**

Deserts are defined by their lack of water. Learn to ration sweat, not water. Rationing water at high temperatures is actually inviting disaster because small amounts will not prevent dehydration. Troops should be encouraged to keep the clothing on, including shirt and hat. Clothing helps by slowing the evaporation rate and prolonging the cooling effect. It also keeps out the hot desert air and reflects the heat of the sun. Arrangement should be made to stay in the shade during the day. As far as possible, one should sit on something 12 or more inches off the ground. Sitting on the ground could be uncomfortable as it can be 30 degrees hotter than a foot above the ground. When planning to travel in the desert, extra thought needs to be given to water supply. Enough water to meet personal requirements, must be carried. If travel is necessary, it is recommended to travel slowly and steadily. Mouth should be kept shut and breathing should be done through nose to reduce water loss and drying of mucous membranes. Conversation should be avoided for the same reasons. Alcohol in any form is to be avoided as it will accelerate dehydration. Food intake should be kept to a minimum if sufficient water is not available. In situations where there is a limited water supply, it is often recommended to throw food away.

**Effects of Heat**

(a) Acclimatization of troops is important for the prevention of effects of heat. To achieve acclimatization, the troops should be involved in progressive daily exercises for 10-14 days. After acclimatization the troops can work and stay well in hot conditions provided an adequate intake of water and salt is maintained (5).

(b) Provision of ample supplies of cool water should be ensured and the fluid intake should be enough to compensate for water loss due to sweating.

(c) Exertion should be judicious and rest and sleep must be adequate, to compensate for the activity. Reveille generally should not be before 0530h.

(d) Bathing must be ensured every day.

(e) Clothing should be light and loose and permeable to water vapour and air (4).

(f) Living quarters should be spacious, well ventilated and cool.

(g) Adequate calories must be consumed by troops as contained in their rations. Dining halls should be cool and comfortable.

(h) Medical examination must be thorough and regular to detect early symptoms of the effects of heat.

(j) Education of troops, including officers and JCOs in preventive measures against ill effect of heat is important.

(k) Cool rooms/Heat stroke Centres should be established at the various MI Rooms/Medical Units as per advice of SEMOs/SMOs.

(l) Special precautions should be observed during operation / recce missions to prevent dehydration and adverse effect of heat, by proper planning for provision of adequate supplies of potable water.

## Heat wave safety rules

**(a) Avoid stressful activities during the hot season**

**(b) Limit activities to cooler times of the day**

Strenuous activities like BPET and parade should be reduced, eliminated, or rescheduled to the coolest time of the day.

**(c) Keep pace slow and carry light loads**

While walking or horseback riding in the desert, maintain an even, comfortable pace. Rest often and never force yourself. Never carry more weight than you can use. Keep in mind, the more weight, the greater the stress and heat production.

**(d) Wear suitable clothing**

While shorts and sleeveless shirts may appear comfortable, they are not suitable for desert wear. Lightweight, light colored clothing is recommended because it reflects heat and sunlight better than darker material. The following items are recommended:

(i) WIDE BRIM HAT, protecting the eyes in front and the neck in back.

(ii) NECK PROTECTION : If the hat does not provide protection to the back of the neck, attach a piece of cloth onto the back of it.

(iii) LONG SLEEVED SHIRT, provide protection from the sun and also help to protect from scratches and insect bites. Cotton is probably the most suitable type of fabric.

Desert survival

- Always inform someone of where you are going, your route, and when you expect to return. Stick to your plan.
- Carry at least one gallon of water per person per day, a first aid kit, and personal survival kit.
- Be sure your vehicle has a sound battery, good hoses, a spare tyre, necessary tools, and sufficient Fuel and oil.
- Keep an eye on the sky. Flash floods may occur any time "thunderheads" are in sight, even though it may not be raining where you are.
- Be alert to three conditions which can pose an immediate threat to your life - HYPERTHERMIA, DEHYDRATION and HYPOTHERMIA.
- Stay near your vehicle if it breaks down. Raise the hood and trunk lid to denote "help needed." Leave a disabled vehicle only if you are positive of the route to get help. Leave a note for rescuers with the time you left and the direction taken.
- When not moving, use available shade or erect some shade from tarps, blankets, or seat covers to reduce the direct rays of the sun.
- Do not sit or lie directly on the ground. In sunlight, the ground usually is 30 degrees hotter than the air.
- Rest at least ten minutes each hour if walking. A normally inactive person should rest 30 minutes each hour. Find shade, sit down, prop up feet.
- If you have water, drink it. DO NOT RATION IT.
- If water is limited, avoid stressful activities. DO NOT talk, eat, smoke, take salt or drink alcohol.
- Keep clothing on, as it keeps your body temperature down and reduces the dehydration rate. Cover your head. Improvise a head covering if a hat is not handy.
- A roadway is a sign of civilization. IF YOU FIND A ROAD, STAY ON IT.
- To avoid poisonous creatures, put your hands and feet only where your eyes can see.

Source : (6)

(iv) LONG-LEGGED PANTS, help the body maintain normal temperatures.

(v) BOOTS, should be durable, fit well, provide support, provide insulation from the hot desert ground and provide traction.

(vi) DO NOT SMOKE : Smoking will hasten dehydration and reduce endurance.

**(e) Drink plenty of water or other non-alcoholic fluids. Do not ration!!**

Drink at regular intervals rather than when you feel thirst. When your body becomes dehydrated, your brain's ability to recognize trouble may be impaired. If there is a limited

amount of water, DO NOT RATION IT; attempt to conserve the liquids in your body instead.

**(f) Never start a desert trip on impulse**

Always be well organized and plan the entire trip.

**(f) Do not take salt tablets**

**(g) Do not drink alcoholic beverages**

Alcohol hastens dehydration.

**(h) Do not get too much sun**

## Endemic Diseases

### Malaria

Apart from occurrence of malaria in endemic form, outbreak of malaria and increased occurrence of falciparum malaria have become annual features. These outbreak should be contained by effective integrated vector control measures.

(a) All ranks should observe strict anti-malaria discipline. Personal protective measures such as use of mosquito nets, repellents, keeping sleeves rolled down and wearing long trousers with boots and anklets after dusk should be ensured. Patrol parties and other personnel engaged in night duties should apply DMP on the exposed parts of the body (7).

(b) Troops can be placed on suppressive treatment when operating in uncontrolled, highly malarious areas on recommendations of DDMS Command (8).

(c) Anti-malaria equipment to be maintained in good state of repair and adequate amount of hygiene chemicals should be provisioned.

(d) Authorised number of trained personnel and anti-malaria squads for spraying of insecticides/hygiene chemicals will be provided in each unit.

(e) Special malaria team should be organised to deal with the problem effectively.

### Skin Diseases

Due attention should be paid to personal hygiene especially keeping the skin clean by regular bath. Adequate laundering facilities should be available in the unit. Minor cuts and wound should be properly treated so that they do not get infected (9,10).

### Excremental diseases

A high standard of living in the camp area is not only conducive to a sense of well being but is of prime importance in the prevention of excremental diseases. Adequate disposal of excreta, refuse, garbage and other refuse matter needs to be strictly followed. Special attention should be paid to the sanitation of cook houses, dining halls and unit wet canteens. Strict anti-fly measures should be enforced. Water for cooking and drinking should be obtained only from authorised sources.

### Respiratory group of diseases

Temperature variations after sunset in desert areas are high. There is a sudden drop of temperature. Hence troops should be adequately clad in the evening and at night to avoid exposure to cold.

### Disposal of waste

Kitchen waste should be disposed off by deep burial. Modified soakage pits to be used for liquid waste. Revetting of DTLs should be done to prevent collapse. Incinerator latrine may be used in sandy desert by small detachments for short periods.

### Snakes and scorpion bites

All personnel should take personal protective measures by wearing ammunition boots and anklets. They should avoid probing into cracks and crevices. Anti snake-bite kits to be provided upto sub-unit level. RMO's/ authorised medical attendants should deliver talks on first aid measures and prevention of snakebite.

Before inducting troops, the unit Cdrs and RMOs must educate them about the prevalent diseases and their prevention and principles of survival in the desert (as given in the box). Maintenance of personal hygiene and cleanliness should be emphasized (11).

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# Managerial Sciences


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# General Concepts in Management

**Introduction**

Historically, management of men, material, money, time and other scarce resources became an inherent requirement for achieving goals ever since people started forming groups to accomplish those objectives which they could not achieve as individuals. In the last century, management emerged as a specialized field and many definitions were formulated by as many authors, none of which alone includes all essential elements of management. The most widely accepted definition of management is that "Management is the art of getting things done through and with people in formally organized groups. It is the art of creating the environment in which people can perform and individuals can co-operate towards attaining of group goals. It is the art of removing blocks to such performance, a way of optimizing efficiency in reaching the organisational goals" (Harold Koontz). A 'process-oriented' definition of management, as described by George R Terry is that "Management is a distinct process consisting of planning, organising, actuating and controlling performed to determine and accomplish the stated objectives by use of human and other resources".

Some other definitions of Management evolved by authors are as under :

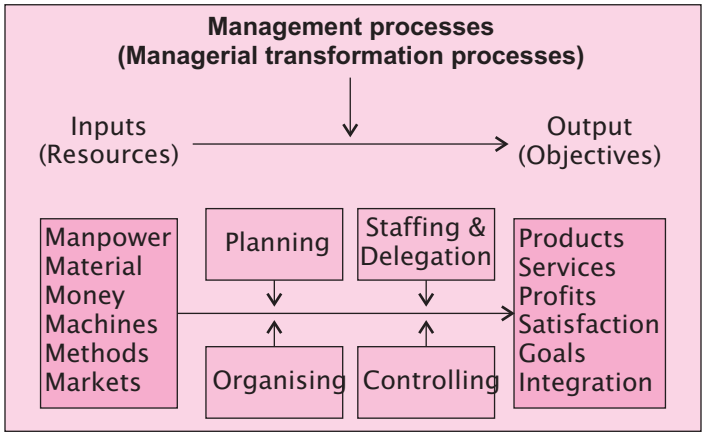
(a) Management is accomplishing a predetermined objective through the efforts of other people. (George R Terry)

(b) Management is the process of organising and employing resources to accomplish predetermined objectives. (Billy J Hodge)

(c) Management is effective utilization of human and other resources to achieve the enterprise's objectives. (William F Glueck)

Inspite of many definitions, the most simple and comprehensive definition remains "Management is getting things done through people. "

Following is the graphical representation of management

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**Management vs Administration**

Many people think management and administration to be distinct functions while many others consider them to be different aspects of management itself. Newman has defined administration as "The guidance, leadership & control of the effort of a group of individuals towards some common goal", while Sheldon has defined administration as "That function in the industry which is concerned with determination of policy, finance, production, distribution and ultimately control the activities for accomplishing objectives. Thus, policy making, planning and decision making are the basic aspects of administration while supervision, implementation and operation are considered main elements of management. Administrative Management can thus be said to be the major function of top management, concerned with decision making and problem solving while operative management is function of lower management, concerned with operative aspects such as supervision & control (Keith Davis). The following

Level-wise Skills in Management

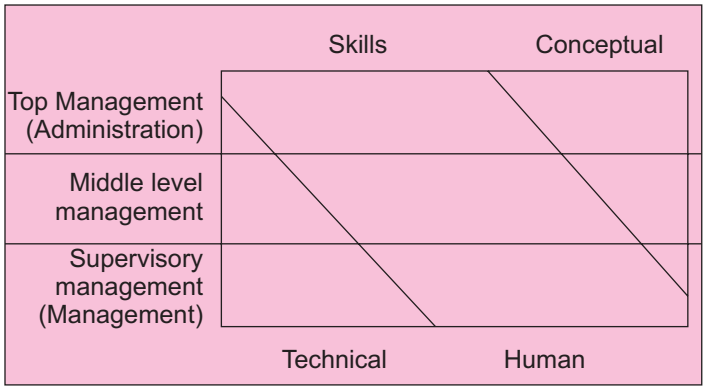
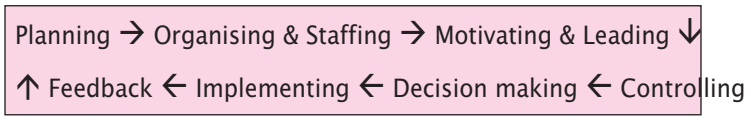



diagram clearly brings out the distinction between Administration and Management :

**Management Processes**




The essential processes in any managerial activity can be summarized as under :

**Planning**

Planning, being the basic process involved in management, is the process by which a manager decides in advance the objectives of organisation in short and long run, and the means to attain those objectives. It is the conscious determination of the course of action and the objectives to be reached, by channelising energies of an

organisation in a systematic manner towards achieving the objectives. Planning is needed to allocate the organisation's scarce resources towards achieving the predetermined objectives in the best possible manner and to anticipate and prepare for future opportunities and problems. For example, going out of the house on a cloudy day with an umbrella is one's way of planning to cover the risk (of getting wet) against an anticipated but uncertain thundershower. The process of planning bridges the gap between where we are presently and where we want to go, by making it possible for things to happen which would otherwise not have happened.

**Thus planning as a managerial process implies :**

(a) Making choices - Choosing the alternative (out of large number of potential actions) which offers maximum potential for profit and cost effectiveness.

(b) Committing resources - Scarce resources (manpower, material, money, time etc) have to be allocated for achievement of organisational goals during the planning stage itself. It must be borne in mind by managers that these resources may not be available for other activities of the organisation.

(c) A time horizon - Planning process must be completed within a stipulated time frame, for it to benefit the organisation.

**Elements of Planning**

(a) What will be done - objectives of the organisation to be reached

(b) What resources to be used - estimation of available and potential resources

(c) How will it be done - determining strategies & policies

(d) Who will do it - assigning responsibilities & delegation of authority

(e) When will it be done - timing & sequence

**Objectives of planning are as under :**

(a) To offset uncertainty and change by anticipating future challenges and opportunities, thereby minimizing losses caused by unfavourable situations.

(b) To focus attention on objectives by making them tangible and concrete.

(c) To make operations more economical by selecting the most cost effective course of action out of the many alternatives available.

(d) To facilitate control through policies, procedures, methods, standards and budgets, which are all part of planning process.

(e) To increase organisational effectiveness by providing basis for allocating optimum resources at minimum cost.

(f) To provide criteria for decision-making through strategies & policies, thereby specifying the limits within which each department of individual has freedom in making decisions.

**However, planning comes at a cost and certain limitations, which are :**

(a) Uncertainty about future : The forecasts and premises in planning stage are subject to change since future can never be predicted with perfect accuracy.

(b) Expensive & time consuming : Planning involves commitment of human, financial and physical resources and time, which may delay action in some cases.

(c) Internal inflexibility : Internal rigidity of an organisation may compel managers to make rigid plans, which can not be subsequently changed in case of changed circumstances.

(d) External factors : Plans may be affected by external factors beyond the control of managers, like government policies, wars, natural calamities etc.

**Any effective plan, in order to achieve it's objectives must have the following components :**

(a) Planning process must start from the top and percolate down throughout the organisation.

(b) Planning must be flexible to anticipate and prepare for uncertainties of the future. Planning process should also cater to alternative and contingency plans.

(c) Manager should be provided clear objectives in terms of short-term plans which should integrate to form long-term plans.

(d) The people responsible for implementation of plans should invariably be involved in planning process from the very beginning to ensure proper implementation of the plans.

The Planning Cycle

**Perception of opportunities :** preliminary assessment of possible future opportunities and their evaluation in light of its strengths and weaknesses.➔**Establishing Objectives :** imply the expected results and indicate end points of what is to be done, where the primary emphasis should be and what is to be accomplished by network of strategies, policies, procedures, rules, budgets & programs. ➔ **Establishing planning premises** in form of various factors that affect planning, like political control, govt policies, demand & supply etc. ➔ **Determining alternative courses of action ➔ Evaluating alternative courses of action** in light of the predetermined objectives ➔ **Selecting the best possible alternative after evaluating all alternatives ➔ Formulating supporting plans for various departments inorder to achieve the overall objective ➔ Numberizing the plans by converting them into budgets**

Any planning process would broadly involve the following steps.

Types of Plans

Various types of plans formulated to achieve the overall objectives are :

**(a) Strategies**

Are any decision or behaviour which takes into account the probable or actual actions, policies and strategies of competitors, suppliers, government, trade unions etc and aims to achieve organisation's objectives by taking into account strategies of rivals and other external factors. Strategies focus on actions and imply development of resources for their implementation.

**(b) Policies**

Are guide to decision-making for the manager and establish the broad framework with which managers operate at various levels. Policies do not tell a manager what he should do in specific situations but tell him what he can do, thereby laying down the limits to his decision.

**(c) Rules**

Are guide to action (in contrast to policies which are guide to decision-making) for the manager. Rules prescribe the acceptable behaviour and define what should and should not be done. Rules are often accompanied by penal clauses for non-compliance. For example, a rule on attendance states that late arrival for three days in a month will result in loss of one day's casual leave of the worker. Rules thus, regulate the behaviour but at the same time restrict the initiative of the manager.

**(d) Procedures**

Lay down the sequence of activities that several individuals should follow to accomplish a specific objective. Procedures are thus, plans that establish a required method and sequence of handling future activities to attain the goal.

**(e) Programs**

Relate to those activities which have distinctive mission and time schedule. Programs can be described as means of achieving some desired results within a scheduled time frame. For example, implementation of various aspects of Vision 2020 by the year 2020 is described under a program.

**(f) Budgets**

Are statements of expected results in numerical terms and are often called 'numerical plans'. Budgets are most widely used planning instruments used for control. Financial budgets are well known in form of profit budgets or capital budgets, however, non-financial budgets also exist in form of manpower budget, performance budget, material budget, sales budget etc.

**Planning can broadly be classified as Strategic Planning and Operational Planning, depending on the time-frame.**

(a) Strategic Planning is long-term planning, covering a period which may extend from a few years to few decades. It also takes into account all activities of an organisation and thus refers to planning process for the entire organisation over a long time.

(b) Operational Planning, also called Tactical or Short term planning usually extends upto a period of one year and is more detailed in nature.

**Organising & staffing**

As one of the major functions of management, organising consists of identifying and grouping of activities, assigning authority to managers and providing for co-ordination. Staffing essentially consists of matching the right people with the right jobs.

Essential steps in process of Organising

**Step 1 :** Detailed enumeration of all activities that will have to be carried out to achieve the organisational goals.

**Step 2 :** Group the various activities into departments in some meaningful manner, for example, all activities related to a particular field of medicine may be grouped into one department (Department of Laboratory Sciences, including Pathology, Microbiology, Blood Transfusion).

**Step 3 :** Assign each department to a manager with sufficient authority necessary to supervise the functioning of that department. This is called 'delegation of authority'. The top manager may delegate part of his authority to his subordinates and make them accountable too. Thus authority, responsibility & accountability are important parts of organising process.

**Step 4 :** Horizontal and vertical co-ordination of various groups to achieve organisational goals in the best possible manner. Since individuals, groups and departments perform their respective tasks mostly in isolation, the overall goals of an organisation can get relegated due to conflicts. For example, Head of Medicine Dept of a medical college may insist on purchase of costly equipment for his dept, even though the overall goal of providing better medical education may be served by establishing a new lecture hall.

Principles of Organising

(a) Unity of direction implying one head and one plan for a group of activities having the same objectives.

(b) Unity of Command implying that one subordinate reports only to one boss, to avoid conflict, which is inevitable if a subordinate receives conflicting orders from more than one boss.

(c) Authority commensurate with responsibility.

(d) Optimum span of control, which is the number of persons which a manager can effectively supervise.

(e) Flexible organisational structure to accommodate changes inside & outside the organisation.

(f) Management by exception wherein all routine decisions should be taken by subordinates and top manager should get involved only in exceptional matters, leaving him free to concentrate on planning and policy matters.

Line functions are those activities that have direct responsibility for accomplishing objectives of the

organisation, while staff functions are those that help the line managers to work most effectively in achieving the objectives. In staff capacity, the primary job is to advise and not command, whereas in line capacity, one must take decisions and issue orders.

### Line Organisation

In an organisation having only line relationship, authority flows in a straight line and no subordinate is under more than one superior.

**Advantages :** A line organisation

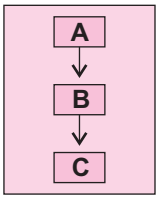
(a) Is simple to implement & understand in an organisation.

(b) Is economical and effective, esp in small organisations

(c) Maintains the unity of command

(d) Directly fixes responsibility for performance

(e) Is conducive to effective control




**Disadvantages :** Such a line organisation

(a) Is not workable in a large organisation

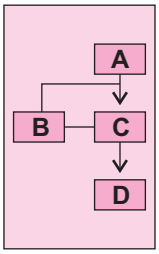
(b) Lack specialization

(c) Does not allow for benefits of expert advice

### Line & Staff Organisation

In an organisation having both line and staff relationships, experts are attached to line managers to advise them, in addition to the line structure.

For example in the organisation shown, A, C & D are in line relationship and B is in staff capacity as advisor and is not in direct line capacity.




**Advantages** : A mixed organisation, besides advantages of line org

(a) Benefits from expert knowledge of staff specialists at various levels

(b) Staff specialists take over specialist functions like accounts & thus take load off from line managers

(c) Help line managers in taking better decisions

(d) Add flexibility to the organisation

**Disadvantages** : Mixed organisations often face some disadvantages as under :

(a) Conflict between line and staff managers regarding authority and advice

(b) Staff personnel are not directly responsible for results, hence may not be fully committed to achieving organisational objectives

(c) Limited promotions for staff appointments result in competition among staff experts to gain favour with senior line managers.

### Functional Organisation

In modern organisations, which are huge and complex organisations, it is not possible to always maintain unity of command and one worker has to take orders from more than one superior on different matters. Therefore different superiors, performing different functions, command the same worker in their respective functions. This is called functional organisation, as depicted in the flow chart at the bottom.

This kind of functional organisation has the following advantages :

(a) Benefits of specialization are available to organisation since one man devotes his entire time to doing only one thing.

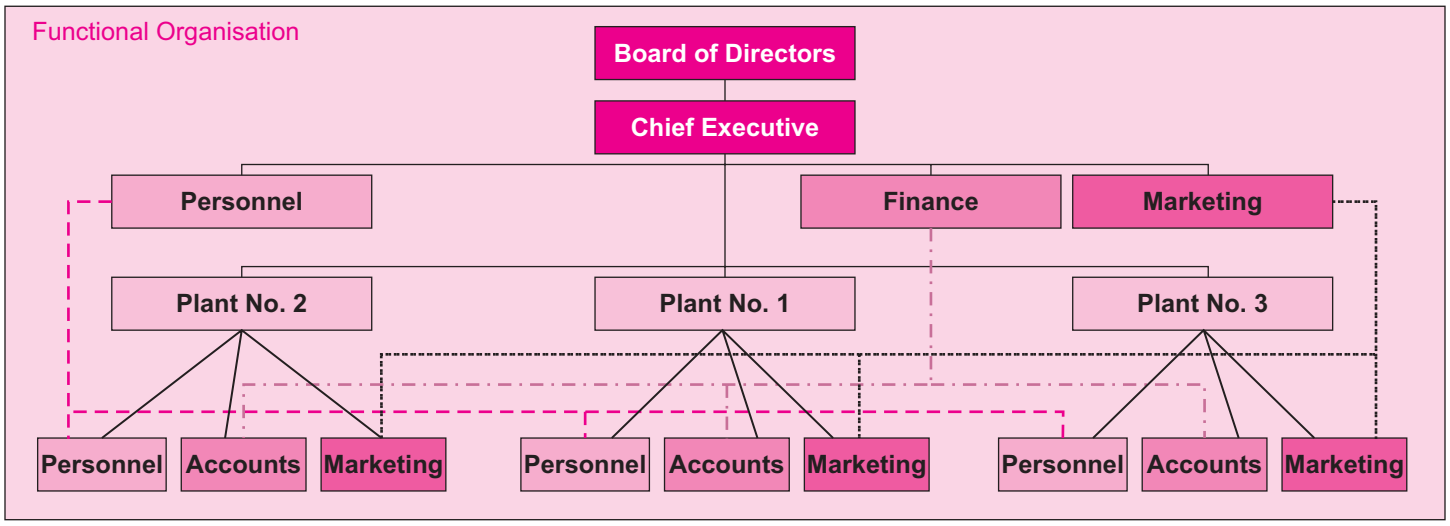
(b) Makes supervision easy because each manager is expert in a narrow range of skills.

Some of the disadvantages of functional organisation are :

(a) System is confusing from procedures / control viewpoint since exact nature of functional activity is not defined.

(b) The clear cut lines of authority and responsibility are completely lost.

(c) Complicates the control process by making



workers work under more than one superior.

(d) Fixing of responsibility for unsatisfactory results is not easy

Having organized related activities and people into formal groups in a specific manner, given them authority with adequate span of control and having found and matched the right people with the right jobs, it becomes essential to retain them. This is where motivation and leadership finds a place.

**Motivating & leadership**

After establishing objectives, plans to achieve these objectives and organisational structure with authority, a manager has to now get his people to work in order to achieve the objectives. This is done through motivation and leadership. Every individual has needs, desires and drives, which prompts him to act in a particular manner, which are collectively called motives and which channelise all his energy towards achieving some objective which the individual perceives to be beneficial to him. A manager's essential role is to channelise all energies of his workers towards attaining the organisational objective through various motivators, which can be described as below :

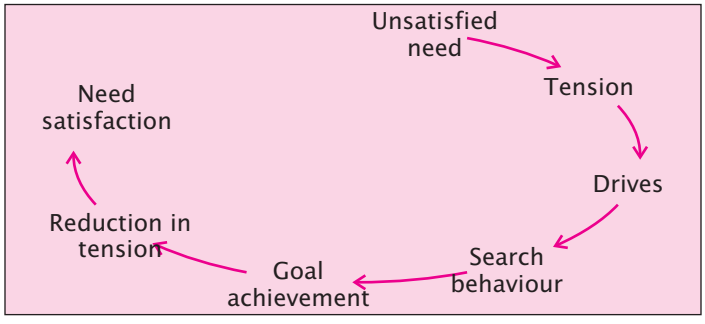
(a) Work Rewards, including monetary benefits (salary) and non-monetary benefits such as free medical cover, company car & driver, furnished house, etc.

(b) Work environment as a motivator, refers to the status of the organisation and the status enjoyed by the worker within the organisation. For example, it is well known that WHO hires only the best health professionals, thus working for WHO itself would be a powerful motivator for any health professional, even if he earns less than private practice.

(c) Work relationships developed with superior, colleagues and subordinates are important motivators. Strained relationship with boss at work place often is reason enough to leave an otherwise attractive job. On the other hand, a congenial & friendly work atmosphere has great motivating value.

(d) Work Content is the design and content of actual work to be done, which is a great motivating factor, if there is an element of freedom to take decisions and experiment with new ideas.

Thus, motivation can be described as the willingness to do something and is conditioned by this action's ability to satisfy some need of the individual. A need is an internal state that makes certain outcomes appear attractive and beneficial to the individual. The basic motivational process can be described graphically as under :




Motivation is described by various authors through Theories on Motivation, as under. The details being out of scope of this book, the reader is recommended to read books on management for detailed description :

(a) Maslow's Hierarchy of Needs (Abraham Maslow)

(b) McGregor's Theory X and Theory Y (Doughlas McGregor)

(c) Herzberg's Motivation - Hygiene Theory (Frederick Herzberg)

(d) McClelland's Achievement, Affiliation and Power Motives (David McClelland)

(e) Expectancy Approach

(f) Psychological Approach

**Leadership**

Leadership is the ability to persuade others to seek defined objectives enthusiastically, by influencing the activities of individuals or groups for achieving the organisational goal in a given situation (Keith Davis). Following are the important elements in leadership process :

(a) Leader tries to influence an individual in a particular way.

(b) Leadership, being rooted in feelings, contemplates interpersonal influence.

(c) It is a dynamic and ever-evolving process. A leader must lead continuously.

(d) Leadership is exercised in a particular situation. A non-leader may also become a leader under a particular situation.

Leadership Styles

The issue of adopting the most appropriate leadership style is essentially concerned with deciding the extent to which a manager should be dictatorial and the extent to which he should be participatory. Broadly, the leadership styles are as under :

**(a) Autocratic leadership**

In this style, the leader gives orders and insists that they should be obeyed, often by instilling the fear of punishment for non-compliance of orders. The leader formulates policies without consulting subordinates and simply tells the group what steps are to be taken immediately, without giving out any future plans. Praise or criticism is awarded to subordinates on initiative of leader alone and the leader remains aloof from the group for greater part of the time.

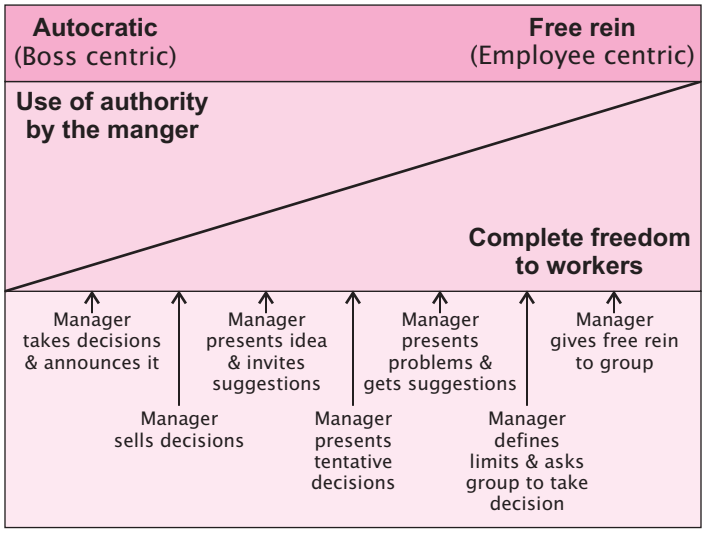
**(b) Democratic leadership**

A democratic leader gives orders only after consulting the group members, policies are discussed and decided by group discussion, subordinates are always asked to do

things after explaining to them the long-term plans on which they are working. The leader participates in the group as an active member.

**(c) Laissez faire leadership**

Such a leader does not lead and leaves the group entirely




to itself. The leader here is incapable of assuming control over his subordinates and does not participate with the group.

**Leadership as a continuum (Tennenbaum and Schmidt)**

The reader may consult books on management for description of leadership styles as under :

(a) Hawthorne Studies (Mayo & Roethlisberger)
(b) Theory X & Y (McGregor)
(c) Iowa Leadership Studies (Lippitt & White)
(d) Michigan Studies on Leadership Styles (Likert)
(e) Ohio State Studies on Leadership Styles (Stogdill)
(f) Scientific Manager's Style (Taylor)

Managerial Grid Theory

Blake & Mouton (1978) proposed that leaders may be task-oriented or person-oriented. Accordingly, leaders are

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| 1,9 | | | | | | | | 9,9 |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | 5,5 | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| 1,1 | | | | | | | | 9,1 |

most effective when they achieve a high and balanced concern for both the task and people. According to the Managerial Grid, all leaders can be rated as under :

**Task orientation**

Although there are 81 possible combinations of person and task orientation, it is important to understand the basic 5 types or leadership shown in the diagram :

(a) The (9, 1) leader is primarily concerned with task at hand and has little concern for welfare or issues pertaining to his subordinates. Known as the Task-Management Leader, he is concerned with his responsibility to complete the work at any cost.

(b) The (1, 9) leader is mainly concerned with welfare of his subordinates and has least concern for the task at hand. Known as the Country Club Management Leader, his main concern is establishing a harmonious, safe & pleasant work atmosphere among subordinates.

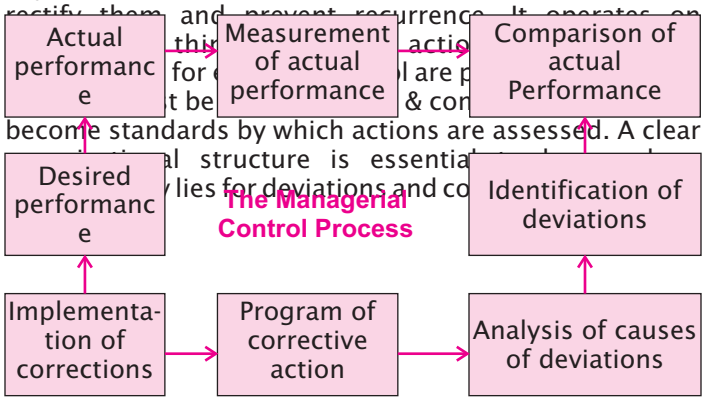
(c) The (1, 1) leader is concerned with neither the task nor the people and avoids the conflict between achievement of goals and establishment of good work atmosphere. Known as Impoverished Management Leader, he remains aloof from his organisation.

(d) The (5, 5) leader, called the Middle of the Road Management Leader, seeks to attain a compromise between attainment of organisational goals and welfare of his subordinates.

(e) The (9, 9) leader, known as Team Management Leader, is extremely concerned about both attainment of objectives and welfare of his subordinates. An ideal situation, this state is difficult to attain.

**Controlling**

The managerial process of controlling consists of measuring and correcting activities of subordinates to ensure that events conform to plans. Thus, controlling is the process of measuring performance against predetermined goals and plans, indicates where deviations from plans exist and helps in achieving organisational goals through remedial actions to correct the deviations. According to Henry Fayol, "In any organisation, control consists of verifying whether everything occurs in conformity with the plans adopted, the instructions issued and principles established. Its object is to point out weaknesses and errors in order to



The Managerial Control Process

become standards by which actions are assessed. A clear structure is essential lies for deviations and co

Thus, it is seen that control process has three essential steps, as under :

(a) Establishing standards, which are criteria for performance and include verifiable goals set in quantitative or qualitative terms. Standards can be based on past performances, managerial judgment or scientific analysis. Standards are used to measure performance and indicate success or failure.

(b) Measurement of performance, which is comparison between "what is" and "what should be" the performance. This has the aim of detecting deviations from the expected well in time and initiate corrective actions, thus it should be undertaken as a prospective action rather than as a post-mortem.

(c) Reinforcing success in case performance is as per expected standards and correcting deviations when they are apprehended or noted.

Important techniques of managerial control

**(a) Budgetary Control**

A budget is a plan showing how resources will be acquired and utilized over a specified period of time. Budgetary control ensures most optimum utilization of resources with the aim to obtain maximum returns. It directs every action towards attainment of organisational goals, provides basis for co-ordination & integration of various activities, measures performance by comparing it with budgeted figures and makes employees conscious about cost & performance. Budgets are democratic way of controlling since subordinates at all levels are involved in preparing budgets and there no undue centralisation.

**(b) Non-Budgetary Control**

**(i) Statistical Data**

Analysis of data in terms of averages, percentages, ratios, correlation etc indicates deviation of actual performance from actual performance.

**(ii) Special Reports & Analysis**

Where routine analysis fails to indicate a specific problem, detailed report by a group is useful in indicating the problem area.

**(iii) Internal Audit**

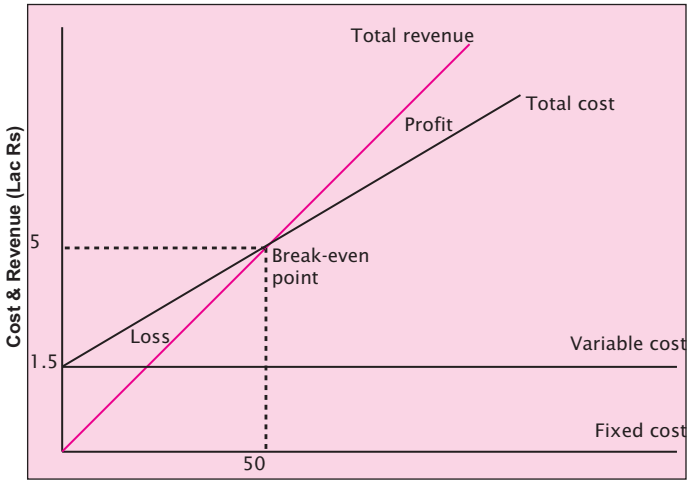
In contrast to external audit which is unconcerned with operational aspects of the organisation, internal audit (also called operational audit) is carried out by manager himself and encompasses entire range of organisational activities including appraisal of policies, procedures, use of authority, quality of management, effectiveness of methods, special problems and issues related to operations.

**(iv) Personal Observation**

As a means to managerial control, personal observation through discussions with subordinates and visits to actual sites of operations provide a manager with valuable information that can only be conveyed through face to face contact personal observation and conversation. For example, with a new man on the job, the supervisor would like to watch his work more closely than work of an experienced worker.

**(v) Break-even Analysis**

Is mainly concerned with the effect that changes in fixed costs, changes in sales volume & changes in sales price will have on the profits. Break-even analysis thus establishes a relationship between cost of production, volume of production, sales & profit. This analysis helps in determining the volume of sales which fully covers total cost price and beyond which profits start accruing and below which there will be loss. The volume of sales at which sales revenue exactly equals total cost of production (no-loss, no-profit point) is known as Break-even point (shown below) :




In the above figure, suppose fixed cost is Rs. 1. 5 lac and variable costs & sale price are Rs 7 and Rs 10 per unit respectively. Here the Break-even point is 50, 000 units of sales because at this point, the total cost is equal to the total revenue. At this point, the total cost is Rs 5 lac (fixed cost Rs 1. 5 lac + variable cost Rs 3. 5 lac) and the total revenue is also Rs 5 lac. The area to the right of this point represents the profit potential and spread to left shows the loss potential.

**(c) Modern Management Control Techniques (Network Techniques)**

Network analysis is a means of planning and controlling process. In this, a project is broken up into small operations which are arranged into logical sequence. Thereafter, the order in which these actions are to be

performed is decided and a network diagram shows the relationship between the various operations involved. Thus, any network analysis indicates the relationship between various operations involved and also points out which activities are to be completed before the others are begun. For example, the simple processes of making tea and snacks may be interlinked with each other by common resource (gas stove). Also the activity of serving tea can not be completed till the time the activity of preparing tea has been completed. This is a highly simplified example of network analysis, which indicates interdependence between two or more activities and the time-schedule between such activities in a large project. Time management of a project, an important managerial control technique, can be done through Critical Path Method (CPM) and Project Evaluation & Review Technique (PERT).

Critical Path Method (CPM)

Here, it is assumed that durations of individual activities in a project are known with certainty. The method thus helps to determine the earliest possible start time & latest possible start time for each activity. CPM also identifies the critical activities, which are critical because if any of these activities are delayed by even short period, the entire project will be delayed. CPM requires greater planning but this is justified by concentrating on critical path only and avoiding expense on strict supervision & control on non-critical activities or on whole project. Besides ascertaining the time schedule of a project, CPM is also the standard method of communicating project plans, progress and costs.

Project Evaluation & Review Technique (PERT)

PERT involves planning, monitoring and controlling of projects where time taken for each activity in the project is not known. It uses probability to estimate the timings of various activities in the project and linear programming for maximizing the achievement of objectives. PERT is classically used in long-term projects like construction of ships, roadways and buildings, in planning & launching of new products, in publication of books etc where exact time for each phase is not known with certainty. PERT uses probilistic and linear programming methods to assist a manager in planning schedules & costs, determining time& cost status, forecasting skill requirements, predicting schedule slippages & cost overruns,

$$\text{Expected Time for an activity} = \frac{\text{Optimistic Time} + (4 \times \text{Most Likely Time}) + \text{Pessimistic Time}}{6}$$

developing alternate time cost plans & committing resources to various tasks. Under PERT, three time estimates are made, as under :

(a) **Most Likely Time** : Time taken most frequently in completing a particular activity.

(b) **Optimistic Time** : Time in which an activity can be completed, if all goes well.

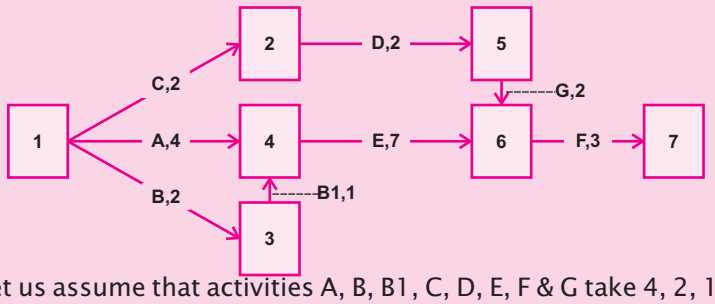
(c) **Pessimistic Time** : Time taken to complete an activity under most adverse conditions.

From the above estimates, expected time for completion of an activity is computed as under :

Unlike in CPM, when time taken for various activities are uncertain, time of completion of the project is uncertain.

Critical Path Method : An illustration

**Let us depict a project by breaking it up into individual activities (A to G) as under :-**




Let us assume that activities A, B, B1, C, D, E, F & G take 4, 2, 1, 2, 2, 7, 3 & 2 weeks respectively in the entire project of Step No 1 to 7. Here we see that A, B & C can be started simultaneously since they do not have any preceding activity. Activities A, E & F for steps 1, 4, 6 & 7 take a total of 14 weeks (4+7+3). This is the critical path since any delay in this sequence will result in delay for entire project. For the sequence 1-2-5-6 (6 weeks), we have a lead time of 8 weeks since sequence 1-4-6 will take minimum of 14 weeks. Similarly sequence 1-3-4 (3 weeks) has a lead time of 1 week over activity A which will take minimum of 4 weeks.

This way, CPM not only helps in planning & sequencing of activities, it also indicates the critical activities (which when delayed, will lead to delay in entire project), thereby concentrating on strict control & supervision of such critical activities.

CPM is an effective managerial control technique where time taken for various activities are known with certainty. However, very often, for long projects, esp in Research & Development, time duration for various activities can not be predicted. Here, we use the Project Evaluation & Review Technique (PERT)

Hence the expected time of completion & variance of project completion time are estimated. The expected completion time can be estimated as in case of length of critical path in CPM method, by replacing activity times by the expected time of various activities. Further, a crude estimate of variance of project completion time can be obtained by adding variances of all the activities on the critical path. Thus, project completion time (when time taken for each activity is not known) is equal to sum of variances of various activities on the critical path. Probability estimates of the completion time of project can be made using the fact that the project completion time has normal probability distribution with mean as expected completion time and variance as variance of the critical path.

### Management By Objectives (MBO)

The purpose of taking any decision in any organisation is to increase either the efficiency, effectiveness or both. Efficiency is the best way of performing a task and is defined as the ratio of output to input (the more output that can be derived from a given input, the more efficient is the utilization of inputs). On the other hand, effectiveness is described as "doing the right task". A manager may be very efficient in his actions, but if he is doing the wrong things (not being effective), his efficiency certainly does not help the organisation. MBO is a managerial tool by which a manager can improve their performance and their overall effectiveness.

The concept of MBO can be considered a mere extension of normal management functions of planning, control & motivation. The term MBO was first used by Peter Drucker more than 25 years ago in a very broad sense as an approach to or philosophy of management. John Humble of United Kingdom described MBO as "a system which integrates an organisation's need to achieve its objectives with the managers' need to contribute and develop himself". Thus, MBO can be defined as a managerial approach which uses objectives as a focal point to improve managerial performance & effectiveness at individual and organisational levels. The important feature of MBO which distinguishes it from other planning and control processes is the emphasis on results (objectives) rather than on activities & processes. In MBO, the emphasis is on outputs and not on inputs. MBO, being based on behavioural approach to management, is based on concepts as under :

(a) Emphasis on results rather than activities.

(b) Defining objectives (expected results) for specific positions.

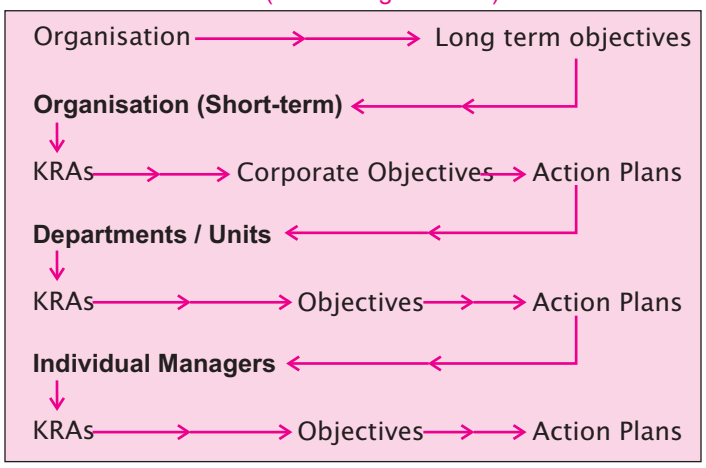
(c) Participatory or Joint objective setting.

(d) Identification of Key Result Areas (KRAs)

(e) Establishing a Periodic Review System.

MBO also emphasizes the concept of "means-ends" sequence. Results at one echelon in an organisation are the means to results at the next higher level and results for a given span of time are the means to results for a longer time-span. MBO leaves detailed methods & actions to the concerned managers by focusing on attaining objectives, and therefore. Results in better delegation, decision-making & job satisfaction at all levels.

Means - Ends Process (Cascading Process)




The MBO Process

There are broadly four steps involved in MBO process, as under

**(a) Identifying the Key Result Areas (KRAs)**

KRAs delineate the broad areas on which the organisation must focus its attention. They are based on the concept that a smaller part of manager's activities yield larger proportion of his results. Here, it is worthwhile to mention the 20 : 80 concept, which implies that 20% of a manager's activities (which are thus critical & important) account for 80% of his results and as much as 80% of his activities (which are thus not important) lead to only 20% of results. KRAs help to identify those 20% activities which will yield 80% of the results, thereby focusing on them and improving effectiveness. Once KRAs have been correctly identified, it is easy to concentrate on important aspects and give low priority to less important activities. A KRA is an area where results are important, where success would lead to significant gains and where failure would be disastrous. Although the emphasis is on objectives in MBO, it is even more important to identify KRAs. There are several ways to identify KRAs, including data analysis and brain storming, wherein all possible KRAs are listed and a short list is thereafter selected. The process of identifying KRAs by the top management consists of the following broad steps :

(i) SWOT Analysis : Analysis of Strengths, Weaknesses, Opportunities and Threats.

(ii) Brainstorming exercise to identify all possible KRAs.

(iii) Discussion, analysis & classification to arrive at an agreed list of KRAs.

(iv) Establishment of specific objectives in each KRA.

(v) Preparation of Action Plans, including assignment of responsibilities for results to be achieved.

**(b) Setting up Objectives**

Having identified KRAs, the next step is to set up

objectives within these KRAs, which will be measurable and quantifiable. The broad organisational objectives define the purpose & mission of the organisation and generally answer the question "what is our business ?" Long-term and short-term objectives emanate from organisational objectives. Strategic objectives are related to choice of product, technology or market. Choice of objectives (statement of expected result) is the starting point for management process in MBO. Hence under MBO, all inputs and processes are modified to meet the requirements of objectives. No doubt that activities are essential to obtain results, but it is well known that all activities do not contribute to achievement of objectives. In addition, objectives should be stated in terms of expected results and not merely in terms of planning activities or activities. It is well established that specific, quantifiable, measurable and concrete objectives result in higher levels of performance as compared to when managers are merely told to do their best. An objective is a statement of expected results, which provides guidelines for decisions and actions at lower level & provides standards against which performance is assessed.

Any objective thus, should have the following four elements, which are also determinants of improved performance :

(i) Quantity
(ii) Quality
(iii) Cost
(iv) Time

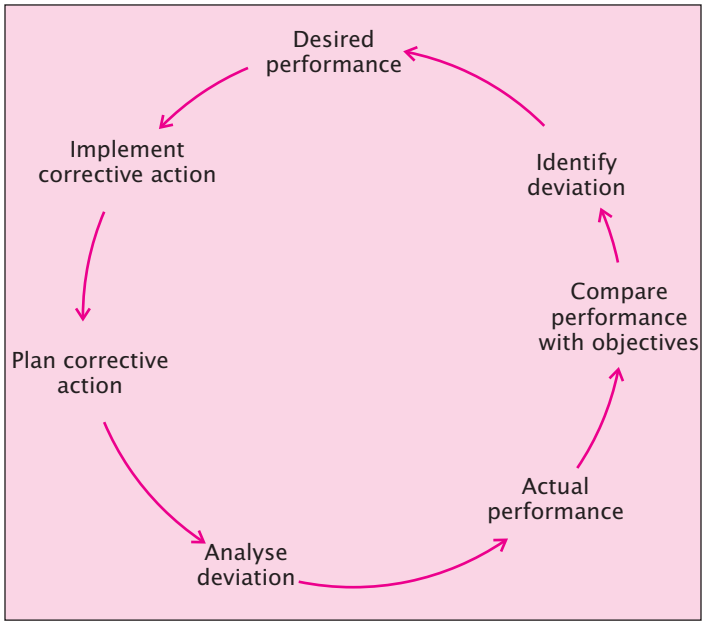
Objectives are successful as guidelines only if they are quantifiable & measurable. If you can not count, can not describe, can not measure what you want, you probably do not know what you want, and hence can not use it as an objective in your plan of action.

**(c) Action Planning**

Action plans are the means to convert objectives into reality. Objectives describe what is to be achieved, whereas action plans describe how these objectives are to be achieved. Every objective has to be achieved only through converting them into specific action plans, which specify what activities will be performed and the specific time when each activity will be performed. The 4 broad steps essential in all action plans are :

(i) Choice of strategies which are essential for achieving objectives.
(ii) Fixing the responsibility for achieving each objective.
(iii) Resource allocation for achieving the objectives.
(iv) Scheduling specific activities in specific sequence for maximum utilization of resources.

Activities (series of acts) have to be done in a particular sequence for attaining the objectives. Thus, all activities have to be arranged sequentially in most logical manner & each activity has to be completed within a stipulated time frame. This is called scheduling, which converts plans into action plans. An example of Action Plan is given below. Let




**Advantages of MBO**

- Greater role clarity, job satisfaction and better measurement of performance.
- No wastage of scarce resources.
- Single-minded dedication to achievement of objectives.
- Motivating factor & weeds out non-performers
- Increases productivity through role clarity & increasing job satisfaction.
- Strengthens superior-subordinate relationship.
- Provides objective appraisal method.

| | | | Action Plan | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S No. | KRAs | Objectives | Jan | Feb | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov |
| 1. | Upgradation of infrastructure | 1. Tiling of rooms | | | | | | | | | | | |
| | | 2. Est of LAN | | | | | | | | | | | |
| | | 3. Est of Comptr | | | | | | | | | | | |
| 2. | Printing of new magazine | 1. Release of funds | | | | | | | | | | | |
| | | 2. Printing | | | | | | | | | | | |

Where ▬ is the planning phase a[illegible] ▬ is the execution of activities

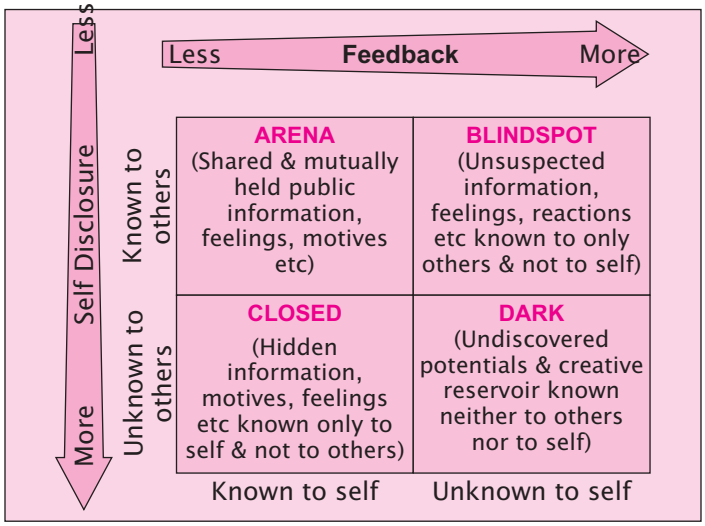
**Disadvantages of MBO**

- Problem of joint setting of objectives among unequals in the organisation.
- MBO may not always percolate to the lowest level in the organisation
- Difficult to implement in situation of change.

**Some additional important managerial concepts**

(a) Developing Interpersonal Styles

The JoHari Window :- Interpersonal relationships between groups is determined by how the groups relate to each other. In order to develop a fruitful relationship, the groups must get to know each other. The JoHari Window is a conceptual model for understanding interpersonal relationships. It is a schematic model that shows how people expose themselves to others and receive feedback from others. The name "Johari" is derived from Joseph Luft and Harry Ingham, who developed the model.




The implication of the JoHari Window is that when Arena is enlarged through self disclosure & feedback, meaningful interpersonal interaction can take place. As the Arena expands, the Closed area shrinks and it no longer becomes necessary to hide or deny things one knows or feels. The Blindspot takes longer to reduce since the person is not even aware of the information, feelings etc. The ultimate goal of this exercise is to move elements from the Dark quarter (of undiscovered potentials) into the Arena (where information, potentials are realized by others as well as self).

(b) Inventory Management

'Inventory' can be defined as 'presently idle but useable resource'. Inventory management deals with determination of correct policies and procedures for procurement of commodities. Broadly speaking, inventory management is concerned with maintaining an adequate supply of some resource to meet an expected demand for that resource. Thus, inventory management is considered a 'necessary evil'. Inventory related costs are

(i) Cost of carrying inventory (holding or opportunity cost of blocking material in non-productive form, expressed as Rupees / item held in stock / unit time)

(ii) Cost of incurring shortages (opportunity cost of not having an item in stock when one is demanded, due to lost sales or backlogging)

(iii) Cost of replenishing inventory (amount of money / efforts expended in procurement of resources, generally called Ordering cost).

Inventory aims at minimizing the uncertainties of demand & supply by 'decoupling' the demand & supply sub-systems. Inventories in form of buffer stock of resources are essential because of uncertainties of demand & lead time, time lags in delivery of resources, backlogging of production process etc.

Types of Inventory Systems

**(a) Lot Size Reorder Point Policy**

Under this policy, the inventory is constantly monitored and as soon as the inventory level falls to a prescribed level (called 'Reorder Point') a fresh replenishment order of a fixed amount of inventory (called Economic Order Quantity, EOQ) is ordered. Thus, the order size is always constant and economically determined.

**(b) Fixed Order Interval Scheduling Policy**

Under this policy, the time interval between two consecutive replenishment orders is always constant, whereas the quantity of stock ordered is determined by the stock already held. This ensures that when high amounts of resources are held, smaller replenishments are ordered.

**(c) Optional Replenishment Policy**

Popularly known as (s, S) policy, here the inventory is periodically reviewed and maximum stock levels (S) and minimum stock levels (s) are pre-determined. If at review of inventory, the stock level is less than or equal to s, an order is placed so that the stock held in hand and order placed equals the maximum stock level of S. If during review, stock held is more than s, no order is placed during that review.

**(d) Other types of Inventory Systems**

Under special circumstances, other types of inventory systems may be adopted. These may be a One-for-one order policy where a replenishment of one unit is demanded whenever there is a requirement of one unit, generally for slow moving goods. Under Multiple reorder policy, more than one reorder points are established. Static Inventory System involves single purchase decision which is adequate for entire project duration and such decisions are not repetitive.

Selective Inventory Management

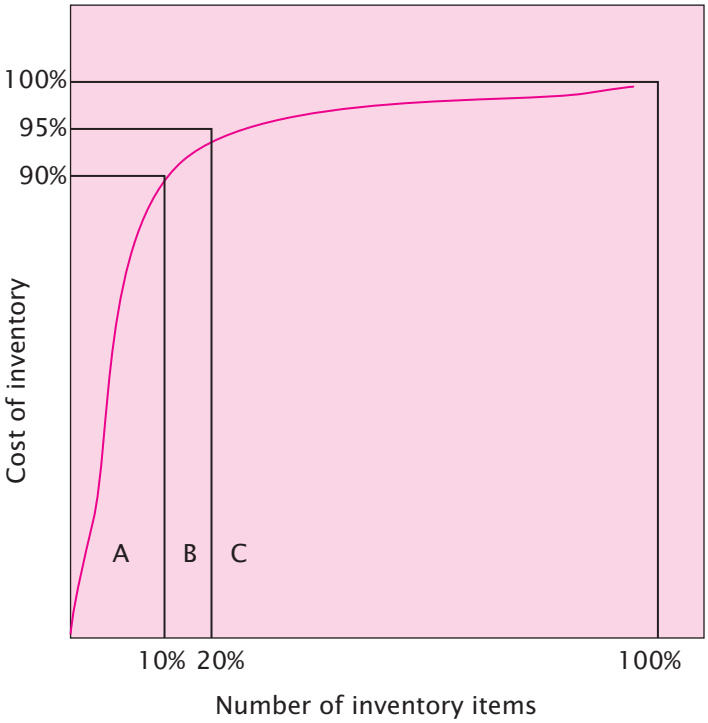
Due to the large variety and numbers of the stocked items in an average organisation, it is prohibitive to apply strict inventory control measures to all items. Appropriate type of inventory policy has to be adopted for selective items depending on the value, criticality and usage frequency of the items. Under selective inventory control, items are

grouped in few categories depending on their value (ABC analysis), criticality (VED analysis) and usage frequency (FSN analysis).

**ABC analysis**

is based on the universal Pareto's Law, which states that in any large quantity, there are 'significant few' and 'insignificant many'. Thus, in any large inventory, there may be only 10% of the items which cost 90% of the entire inventory cost, making them the significant few which require strict inventory control. This is depicted graphically as under :

ABC Analysis




In the example shown, 10% of the items categorized as A account for as much as 90% of the cost of total inventory, 10% of goods classified as B account for 5% of total inventory cost and 80% of total inventory goods classified as C cost only 5% of the total inventory cost. It is thus natural that item A should be subjected to strict control since it costs as much as 90% of the total inventory cost.

**VED Analysis**

Here, the inventory items are classified into three categories (Vital, Essential & Desirable), depending on the seriousness of consequences of stockout of the item. vital items are most critical and shortage of such items may be disastrous for the organisation, Essential items are quite critical for functioning of an organisation and should be by and large available whereas Desirable items do not have serious consequences when in short supply.

**FSN Analysis**

This is based on frequency of demand of various items and items are grouped as 'Fast-moving', 'Slow-moving' and 'Non-moving' items. Obviously, fast moving items must be replenished on priority as any shortage of such items is bound to adversely affect the functioning. Slow

**Further suggested readings**

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Lt Col AS Kushwaha

# Health Care System in India

### Historical Perspective

History of health care and public health in India dates back to antiquity. The "Indus Valley Civilization" excavations revealed existence of well planned cities with drainage and sanitary practices as far back as 3000 B. C. Anecdotes of traditional practices of medicine and battlefield medical care and environmental sanitation are mentioned in the epics of Mahabharata and Ramayana. The systems of medicine that are considered to have originated in India are Ayurveda and Siddha. Both these systems are quite similar in concept and practice. Ayurveda means "Knowledge of Life". This comprehensive system of medicine has its roots in Vedic period. The famous practitioners of this system in India were Atreya, Susruta, Charaka and Vaghbhatt. The famous treatise on Indian health and medicine include Manu Samhita, Charaka Samhita and Susruta Samhita. The practice of setting fractures, amputations, cataract surgery is recorded in history. Ayurveda is based on "Tridosha" theory wherein body in health has equilibrium of three humors namely "Vata (wind), Pitta (gall) and Kapha (mucus)". Disease results whenever this equilibrium is disturbed. Ayurveda flourished during Buddhist times. Indian medicine spread to China, Indonesia, and Central Asia and as far as Japan and played a similar role as Greek medicine played in Europe. (1)

Other systems of Indian medicine are Unani (Greek-origin) Siddha and Homeopathy which are not indigenous but widely practiced. Unani-Tibb system of medicine was brought to India by Muslim rulers in 10th century. Besides the above system many types of traditional healing practices continue to be in vogue despite rise of scientific medicine.

## Evolution of Health System in Modern India

Epidemiologically, India is passing through a transition phase in health like any other developing country. It continues to face the scourge of emerging and re-emerging infectious diseases on account of population explosion, haphazard development, in-sanitary conditions, poorly staffed and under equipped public health infrastructure and lack of basic amenities like safe water and sanitation to the poor and underprivileged. Newer, fast growing epidemics of non-communicable diseases are posing a health challenge on the other front due to rapidly growing economy and increasing life expectancy. India has already been dubbed as the Diabetic Capital of the world.

In the pre-independence period, the British had started a number of Public Health initiatives. Quarantine act was passed in 1825. Commission of Public Health in 1859 had pointed out the need of safe water and environmental sanitation to prevent occurrence of epidemics. Sanitary commissioners were appointed in all three provinces of Bombay, Madras and Bengal. Local self government act was passed in 1885. Decentralization of health administration had begun in 1919 with Montague-Chelmsford constitutional reforms. Bhore committee constituted in 1943 laid the framework on which the health care was eventually built in the independent India. The health care in India has since moved from bureaucratic government based top down approach to decentralized community based bottom- up system after the Panchayati Raj came into being. This model was long ago propagated by the Father of the nation "Mahatma Gandhi".

### Bhore Committee

In 1943, Government of India appointed the "Health Survey and Development Committee" under chairmanship of Sir Joseph Bhore. The committee submitted its report in 1946. (2) The recommendations on integration of curative health care with preventive services and development of primary health centre in rural areas were made by this committee. It envisioned development of Primary Health Centre in both short and long term perspective. A PHC would serve a population of 40, 000 as a short term measure, with a staffing of 2 medical officers, 4 Public Health Nurses, 1 Nurse, 4 Midwives, 4 trained Dais, 2 Sanitary inspectors, 2 Health assistants, one pharmacist and fifteen other class IV employees. In the long term (3 million plan), the PHC would have a 75 bedded hospital for a population of 10-20, 000. It also reviewed the system of medical education and research. This document laid the utmost emphasis on primary health care which became the key strategy to achieve Health for All (HFA) by 2000 during Alma-Ata conference. The Bhore committee model was based on the allopathic system of medicine. The traditional health practices and indigenous system of medicine prevalent in rural India, which had greatest influence and were part of their socio-cultural milieu were not included in the model proposed by Bhore committee. The approach was not entirely decentralized but had a top down approach. However it provided a ready-made model at the time of independence and thus was adopted as a blueprint for both health policy and development of the country.

### Mudaliar committee

To review the progress made since submission of Bhore committee report and to make recommendations for development of Health services based on the needs, Government appointed "Health Survey and Planning Committee" under Dr A L Mudaliar in 1959. It found that services provided by PHCs were inadequate. It recommended strengthening of PHCs and development of referral centres. It also suggested constitution of an All India Health Service. (3)

### Jungalwalla Committee

In 1967, Central Council of Health appointed "Committee on integration of Health Services" headed by Dr N. Jungalwalla. It recommended a unified cadre, common seniority, no private practice and good service conditions.

**Kartar Singh Committee**

The Committee headed by then additional secretary, MOH and Family planning was constituted to study and make recommendations on the structure for integrated health services at peripheral and supervisory levels. It was to study the feasibility of bipurpose and multipurpose workers in the field. It recommended "Female Health Worker" in place of ANM and "Male Health Worker" in place of malaria surveillance worker, vaccinators, health education assistants and family planning health assistants. The committee proposed a PHC per 50, 000 population with 16 subcentres, each covering a population of 3000-3500. (4)

**Shrivastav Committee**

This was a "Group on Medical Education and Support Manpower" constituted in 1974 by the Government. (5) The concept of community participation in the health sector originated wherein it was felt that "health of the people is placed in the hands of people". This group recommended that primary health care be provided within the community itself through specially trained workers. Based on these recommendations "Rural Health Scheme" was launched by the government in 1977-78.

**Alma-Ata Declaration**

The concept of health care passing through the stages of "Comprehensive health care" and "Basic health services" had finally moved on to the concept of "Primary Health Care". This new strategy was adopted by all member countries during Alma-Ata conference held in 1978 in then USSR, as the key to attainment of "Health for All by 2000". Primary Health Care has been defined as "essential health care made universally accessible to individuals and acceptable to them, through their full participation and at a cost the community and country can afford". (6) This concept of Primary health care is based on the principles of equitable distribution, community participation, intersectoral coordination and use of appropriate technology. The basic principle in this remains the involvement of the community in health care.

**Health for All (HFA) by 2000**

During 30th world Health Assembly "Health for All by 2000" was set as the social goal for all the member countries. All countries were to develop their norms and indicators and formulate their own strategy to achieve this with "Primary Health Care" as the key strategy. The HFA was defined as "attainment of a level of health that will enable every individual to lead a socially and economically productive life". The important elements of primary health care as included in Alma-Ata declaration are education on prevalent health problems and methods to prevent and control them, adequate food supply and proper nutrition, provisioning adequate and safe water and access to basic sanitation, MCH care including family planning, immunization services, prevention and control of locally endemic diseases and appropriate treatment of common diseases and injuries and provisioning of essential drugs. WHO proposed 12 global indicators for assessment of a country's progress towards HFA that included a minimum life expectancy of 60 years and maximum IMR of 50 per 1000 live births. (7) Report of the study group on "Health for All- an alternative strategy" sponsored by ICSSR and ICMR under the chairmanship of Professor V Ramalingaswami and report of the working group on HFA by 2000 of Ministry of Health and Family Welfare formed the framework for formulation of National Health Policy-1983. Goals that were set to be achieved by year 2000 are given in Table 1. Subsequently the National Health Policy was revised in 2002 and fresh targets were laid down (

Table - 1 : National Health Policy- HFA by 2000 Goals

| Sr. No | Parameter | Present (1983) | Goal to be achieved by 2000 |
|---|---|---|---|
| 1 | Reduce IMR | 125 | < 60 |
| 2 | Raise Life Expectancy | 52 | 64 |
| 3 | Reduce CDR | 14 | 9 |
| 4 | Reduce CBR | 33 | 21 |
| 5 | Achieve NRR | NRR = 1 by 2000 | |
| 6 | To provide potable water to the entire rural population by 2000 | | |

refer to chapter on National Health Policy for details)

**Millennium Development Goals**

During millennium summit in September 2000 at New York, 189 member countries adopted United Nations Millennium Declaration. The goals to be achieved related to health, poverty, gender inequality, environmental sanitation etc are referred to as Millennium Development Goals (MDGs) (8). Three of the 8 goals, 8 of the 18 targets and 18 of the 48 indicators are health related. Governments have set out 2015 by which they plan to achieve these goals. Tackling poverty and hunger is the top priority.

The list of health related goals (MDGs) is given as under -

Goal 1- Eradicate extreme poverty and hunger

Goal 4 – Reduce Child mortality

Goal 5 – Improve Maternal health

Goal 6 – Combat HIV/ AIDS, malaria and other diseases

Goal 7 – Ensure Environmental sustainability

Goal 8 – Develop global partnership for development

To achieve these goals, a number of targets and indicators have been decided by each country and suitably modified.

**Panchayati Raj**

In 1952 community development programme was started for all round development of the rural areas. This was a multipurpose programme including the facets of agriculture, communication, education, health and sanitation. A block consists of 100 villages & a population of 80,000 to 1,20,000.

The village panchayats have existed in India since ancient times. Gandhiji defined his vision of village Panchayats in the following terms "Village swaraj is a complete republic independent of its neighbours for its own vital wants and yet interdependent for many others in which dependence

is a necessity". Panchayati Raj represents the struggle of the people to regain the power vested in them at independence. It means resources and power and to control them administratively. The Panchayati Raj is a form of local self government in India. It is structured at village, block and at district level. People's model of health is based on the strengths of our own culture and utilizes all modes and systems of appropriate health and medical care in an integrated and holistic manner. At the village level there is a panchayat, Panchayat Samiti at Block and Zila Parishad/ Zila Panchayat at the district level. The aim of these institutions is to make people participate in the development process.

### Health Resources

The resources required to look after the health needs of the community depend upon the size of the population, communication facilities and the educational status. The resources available depend upon the economic status, political will, priority of health in national development planning process and level of awakening and empowerment of the community. Three elements of health resources are Health manpower, money and material and time. Health manpower planning is an important step in Community Health care planning (10). Suggested norms for health personnel is given in Table - 2.

Table - 2 : Suggested Norms for Health Personnel

| SNo | Category | Suggested Norm / population |
|---|---|---|
| 1 | Doctors | 1/ 3500 |
| 2 | Nurses | 1/5000 |
| 3 | Health worker Male/Female | 1/5000-Plains 1/3000- Hills/Tribal areas |
| 4 | TBAs | 1/village |
| 5 | Health Assistant | 1/30,000 |
| 6 | Pharmacists | 1/10,000 |
| 7 | Lab Technicians | 1/10,000 |

### Five Year Plans

Planning commission formulates five year plans. Health sector for purpose of planning has been divided into many sub-sectors like water supply and sanitation, control of communicable diseases, medical education, training and research, medical care including hospitals and PHCs, family planning and indigenous system of medicine. Tenth five year plan (2002-2007) has focused on the optimizing coverage and quality of care by improving access and quality of primary health care in both urban and rural areas. The percentage of fund allocation for health has been grossly inadequate The spending on health has never touched 5% of the national plan outlay which has been suggested by WHO as goal to achieve HFA. India spends 3% of GNP on health. The health infrastructure saw some growth in the first two plans but later plans focused on urban-based curative services. The PHCs were relegated to mere instruments of achieving national targets. Some key facts are shown in Table - 3, 4 & 5.

### National Rural Health Mission

It was launched on 5th April 2005 for a period of seven years (12). The details are discussed in a separate chapter.

## Organization of Health System in India

Health is the responsibility of the state as enshrined in constitution of India. Health is a basic right of every individual. Based on these principles, various health programs were formulated and implemented. However the involvement of community and its importance was realized only after these "Vertical" programs failed to achieve the desired results and the "Health Gap" between the urban and rural areas continued to widen. The "Primary Health Care" promises to fill this gap. There has been some progress on the health front since independence, albeit a bit slow. The economic progress promises to hasten this progress coupled with emphasis on strengthening of rural health infrastructure under

Table - 3 : Plan wise Expenditure on Health and Family Welfare

| Plan Period | Total plan outlay (in Rs. Crores) | Health | Family Welfare | Sub Total |
|---|---|---|---|---|
| 1951-56 | 1960 | 65.2 (3.3 %) | 0.1 | 65.3 ( 3.3%) |
| 1956-61 | 4672 | 140.8 (3%) | 5 (0.1%) | 145.8 (3.1 %) |
| 1961-66 | 8576.5 | 225.9 (2.6%) | 24.9(0.3%) | 250.8 (2.9%) |
| 1966-69 | 6625.4 | 140.2 (2.1%) | 70.4 (1.1%) | 210.6 (3.2%) |
| 1969-74 | 15778.8 | 335.5 (2.1%) | 278.0 (1.8%) | 613.5(3.9%) |
| 1974-79 | 39426.2 | 760.8 (1.9%) | 491.8 (1.2%) | 1252.6(3.2%) |
| 1980-85 | 109291.7 | 2025.2 (1.8%) | 1387 (1.3%) | 3412.2(3.1%) |
| 1985-90 | 218729.6 | 3688.6 (1.7%) | 3120.8 (1.4%) | 6809.4 (3.1%) |
| 1990-91-92 | 137033.5 | 2253.8(1.64%) | 1805.5(1.32%) | 4059.3(2.9%) |
| 1992-97 | 798,000.0 | 7582.2 (1.75%) | 6500 (1.5%) | 14082.2 (3.25%) |
| 1997-2002 | 859,200.0 | 10818.4 (1.26%) | 15120(1.75 %) | 25938(3.01%) |
| 2002-07(X Plan) | 1484131.3 | 31020.3 (2.09%) | 27125 (1.82%) | 58145(3.91%) |

Table - 4 : Targets for Xth Plan (2002-07)

| S. No. | Target | Remarks |
|---|---|---|
| 1 | Reduction of Poverty | 5% points by 2007<br>15 % points by 2012 |
| 2 | Primary Education | All children to attend school-2003<br>All children to complete 5 year of schooling by 2007 |
| 3 | Reduce Gender gap | Literacy and Wage rate by 50% by 2007 |
| 4 | Literacy | 75% within plan period |
| 5 | Reduction of IMR | To 45 per 1000 live births by 2007<br>To 28 per 1000 live births by 2012 |
| 6 | Reduction of MMR | 2 per 1000 live births by 2007<br>1 per 1000 live births by 2012 |
| 7 | Access to Potable | All villages |

Table - 5 : The progress of various key parameters since independence

| Sr. No. | Item of information | 1951 | 1991 | Current |
|---|---|---|---|---|
| 1 | Population (in million) | 361 | 846 | 1131(mid 2007) |
| 2 | Crude Birth rate | 39.9 | 29.5 | 24 |
| 3 | Crude Death rate | 27.4 | 9.8 | 8 |
| 4 | Infant Mortality Rate | 134 | 80 | 57 (SRS 2006) |
| 5 | Annual Growth Rate (%) | 2.19 | 2.07 | 1.96 |
| 6 | PHCs | 4793 | 20139 | 22669 |
| 7 | Sub Centres | 17521(1967) | 130984 | 144988 (2005) |
| 8 | CHCs | - | 2070 | 3910 (2005) |
| 9 | Beds per lakh population | 32 | 83 (1982) | 89 (2003) |
| 10 | Doctor per lakh population | 17 | 47 | 70 |
| 11 | Health expenditure (%of GDP) | | 0.22 | 0.960.91 |

NRHM based on the pillars of primary health care.

### At Centre

Before 1947, the medical and health services at the centre were administered by two separate departments, one under the Director General of Indian Medical Service and the other under the commissioner of Public Health.

Presently, the Union Ministry of Health and Family Welfare is headed by a cabinet minister. The ministry has three main departments- Health, Family welfare (created in 1966) and Indian system of Medicine and Homeopathy. Department of Health deals with medical and public health matters, including drug control and prevention of food adulteration. The secretary to the Government of India in Ministry of health and family welfare is in overall charge of Family Welfare. The functions of the Union Ministry of Health are given in 7th schedule of Article 246 of constitution of India under concurrent and union list. Technical advice on all medical and public health matters is rendered by the Director General Health Services (DGHS). The directorate comprises of Medical care and hospitals, Public Health and general administration. The main functions are listed in table-6

### Central Council of Health

This was created to ensure coordination and cooperation on health related function of states and centre under concurrent list. This council is headed by Union Minster of Health and Family Welfare and State Health Ministers are the members.

### State Level Organization

Each state has a state ministry of health and state health directorate. The state health minister heads the ministry assisted by a deputy

Table - 6 : Functions of DGHS

| SNo | Function | Remarks |
|---|---|---|
| 1 | International Health Relations & Quarantine | All international Sea and Air ports |
| 2 | Control of Drug standards | Drug controller |
| 3 | Medical Store Depots | Mumbai, Chennai, Kolkata, Karnal, Guwahati , Hyderabad |
| 4 | Post graduate Training | AIIHPH Kolkata, NIMHANS Bangalore, NTI Bangalore, NICD Delhi, CRI Kasauli, NIHFW Delhi |
| 5 | Medical Education | LHMC Delhi, MAMC Delhi, Medical Colleges at Goa and Pondicherry |
| 6 | Medical Research | ICMR, Research centres e.g. NIN, NIV |
| 7 | Central Government Health Service | |
| 8 | National Health Programs | RNTCP, NLEP, NMCP, NACP |
| 9 | Central Health Education Bureau | Preparationof health education material |
| 10 | Health Intelligence | CBHI |

minister. Health Secretariat is the official organ of this ministry and is headed by a Secretary. Director of Health Services is the chief technical adviser to the state government on all issues of medical care and Public health. In some states this designation is also known as Director of Health and Family welfare. The director is assisted by a number of Deputy and Assistant directors. They may be regional or functional in their nature of duties. Director Medical Education has also been added as new appointment due to increased number of medical colleges. Public Health Engineering is an organization which functions under the umbrella of Public Works Department.

### District Level

The district is the principal functional unit of administration in the country and this also holds true for health care delivery and management. The district is sub-divided into sub-divisions, tehsil / taluka, community development blocks, villages and panchayats. The Blocks comprise of about 100 villages and a population of 80, 000 to 1, 20, 000. The Block is basic unit of rural development and planning. The urban areas of district are organized into the forms of local self government based on the size of population covered e. g. town area committees (population 5000-10, 000), Municipal Boards (Population 10, 000-200, 0000), Municipal corporations (Population > 2 lakh).

The medical and health organization varies from state to state. Under the MPW scheme, it has been suggested to have a Chief Medical Officer assisted by three Deputy CMOs. The District Hospitals have been re-christened as District Health Centres thus integrating preventive, promotive and curative services.

## Levels of Health Care

Traditionally health care has been described as Primary, Secondary and Tertiary involving varying degrees of technical expertise and complexity. Primary or "First contact" care is provided by Primary Health Centres and their Sub-Centres. Secondary care is provided through Community Health Centres (CHCs) and District Health Centres. The CHCs are also referred to as FRUs (First Referral Units). Tertiary health care is very sophisticated, technically advanced form of medical care with super specialist facilities available only at select institutions at state and central level.

### Primary Health Care

As adopted during Alma-Ata Conference, Primary Health care is the key strategy to attain "Health for All". The underlying principles of Primary Health Care are equitable distribution of health services, community participation, and intersectoral coordination and by using appropriate technology. By equitable distribution it is implied that health services are made available to all irrespective of socio-economic status and place of residence. Most of the health facilities are concentrated in the Urban areas with the majority of rural and under privileged still do not have access to basic health care. Community participation it is meant that community must be actively involved in planning, implementation and maintenance of health services. The Village Health Guides and ASHA are steps in this direction. All related sectors and aspects of community development like agriculture, animal husbandry, food, industry, education, communication and housing must work hand in hand with health care system. Appropriate technology means a technology that is scientifically sound, adapted to local needs and acceptable to the community and based on the principles of self reliance and affordable.

### Health Care Services

The basic aim of health services is to improve the health status of the population to achieve the goal of Health For All as defined during Alma-ata conference. The health services should be comprehensive, accessible, and acceptable to community with their participation and at a cost the country or community can afford.

In India, the health services are provided by Public Health sector, Private sector, traditional / indigenous systems of medicine, voluntary health agencies and various national health programs related to various diseases and disorders. Besides the above there are comprehensive health care services of Defence and Railways.

### Village Level

At the village level, Village Health Guide scheme was introduced in 1977. These health volunteers came from the same community they were supposed to serve. All the VHGs are now females. They are trained at PHC for 3 months (300 hours). They are volunteers who do this health care task for 2-3 hours and continue to pursue their vocation.

At present there are 3. 23 lakh VHGs. The target is to provide one VHG in each village or per population of 1000. Under Rural Health Scheme (1977-78), a program was initiated to train local dais (Traditional Birth attendants). This training is for 30 days at PHC and she is required to conduct at least 2 deliveries under supervision and guidance of Health Worker (F), ANM or Health Assistant (F). She is issued delivery kits and receives honorarium of Rs 10 per delivery and Rs 3 per child registered.

ICDS (Integrated Child Development Services) program based on supplementary nutrition was launched in 1975 in pursuance of National Policy for Children. Under ICDS there is a provision for an Anganwadi for a population of 1000. The beneficiaries are pre-school children below 6 years of age, adolescent girls in age group of 11-18 years and pregnant and lactating mothers. There are 100 Anganwadi workers in each ICDS project. As of date 5671 ICDS blocks are functional across the country.

### Sub-Centre

The Sub-Centre is the most peripheral health delivery unit in Primary Health Care. A Sub-centre is provided for a population of 5000 in plains and 3000 in hilly and tribal areas. The Sub-Centre is staffed with a Multipurpose Health Worker (MPW) male and MPW female. They function as link between the population and PHC. They provide the basic MCH services. It has been planned to upgrade their training and job description under NRHM. The work of these Health workers is supervised by Health Assistant at

PHC.

Health Worker Female registers all antenatal cases, eligible couples and newborn children. She provides care for antenatal cases including distribution of Iron and folic acid tablets, immunization against tetanus, vitamin A solution to children. She carries out deliveries and supervises the deliveries by TBAs and refers difficult cases to PHC/ District Health Centre. She makes at least 3 visits after the delivery to educate mothers on breast feeding, postnatal care and motivate them for family planning. She also distributes contraceptives. She carries out universal immunization and growth monitoring of children. She helps MO and Health Assistant in all MCH and Family planning activities during the clinic at sub-centre.

Health Worker Male is responsible for record keeping on demographic data on Family records and village registers. He undertakes activities related to Malaria, Communicable diseases like diarrhea, fever, STDs etc. He also refers cases of blindness and cataract. He also carries out task related to management and treatment of Tuberculosis and Leprosy. He also ensures water safety and environmental sanitation. He helps and compliments the Health Worker Female in Family planning and immunization activities.

**Primary Health Centre**

The genesis of Primary Health Centre can be traced back to the concept of "Rural Health Centre" envisioned by Health Organization of League of Nations during European conference on Rural Hygiene of Geneva in1931. (13) The Bhore Committee Report recommended development of PHCs as the institutions to deliver integrated health care in rural area. The recommendations of Bhore committee on staffing of a PHC still remain to be realized even after 60 years. These PHCs were developed for a population of a block (80, 000 – 100, 000). They failed to deliver due to poor staffing and a large population base to serve. The national health policy in 1983 laid down the requirement of one PHC for a population of 30, 000 in plains and for every 20, 000 in hilly and tribal areas. As of 2005, a total of 23236 PHCs have been established. The functions of the PHC include medical care, MCH and Family Planning, prevention and control of locally endemic diseases, basic lab support, national health programs, training, referral and collection and reporting of health data. The staff (total 15) at PHC includes a medical officer, pharmacist, ANM, HW (M&F), Health assistant (M&F), UDC & LDC, Lab Technician, driver and 4 class IV employees. The job description of Health male and female is same as for them at a sub-centre. The Health Assistants supervise and monitor the work of 6 Health Workers under them.

**Community Health Centres**

Each CHC is required to provide cover to a population of 80, 000 to 1. 2 lakh. These have been established by upgrading the PHCs. There are 30 beds and facilities are provided in the specialties of surgery, medicine, gynecology and pediatrics along with facilities for X-ray and laboratory services. A second medical officer is provided in some states in place of community health officer who is a non-medical person. Under IPHS criteria each CHC is required to provide "assured services". These are also referred to as Rural Hospitals in some states. They are also referred as the First Referral Units in Primary Health Care setting.

Indian Public Health Standards for Community Health Centre (CHC)

These standards have been designed to ensure and achieve an acceptable standard of quality of care at CHCs.

The assured services include -

(a) Care of routine and emergency cases in surgery and medicine including hernia, hydrocoele, appendicitis, fistula, intestinal obstruction, dengue/DHF, cerebral malaria etc.

(b) 24 hour delivery services including normal and assisted deliveries

(c) essential and emergency obstetric care including caesarean

(d) safe abortion services

(e) newborn care

(f) Routine and emergency care of sick children

(g) Procedures like tracheostomy, nasal packing and foreign body removal

(h) Delivery of all national health programmes

(j) Diagnostic and surveillance facilities

(k) Blood storage facility

(l) Transport for referral

(m) Essential laboratory services

To achieve the above, additional posts of an anesthetist, eye surgeon (for every 5lac population under "Vision 2020") and a public health programme manager (Block Surveillance Officer) making a total staff of 21-22+2* (*1ANM and 1 PHN for family welfare under ASHA scheme) personnel has been recommended.

Besides the above, all national health programs are delivered through CHCs. Providing DOTS, AIDS control program activities, NLEP, Vector borne diseases like malaria, filarial, dengue, JE etc their diagnosis and management are also the functions of the CHC.

**ASHA (Accredited Social Health Activist)**

ASHA is selected for a population of 1000, from the local population as any lady who is in age group of 25-45 years, educated minimum up to 8th standard who functions as health activist. She is a community health activist who shall create awareness amongst the population on health issues, counsel women on MCH care, motivate people to access health care services, provide elementary medical care for minor ailments and provide DOTS. She will be provided with a drug kit including drugs of indigenous system of medicine. She will be guided and trained under the Anganwadi worker and ANM. ASHA will identify, escort and guide pregnant women and those children requiring treatment and admission at nearest health facility. She will function as depot holder for essential drugs like ORS, Iron and Folic acid, chloroquine, OC pills, disposable delivery

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# National Health Programmes

## Introduction

India was one of the first countries in the World to conceptualize a comprehensive health care system, based on primary health care. In 1946, the Health Survey and Development Committee, headed by Sir Joseph Bhore recommended establishing a well-structured and comprehensive primary health care infrastructure. This report, besides being a historical landmark in development of Indian public health system, also laid down the blueprint for subsequent health planning and development in independent India. The report also recommended addressing the major health problems, through special programs under the overall umbrella of general health care services to be made available to all. Subsequent health committees constituted from time to time have also endorsed this view-point of having vertical or horizontal health programs, under the overall umbrella of primary health care (1).

## Relevance of National Health Programs for Indian Armed Forces

Armed Forces Medical Services (AFMS) provide comprehensive health services (promotive, preventive, and curative) to its clientele. By and large these services are self sufficient and insulated from the civilian health services. National Health Programs are planned to deal with specific health problems among most affected population subgroups, allocating large sums of money. These health problems are also relevant to defence service persons and their families. All efforts should be made to take full advantage of the resources available through these programs, by maintaining good liaison with civil health authorities at all levels. The following examples of collaboration between the civilian health authorities and military medical services bring out the importance of the national health programs in service settings. Implementation of national health programs within their respective areas of responsibility is an important task of specialists in Preventive and Social Medicine in Indian Armed Forces (2, 3).

### (a) Liaison with Civil Health Authorities

Communicable diseases do not respect any boundaries, natural or man-made. Most cantonments/military stations exist in close proximity with civilian settlements. Any public health menace in the civil population will spill over among the troops and families. Health intelligence on prevailing disease patterns among local population has to be obtained by liaison with civil health agencies. At times, combined efforts by the military and civilian health authorities may be indicated.

### (b) Supply of Vaccines

Under Universal Immunization Program, all vaccines for childhood immunization in Armed Forces are obtained from local civilian health authorities, to maintain cold chain. Reports and returns on vaccine utilization and surveillance on vaccine preventable diseases have to be periodically submitted to local civilian health agencies.

### (c) Family Welfare Program

There is close collaboration in family welfare program between the civilian and military health services. Service hospitals are actively participating in the National Family Welfare Program, by providing ante-natal care, immunization services and family planning services including tubectomies and vasectomies.

### (d) Treatment of Families and Dependants of Service Personnel for Certain Diseases

Families and dependants may not be entitled for indoor treatment of certain chronic diseases like Hansen's, malignancies, tuberculosis, etc. in a particular station or else the family may be staying in a place (e.g., native village) where no service medical facility is available. Awareness of the benefits available to the common citizen under the various health programs enables the service medical officers to appropriately counsel the clientele about sources from where appropriate treatment and care is available through civil health sources.

### (e) Adoption of Disease Control Strategies in Service Setting

At times, disease control strategies being followed under some national health program can be adopted in service setting with advantage. On the other hand, we may also learn lessons from failures in our National Health Program (e.g., NMEP) so that similar mistakes can be avoided in our public health practice.

### (f) Reports and Returns

Reports and returns for various diseases and health problems sent periodically from all Armed Forces establishments, compiled at the highest level should contribute to the statistics of our programs at the national level.

A brief account of important National Health Programs, currently in operation, is given in succeeding paragraphs.

## National Anti-Malaria Program

National Malaria Control Program (NMCP) was launched in India in April 1953, with broad objectives of reducing malaria transmission to a level where it would cease to be a public health problem and to hold down malaria transmission at such low level indefinitely. It was based on indoor residual spraying (IRS) with DDT (1 g per sq m of surface area) twice a year in endemic areas where spleen rates were over 10 per cent. The NMCP was in operation for 5 years (1953-58). The program was initially highly successful in that the incidence of malaria declined sharply from 75 million cases in 1953 to 2 million cases in 1958, an estimated 80% reduction of the malaria problem. It also paid rich dividends in different fields like agriculture, land projects and industry. Encouraged by these spectacular results and based on recommendations of 8th World Health Assembly (1955), Government of India (Ministry of Health) changed the strategy from malaria control to eradication, and launched an ambitious

National Malaria Eradication Program (NMEP) in 1958, with the objective to eradicate malaria in the next 7-9 years. According to International standards, the program was divided into preparatory, attack, consolidation and maintenance phases.

Initially, NMEP was apparently highly successful and no death from malaria was reported in 1965. But very soon setbacks appeared in form of focal outbreaks. These focal outbreaks soon assumed epidemic proportions and annual incidence of malaria cases in India escalated from 50,000 in 1961 to a peak of 6.4 million cases in 1976 (4).

### Revised Strategy - Modified Plan of Operation (MPO) (4)

Based on recommendations of several Expert Committees appointed by the Govt, attempts at malaria eradication were soon abandoned and a Modified Plan of Operations (MPO) to control malaria was evolved, put into operation from April 1977 with objectives

(a) To prevent deaths due to malaria

(b) To reduce malaria morbidity

(c) To maintain agricultural and industrial production by undertaking intensive antimalarial measures in such areas

(d) To consolidate the gains so far achieved.

Flexibility in policies & implementation according to the epidemiological situation and local conditions was the essential feature of this program.

Reclassification of Endemic Areas

Under MPO, areas with Annual Parasite Incidence (API) of 2 and above were taken up for spray operations, to stabilize malaria transmission in the country. This led to abolition of earlier classification into attack, consolidation and maintenance phase areas, and reclassification of areas according to API.

**Areas with API of 2 or more**

The following activities were carried out :

(**a) Residual Indoor Spray :** 2 annual rounds of DDT indoor spray. In case vector was found to be resistant to DDT, 3 annual rounds of indoor spray with malathion were recommended. Areas refractory both to DDT and malathion were to be treated with 2 rounds of synthetic pyrethroids spray at intervals of 6 weeks. DDT, malathion, and pyrethroids dosage applied were 1.0, 2.0 and 0.25 g per sq. meter surface respectively. BHC has been discontinued since April 1997 because of its adverse environmental effects.

(**b) Entomological assessment :** Carried out by entomological teams by conducting susceptibility tests and suggesting appropriate insecticides to be used in particular areas.

(**c) Surveillance** : Collection and examination of blood slides was a key element under MPO. Active and Passive surveillance activities were to be carried out fortnightly in all areas with API 2 and above.

(**d) Treatment of cases** : Emphasis on presumptive and radical treatment of cases.

**Areas with API less than 2**

The following activities were undertaken : -

(a) **Spraying** : Focal spraying was to be done only in areas where *P. falciparum* cases were detected during surveillance. Routine indoor residual spray was not done.

(b) **Surveillance** : As these areas were not under regular spraying, active and passive surveillance operations were to be undertaken vigorously every fortnight.

(c) **Treatment** : All detected cases were to receive radical treatment as prescribed

(d) **Follow-up** : Follow-up blood smears were collected from all positive cases on completion of radical treatment and thereafter at monthly intervals for 12 months.

(e) **Epidemiological Investigation** : All malaria positive cases were investigated, including mass surveys.

Drug Distribution Centres (DDC) and Fever Treatment Depots (FTD)

With increasing number of malaria cases, demand for antimalarials also increased tremendously. It became clear that drug supply only through surveillance workers and medical institutions was not enough. This led to establishment of a wide network of Drug Distribution Centres and Fever Treatment Depots. Drug Distribution Centres are only to dispense the antimalaria drugs as per NMEP schedules. Fever Treatment Depots collect blood slides in addition to the distribution of antimalarials. These centres are manned by voluntary health workers from the community.

*P. falciparum* Containment

Within MPO, an additional component known as "P. falciparum containment program" was introduced from October 1977, with assistance from Swedish International Development Agency (SIDA). The specific purpose of this component was to prevent or contain spread of falciparum malaria.

Currently the program is operating in North East India, and some areas in the states of Orissa, Bihar, West Bengal, Andhra Pradesh, Madhya Pradesh, Gujarat, Maharashtra and Rajasthan. Four zones have been established to tackle the problem in these districts. Under this program, special inputs have been provided to strengthen the supervision of field operations.

### Malaria Action Plan (MAP)

Modified Plan of Operation (MPO) was able to contain malaria deaths for some time after its implementation. From 1994 to 1996, malaria outbreaks were reported from several states like Rajasthan, Manipur, Nagaland, Assam, Maharashtra and West Bengal. An expert committee formed to review the situation recommended criteria to identify "high risk areas" in rural areas and identified 20 worst affected cities which contributed as much as 80% of urban malaria. Based on the recommendations, guidelines for malaria control, known as Malaria Action Plan (MAP) were formulated. Under this, malaria control activities were 100% centrally sponsored for seven North-Eastern states, Andhra Pradesh, Bihar,

Gujarat, Maharashtra, Orissa and Rajasthan. The expert committee identified epidemiological parameters for high risk areas and strategies for anti-malaria activities, as under :

(a) Hardcore Areas (Tribal Areas)

Where malaria control operations for the last 40 years had failed to contain the disease. These included areas with :

(i) Predominantly tribal population

(ii) High prevalence of *P. falciparum*

(iii) Stable malaria with transmission period of more than 9 months

(iv) High incidence of deaths due to malaria, difficult terrain and remote areas

The control strategy under MAP in these areas consist of early case detection through Multipurpose Workers (MPW), presumptive treatment of fever through DDC / FTD / ACD / PCD, slide collection and examination and radical treatment within 48 hours with priority for Pf cases. Alternative drug therapy has been introduced in chloroquine resistant areas.

(b) Epidemic prone areas

Where periodic malaria outbreaks have caused large number of deaths due to malaria, including areas of North-Western plains, semi-arid regions with upto 100 mm of annual rainfall and Indo-Gangetic plains. The control strategy in such areas is similar to that in hardcore areas.

(c) Project Areas

These are areas where development of large scale projects attracts migrant labour from infected areas or non-immune labour into endemic areas. There is large scale increase in vector breeding places and increased man-mosquito contact. The strategies recommended for malaria control in such project areas include mass screening of migrant labour, mass presumptive treatment along with single dose of 45 mg primaquine and alternative drug therapy in chloroquine resistant areas.

(d) Urban areas

Under the Urban Malaria Scheme, it was found that 15 cities accounted for as much as 80% of Pf cases in the country. The control strategies adopted were active weekly surveillance for malaria in slums, intensified passive surveillance in hospitals by establishing a malaria post, presumptive treatment to all fever cases and radical treatment with priority to Pf cases. Under this, it was proposed to provide one worker for 20,000 slum population and establish one malaria clinic for every 50,000 population, preferably adjoining slum areas.

Research

Various monitoring teams are working in different parts of the country to identify P. falciparum sensitivity to chloroquine. Studies by ICMR have identified chloroquine-resistant foci in Orissa, Assam, Bihar, Maharashtra, North Eastern States, UP, Andhra Pradesh, Delhi, Madhya Pradesh, Andaman and Nicobar islands.

Reorganization

Before implementation of MPO, NMEP units were formed on the basis of poplulation, which in many places did not conform to administrative boundaries. This was now rectified and Anti-malaria Units have been reorganized in conformity with the geographic boundaries of the district making the District Health Officer (DHO) responsible for implementation of the program. The existing Unit Officers have been designated as District Malaria Officers (DMOs) and are posted at district headquarters. They have been entrusted with operational and evaluation aspects of the program. Asst. Malaria Officers usually assist the DMO. Under MPO, laboratory services were decentralised to minimise time lag between collection of blood smears and their examination. Laboratory technicians were posted at each PHC. Entomological teams were attached to all 72 zones in the country. The Chief Medical Officers and the Medical Officers of PHCs have to play a key role in execution of the program. The program, which was vertical before, is now horizontal and integrated with general health services from district level to the periphery and gradually surveillance workers are being replaced by Multi-purpose workers.

The 1994 resurgence of malaria compelled the Government of India to appoint an Expert Committee on Malaria to identify the problem areas and to suggest specific measures against the different paradigms of malaria. Thus Malaria Action Program (MAP) was evolved and guidelines were distributed to all the states for prediction, early detection and effective response to malaria outbreaks at district level (5, 6). It necessitated the need to strengthen the health promotion component of the program by observing "Anti-malaria month" before the onset of monsoon i.e. during the month of June to create awareness in the community regarding malaria and its prevention.

**Enhanced Malaria Control Project (EMCP)**

Enhanced malaria control project was launched in April 1997 with the assistance of the World Bank. This will directly benefit six crore tribal population of the eight peninsular states covering 100 districts and 19 urban areas. However, the population living in other malaria endemic areas will also benefit, as the strengthening of IEC, Training and Management Information System will cover the entire country.

The aim of the project is to cover most problematic areas where :

(a) API is more than 2 for the last 3 years

(b) Pf cases are more than 30% of the total malaria cases

(c) 25% of the population of the area is tribal

(d) The area has been reporting deaths due to malaria and also has the flexibility to direct resources to any needy areas in case of outbreak of malaria.

**Objectives**

(a) Effective control of malaria to bring reduction in malaria morbidity.

(b) Prevention of death due to malaria; and

(c) Consolidation of the gains achieved so far.

Strategies

(a) Early case detection and prompt treatment.

(b) Vector Control by indoor residual insecticidal spray in rural areas with API of 2/1000 and above in the preceding three years with appropriate insecticide.

(c) Health education and community participation.

Components of Enhanced Program

**(a) Early case detection and prompt treatment :** The equipment and staff provisions with their functions for early detection and prompt treatment are as follows:

(i) A link worker in high Pf areas for population of 2000 to be appointed by Panchayat and paid Rs 500 per month. He/she will collect blood smears, provide presumptive treatment and forward slides to PHC.

(ii) A microscope for every 30,000 population at PHC in rural areas and for 50,000 in urban areas.

(iii) Dipstick test in selected areas.

(iv) One fever treatment depot for every village.

(v) Existing MPWs and ANMs will continue to function as doing previously.

(vi) Adequate quantities of drugs should be made available.

(vii) Involvement of private sectors in case detection and treatment.

**b) Selective Vector Control**

**(i) Bio-environmental methods**

- Introduction of larvivorous fish
- Use of Biocides - Bacillus thuringiensis H-14(Bt) in selected urban areas
- Environmental Management Methods would be applied

**(ii) Selective Spray**

Village in which there is one case of falciparum malaria or more would qualify for spray in project area.

**(c) Legislative Measures** : Model bylaws for control of mosquitoes as in Bombay Municipal Corporation would be extended to cover the whole country which will bring changes in structural design of buildings to prevent mosquitoes.

**(d) Personal Protective Measures :** Bednet treatment program is more cost effective as compared to residual spray. Social marketing techniques involving local NGOs will be used for promotion of bednets. In areas where use of bednets is wide-spread and which also contribute most of the Pf cases in the country, a program has been launched for use of Insecticide Treated Bednets using synthetic pyrethroids mainly deltamethrin (2.5%) at a dosage of 25mg/sq m and cyfluthrin (5%) at 50 mg/sq m.

**(e) Epidemic Planning and Rapid response & Intersectoral Coordination:** Sectors like agriculture, environment, education and so on will be sensitized to the malaria problem and the steps to be taken for its prevention.

**(f) Institutional and Management Capabilities Strengthening :** Training in and strengthening of Management Information System (MIS) and Information Education and Communication (IEC) is required in the country.

**(g) Operational Research**

(i) Health seeking behaviour especially of malaria patients

(ii) Economic analysis of various interventions

(iii) Alternative drug regimens

(iv) Evaluation of impregnated bednets and curtains

(v) Trials with biolarvicidal agents

(vi) Entomological monitoring

(vii) Migratory patterns leading to malaria outbreaks (7, 8)

**(h) Community Participation :** Planning would be "bottom up" in which village Panchayat would be responsible for all matters related to health and development.

Progress of Enhanced Program

After its inception in 1997, 62.2 million population in 1045 PHCs in 100 districts (predominantly endemic and tribal districts) in peninsular states on Andhra Pradesh, Jharkhand, Gujarat, Madhya Pradesh, Chhatisgarh, Maharashtra, Orissa and Rajasthan have been covered. In addition, 19 cities with high incidence of malaria have also been covered under the project. Since 1997, Pf cases had declined from 0.72 million in 1997 to 0.41 million by 2004.

### National Vector Borne Diseases Control Program (NVBDCP) (9)

With the aim to conserve precious resources, including manpower and avoid duplication of effort, Govt of India, in 2003-04, approved National Vector Borne Diseases Control Program (NVBDCP), with the objective to control five major vector-borne diseases, namely, Malaria, Kala Azar, Filaria, Japanese Encephalitis and Dengue group of diseases. The program is presently 100% sponsored in North-Eastern states.

Strategies for prevention and control of malaria in rural areas under NVBDCP

(a) Early diagnosis and treatment

(b) Integrated vector control through optimal combination of various vector contol measures like indoor residual spray, anti larval measures, use of insecticide treated bed nets, larvivorous fish, environmental & engineering measures.

(c) Epidemic preparedness and rapid response for initiating epidemic control measures.

(d) Social mobilization and behaviour change, resulting in better awareness.

(e) Intersectoral collaboration by involving various govt / non-govt departments like Defence, Railways, corporate sector, local self govt etc.

(f) Capacity building by training medical and paramedical workers at primary, secondary and tertiary levels.

(g) Monitoring and evaluation of the program through periodic reviews, field visits etc.

Strategies for Urban areas (Urban Malaria Scheme) (9)

The urban malaria scheme was launched in 1971 to reduce and interrupt malaria transmission in towns and cities, after it was realized that urban malaria was a significant potential and unchecked mosquito breeding in urban areas could negate the advances made under NMEP. The strategy consists of early detection and prompt treatment (EDPT) through passive surveillance at hospitals, vector control by intensive antilarval measures, bio-environmental measures like desilting, deweeding, filling ditches, water disposal and sanitation, biological control using larvivorous fish, IEC campaigns and urban bylaws like those being implemented in Delhi, Mumbai and Goa. The scheme covers all towns with more than 50,000 population and showing API more than 2 in the preceding three years.

**Organisational setup**

UMS is a centrally sponsored scheme implemented by local administrative authorities under the supervision of state health authorities. The scheme is implemented and supervised by Director, NVBDCP at Central level, Additional / Joint / Deputy Director (Malaria & Filaria) at State level and Biologist at Town level.

At present, Urban Malaria Scheme as part of NVBDCP protects more than 967 lakh population in 131 cities in 19 states and UTs. Model civic bylaws have been prepared under NVBDCP which are implemented in Delhi, Mumbai, Kolkata, Chandigarh, Banglore, Chennai and several other cities.

**Malaria Surveillance**

Surveillance in malaria is of two types, namely, active and passive.

Active Surveillance

This is carried out by the multipurpose workers (MPWs). Each MPW is allotted a population of 10,000 or approximately 2,000 houses and for every 4 MPW, there is a surveillance inspector (Health Assistant). For difficult terrain areas, there is one surveillance worker (MPW) for a population of 8,000 and one surveillance inspector for 32,000 population. The surveillance worker (MPW) will visit each house in his area once a fortnight and enquire :

(a) Whether there is a case of fever in the house, including guests or visitors in the house

(b) Whether there was a fever case in the house between his previous visit and the present visit. If the answer to either of these two questions is "yes", the surveillance worker/MPW collects a blood film (thick and thin on the same slide) and administers a single dose (600 mg for adults and proportionate doses for children) of chloroquine according to the prescribed NMEP schedule. This is known as "presumptive treatment". The MPW makes necessary entries in the stencil or house card about his visit and dispatches the blood slides at least twice a week to the unit laboratory (primary health centre) for microscopic examination. He is also required to collect the blood slides from the subcentres and fever treatment depots and send these to the laboratory. If the blood film is reported positive for malaria parasite, the MPW returns to the patient and administers a course of radical treatment for malaria, as prescribed.

Passive Surveillance

The search for malaria cases by the local health agencies such as the primary health centres, sub-centres, hospitals, dispensaries and local medical practitioners amongst people reporting to the facilities is known as "passive surveillance". Their contribution to case detection is by no means small, because cases of fever which escape the net of active surveillance workers are screened by the passive surveillance agencies. The passive agencies collect blood smears from all fever cases and also from those with history of recent fever. After the collection of blood smear, a single dose treatment for malaria is administered as is done under the active surveillance program. The blood slides are collected by the MPW and sent to the unit laboratory for examination. The results of the blood examination are communicated to the local surveillance worker/MPW for institution of radical treatment.

**Parameters of Malaria Surveillance**

These include annual parasite incidence (API), annual blood examination rate (ABER) and slide positivity rate (SPR). The details are given in the chapters on Malaria in the section on Communicable diseases.

**National Drug Policy for Malaria in India**

The National Drug Policy for Malaria under NVBDCP issues the following guidelines for treatment of various forms of Malaria (10) :

Any fever case in an endemic area during malaria transmission season without any other obvious cause must be investigated / treated for malaria.

Though drug resistance foci are present in India, chloroquine still remains safest, effective, cheapest and simplest to administer antimalarial.

Diagnosis on the same day as collection of blood smear and prompt treatment remains the best approach to malaria control.

Broad Drug Policy for malaria is enumerated as under. However, minor changes have to be incorporated for infants and children, for which the reader may consult textbooks in Preventive Medicine.

Low Risk Areas

**Presumptive treatment** : Single dose of chloroquine @ 10 mg/kg b.w. to all fever suspected malaria cases.

**Radical treatment on confirmation**

| | |
|---|---|
| *P.vivax* | Chloroquine 10mg/kg b.w & Primaquine 0.25mg/kg b.w on day1 |

| | |
|---|---|
| | Primaquine 0.25mg/kg b.w/day for next 4 days(total 5 days) |
| *P. falciparum* | Chloroquine 10mg/kg b.w & Primaquine 0.75mg/kg b.w stat |

High Risk Areas

**Presumptive treatment**

Day 1 Chloroquine 10mg/kg b.w

Day 1 Primaquine 0.75mg/kg b.w

Day 2 Chloroquine 10mg/kg b.w

Day 3 Chloroquine 5mg/kg b.w

**Radical treatment on confirmation**

| | |
|---|---|
| *P.vivax* | Primaquine 0.25mg/kg b.w for 5 days |
| *P. falciparum* | No further treatment is given |

Chloroquine resistant

| | |
|---|---|
| Pf case | Sulfadoxine or Sulfalene 25 mg/kg b.w Pyrimethamine 1.25mg/kg b.w on Day1. Followed by Primaquine 0.75 mg/kg bw - the next day |

***Primaquine is contraindicated in pregnancy and infants

**Severe and complicated malaria** : Quinine 10 mg/kg b.w IV infusion in 5% dextrose solution 8 hourly. Total duration of treatment 7 days including both parental and oral doses. Semiconscious or comatose patients with severe Pf infection should be treated with injectable Quinine, which also is the drug of choice in pregnant women and infants. OR

Injectable Artimisine compounds are recommended for management of severe and complicated malaria.

Injectable Choloroquine is likely to produce low blood pressure in any age group and is associated with high mortality and is thus more hazardous than parenteral administration of injectable quinine.

### Global Malaria Control Strategy : Roll Back Malaria (11)

Roll Back Malaria (RBM) is a global partnership founded in 1998 by WHO, UNDP, Unicef and the World Bank with the objective to reduce world's malaria burden by half by the year 2010 (7, 8). In April 2000 in Abuja, Nigeria, political leaders from 44 African Nations endorsed the RBM goal for 2010 as the "Abuja Declaration".

RBM, which is a partnership involving national governments, civil society, NGOs, research institutions, professional associations, various United Nations development agencies, development banks and private sector, set interim targets to :

(a) Provide prompt access to correct, affordable and appropriate treatment to at least 60% of malaria cases within 24 hours of onset of symptoms.

(b) Provide suitable combination of personal and community protective measures to at least 60% of those at risk from malaria, particularly pregnant women and children.

(c) Provide chemoprophylaxis or presumptive intermittent treatment to at least 60% of pregnant women at risk of malaria.

Roll Back Malaria is based on four main technical strategies of providing prompt access to effective antimalarial treatment, promoting the use of insecticide treated bednets, prevention and treatment of malaria in pregnant women and improving the response capacity of local governments to malaria epidemics. The strategy also accords importance to research in malaria and measures to prevent re-emergence.

### National Filaria Control Program

National Filaria Control Program has been in operation since 1955. According to recent estimates about 450 million people are exposed to the risk of infection. It is estimated that 6 million people have attacks of acute filarial disease every year and 45 million persons suffer from one or more chronic filarial lesions (12 – 14).

In June 1978, the operational component of the program was merged with urban malaria scheme for better cost effectiveness. Initially all control activities were confined to urban areas, however, since 1994, the program has been extended to rural areas also. The training and research components are with the Director, National Institute of Communicable Diseases.

The following activities are carried out under the program :

a) Delimitation of the problem in hitherto unsurveyed areas.

b) Control in urban areas through :

(i) Recurrent antilarval measures

(ii) Anti-parasitic measures

So far, 238 of the 300 districts situated in endemic areas have been surveyed, and 175 have been found to be endemic for filariasis. Survey work is in progress in other districts.

National Filaria Control Program is being implemented through 206 filaria control units, 27 survey units, and 199 filaria clinics functioning in the endemic urban areas. The population protected so far is hardly 47 million out of 450 million at risk. Since the "vertical" approach to the control of filariasis has had a limited success, it is now recognized that the horizontal approach making use of the primary health care is essential. The village health guides are responsible for anti-filaria activities under supervision of Medical Officer of PHC. Training in filariology is being given at three Regional Filariasis Training and Research Centres situated at Calicut (Kerala), Rajahamundry (AP), and Varanasi (UP), under the National Institute of Communicable Diseases, New Delhi. Besides 12 Headquarters Bureau are functioning at the State level. Details of filarial control measures in the Armed forces are given in DGAFMS medical memorandum (15).

National Health Policy – Elimination of Lymphatic Filariasis by 2015

This strategy follows the WHO recommendation of Annual Single Dose – Mass Drug Therapy with DEC as a supplement to existing activities in highly endemic areas

to reduce transmission of filariasis to very low levels. It was proposed to implement this strategy as a pilot project in 13 endemic districts of Andhra Pradesh, Bihar, Kerala, Orissa, Tamil Nadu, Uttar Pradesh and West Bengal for five years covering 400 million population. The strategy was initially introduced in South Arcot, Vallalar district in 1996 by the State of Tamil Nadu and in 8 districts of Kerala, Orissa, Uttar Pradesh, and West Bengal since 1997 by observing Annual Filariasis Day. Approximately 49.7 to 94 percent coverage was observed in these districts. The drug was distributed from door to door in Tamil Nadu and by booth system in other States. The centre provides DEC tablets for the mass therapy campaign and cash assistance for IEC activities to these states. As a long term measure, the national health policy – 2002 envisages to achieve elimination of lymphatic filariasis by the year 2015, besides other targets in respect of other programs (16).

## National Leprosy "Eradication" Program

The National Leprosy Control Program was launched in 1954-55 as a centrally aided program to achieve control of leprosy through case detection and dapsone monotherapy on an ambulatory basis. The program gained momentum during the 4th Five Year Plan after it was made a centrally sponsored program. In 1980 the Government of India declared its resolve to "eradicate" leprosy by the year 2000 and constituted a working group to advise accordingly. In 1982-83 the control program was re-designated as National Leprosy "Eradication" Program (NLEP) with the objective to eliminate leprosy as a public health problem by the year 2000 (17). Multi Drug Treatment (MDT) was initially launched in Purulia (WB) and Wardha (Maharashtra) and by 1995-96, all districts in the country were brought under MDT in a phased manner. In 1991, WHO also proposed elimination of leprosy as a public health problem. Accordingly, the target for Ninth Plan was to reduce case load to 1 (or less) per 10,000 population.

### Strategy

The initial strategy was based on early detection of cases (by population surveys, school surveys, contact examination and voluntary referral), short term multi-drug therapy (MDT), health education, ulcer and deformity care, and rehabilitation of the cases. The regimen recommended by the WHO was adapted to local operational and administrative requirements .

The program provides free domiciliary treatment in endemic districts through specially trained staff, and in moderate to low endemic districts it provides services through mobile leprosy treatment units and primary health care personnel. Treatment of leprosy cases with MDT was taken up in a phased manner. As a result number of cases discharged as cured are increasing over the years.

### Infrastructure

NLEP was initially implemented through the establishment of Leprosy Control Units (LCU); Survey, Education, and Treatment (SET) Centres; and Urban Leprosy Centres. The Leprosy Control Units were established in endemic areas with one medical officer, 2 non-medical supervisors and 20 paramedical workers – each unit covering a population of 4.5 lacs. Each paramedical worker covered 15 to 20 thousand population and was expected to examine at least 8000 persons per year by house to house surveys in the population under his care. The staff appointed at SET centres comprised of 1 paramedical worker for 20 to 25 thousand population, and one non-medical supervisor for every 5 paramedical worker. The SET centres were attached to Primary Health Centres and placed under the administrative control of the medical officer in charge of the primary health centre. One urban leprosy centre was established for every 50,000 population.

Mobile leprosy treatment units provided services to leprosy patients in non-endemic districts. Each mobile unit consisted of one medical officer, one non-medical supervisor, two para-medical workers and a driver. 2 MLTU for each moderately endemic district and 1 MLTU for each low endemic district.

Under the NLEP, the State Leprosy Officer was the chief coordinator and technical advisor to concerned State Government. At Central level, leprosy division of Directorate General of Health Services, New Delhi, was responsible for planning, supervision and monitoring of the program. The division was under control of a Deputy Director General who advised the Government on all anti-leprosy activities.

World Bank assisted NLEP Phase I (1993 – Sep 2000)

Phase I of World Bank assisted NLEP from 1993 to Sep 2000 provided logistic support to the vertical program in endemic districts. Mobile Leprosy Treatment Units (MLTUs) were established for moderate and low endemic districts. District Leprosy Societies were also formed under the program. In Jan 1997, the program was re-designated as National Leprosy Elimination Program with the objective to reduce prevalence rate to 1 or below 1 per 10,000 population. In Feb 1998, 1st Modified Leprosy Elimination Campaign (MLEC) was launched which included 3 day technical training to general health care services staff, intensive IEC campaign and active search for leprosy patients by staff of general health services.

World Bank assisted NLEP Phase II (Oct 2000 – Dec 2005)

Phase II of World Bank assisted NLEP was launched in Oct 2000 with the objectives of achieving elimination of leprosy (defined as prevalence rate of 1 or less than 1 per 10,000 population) by end 2005 and to integrate leprosy control activities with general health care services in the country. The elimination strategy also included decentralization of NLEP to States & Districts, leprosy training to functionaries of general health care services, surveillance for early diagnosis and prompt MDT, promotion of self reporting, intensified IEC using local and mass media approaches, prevention of impairment & disability (POID), rehabilitation (medical, social and economic) and reconstructive surgery. In addition, NGOs have been actively involved in leprosy control activities in the country.

### Strategic Plan of Action (2004-05)

During 2004-05, the focus of NLEP shifted from states to districts & blocks with high and medium endemicity. A strategic plan of action was implemented which included intensified focused action with strong supervisory support in 72 high priority districts (with prevalence rate of more than 5/10,000) and 16 moderately endemic districts which had more than 2000 leprosy cases detected during 2003-04. Under this program, intensive IEC, training and integrated service delivery was undertaken in high endemic pockets in 86 medium priority districts. A two week long Block Leprosy Awareness Campaign (BLAC) was launched, through Leprosy Counseling Centers at subcenter level, in 836 blocks with prevalence rate of more than 5/10,000 population, with the aim to follow up existing cases and encourage self reporting of new cases.

Focused Leprosy Elimination Plan (FLEP-2005)

In Mar 2005, priority areas (42 districts and 552 blocks in 7 endemic states) with prevalence rate of more than 3/10,000 population were identified for undertaking focused action, which included intensive IEC, training and integrated service delivery.

Modified Leprosy Elimination Campaign (MLEC)

A mid-term appraisal of the program in April 1997 indicated that while the progress of the program is satisfactory at national level, it is uneven in some states. It was decided to launch a leprosy elimination campaign by giving short term orientation training in leprosy to all health staff including medical officers, health workers and volunteers and increase public awareness about leprosy. House to house search has been conducted to detect new leprosy cases throughout the country.

Research into the basic problem of leprosy is also part of the activities of the program. This is mainly carried out in the Government sector, viz. the Central JALMA Institute of Leprosy at Agra and the Central Leprosy Teaching and Training Institute at Chingelput, Chennai, supported by Regional Training and Referral Institutes at Aska (Orissa), Raipur (Chhattisgarh) and Gouripur (WB). In the field of leprosy eradication, there is considerable element of foreign assistance from international agencies, viz. SIDA, DANIDA, WHO, UNICEF, Damien Foundation, etc. It is understood that presently about 285 voluntary organisations are working towards leprosy prevention and control in our country. With the inclusion of leprosy eradication in the 20-point program a new impetus has been given both for expansion and monitoring activities

India achieved elimination of Leprosy in 2005

The World Health Assembly in May 1991 adopted a resolution for global elimination of leprosy by 2000. In 2001, after majority countries achieved leprosy elimination, a target was reset for the remaining 15 countries to achieve leprosy elimination on a national level by Dec 2005. The National Health Policy – 2002 also sought to eliminate leprosy from our country by the year 2005. The country achieved the goal of leprosy elimination as a public health problem (defined as less than 1 case per 10,000 population) in the month of Dec 2005. As on 31 Dec 2005, India recorded a prevalence rate of 0.95/10,000 population. 24 States / UTs (Nagaland, Haryana, Meghalaya, Himachal Pradesh, Mizoram, Tripura, Punjab, Sikkim, Jammu & Kashmir, Assam, Manipur, Rajasthan, Kerala, Arunachal Pradesh, Daman & Diu, A & N Islands, Pondicherry, Gujarat, Karnataka, Tamilnadu, Lakshadweep, Andhra Pradesh, Uttaranchal and Madhya Pradesh) had achieved leprosy elimination by Mar 2005. Maharashtra & Goa achieved elimination status in Sep 2005 and Nov 2005 respectively. As on 31 Dec 2005, there were 6 states of Bihar, Chhattisgarh, Jharkhand, Orissa, UP and West Bengal with prevalence rate between 1 and 3 per 10,000 population. These 6 states with 41% of country's population now contribute more than 60% of the country's case load of leprosy.

During the tenth Five-Year Plan (2002-2007), it was envisaged to eliminate leprosy from all parts of the country, for which the following strategies have been adopted :

(a) Horizontal integration of NLEP with the general health care system by 2007, wherein all personnel employed under NLEP will be transferred to States.

(b) Integration of leprosy workers under NLEP with primary health care system of the country by retraining and redeployment of more than 30,000 leprosy workers. It is proposed to fill the existing vacancies of male multipurpose workers and laboratory technicians in the primary health care system.

(c) Skill upgradation of existing personnel in primary health care system, to enable them for early detection, treatment and referral of leprosy cases.

(d) Provisions for reconstructive surgery within easy reach so to reduce functional disability of leprosy patients.

(e) Increased contribution and involvement of NGOs in detection and management of leprosy cases in community (17, 18, 19).

## National Tuberculosis Control Program

National TB control program (NTP) was launched in 1962 in the country with the objective of early detection and treatment of cases, as under (20) :

**(a) Long Term Objectives**

To reduce tuberculosis in the community to that level when it ceases to be a public health problem, i.e.,

(i) One case infects less than one new person annually

(ii) The prevalence of infection in age groups below 14 years is brought down to less than 1 percent against about 30 percent at present.

**(b) Operational or Short Term Objectives**

(i) To detect maximum number of TB cases among the outpatients attending any health institution with symptoms suggestive of tuberculosis and treat them effectively

(ii) To vaccinate newborns and infants with BCG.

(iii) To undertake the above objectives in an integrated manner through all the existing health institutions in the country.

**District TB Program (DTP)**

NTP operated through the District Tuberculosis Program (DTP) which was the backbone of NTP. Over 600 TB clinics were set up in the country, of which 390 were upgraded as District TB Centres (DTC) to undertake district-wise TB control in association with general health and medical institutions. This concept was evolved by the National Tuberculosis Institute, Bangalore and was accepted by the government for implementation in 1962. District Tuberculosis Centre (DTC) was the nucleus of DTP. The function of DTC was to plan, organize and implement DTP, in the entire district, in association with general health services. The health institutions available for inclusion in DTP were government general hospitals and community health centres, primary health centres, tuberculosis clinics, clinics other than DTC and OPDs of tuberculosis sanatoria and hospitals, hospitals including those managed by the government health schemes (e.g., CGHS, Railways, etc), Employees State Insurance Scheme, local bodies, religious missions, voluntary organizations, and private charitable societies. Only those PHIs (peripheral health institutions) were to be selected for implementation of the program, which were under charge of qualified Medical Officers. At present out of 460 districts in the country, District TB Centres have been established in 446 districts. Besides the DTC, 330 TB clinics are functioning in the country. A total of 47,600 beds are available for tuberculosis patients (21).

17 TB training and demonstration centres have been established in major States of the country. Two premier TB institutes, namely National Tuberculosis Institute Bangalore, and Tuberculosis Chemotherapy Centre, Chingleput, Chennai conduct training and research activities.

Activities of DTC : Under NTP, activities of DTC included (20) :

**(a)Case finding**

An average district has a population of 15 lakhs, and the number of sputum positive cases in each district was expected to be 3000. There would be at least 2 to 3 sputum positive cases and 8-12 radiologically active TB cases, in each of our villages with an average population of about 700 at any point of time. A review of case finding activities in various states revealed that case-finding efficiency was hardly 30 percent of its potential. In view of this, targets were fixed for the first time in 1982-1983, for the conduction of sputum examination at each primary health centre to detect new TB cases in rural populace. According to the new strategy, each PHC would have to examine 2 sputum per day (50 per month and 600 per year) from symptomatic patients so as to diagnose 5 new bacillary cases per month or 60 cases per year. To further improve case finding, male health workers were required to collect and fix sputum of the symptomatic on a slide during their routine visits to the villages and send these to the nearest health centres for microscopic examination. In this way, case finding was expected to reach the very doorsteps of all symptomatic patients, even at the periphery.

**(b) Treatment**

Treatment was free and was offered on domiciliary basis from all health centres. It was organized in such a way that patients were expected to collect drugs once a month on fixed dates from the nearest treatment centre. When the patient failed to collect drugs on "due date", a letter was sent and in the event of no response within 7 days a home visit was paid by the health staff. The compliance for one year was the most important part of the program. Short course chemotherapy was introduced in 18 selected districts as a pilot project. Later, more districts were covered in a phased manner, and at present 292 districts have been covered.

**(c) BCG Vaccination**

With the inclusion of BCG vaccination in the UIP, the BCG coverage had gone up to 97 per cent of the target by 1998.

**(d) Recording and Reporting**

The names and addresses of all the sputum positive cases are sent to the DTC every Saturday. The DTC registers all sputum-positive cases in the "District Tuberculosis Case Index" which is the nerve centre of DTP.

**(e) Supervision**

The DTC team visits the peripheral health institutions regularly and helps them in planning and rendering TB control services. These visits are called "supervision" visits. Supervision includes guidance, keeping the supplies moving and ensuring proper work standards.

Organization

District Tuberculosis Program consists of one District Tuberculosis Centre (DTC) and on an average 50 peripheral health institutions comprising of PHCs, general hospitals, rural dispensaries, etc.

To implement the program, a specially trained team of key program personnel is posted at each DTC. The team consists of:

(a) District Tuberculosis Officer
(b) Second Medical Officer
(c) Laboratory technicians
(d) Treatment organizer/health visitor
(e) X-ray technician
(f) Non medical team leader
(g) Statistical assistant
(h) Pharmacist

**Revised National Tuberculosis Control Program (22, 23)**

Need for revised strategy : In 1992, Govt of India conducted a nationwide survey with the help of WHO and SIDA, which highlighted the following reasons for failure of NTP :

(a) Treatment completion rate was only 30%.
(b) Inadequate budgetary outlay
(c) Irregular supply and shortage of antitubercular

medicines

(d) Undue emphasis on diagnosis through radiology

(e) Poor quality of sputum microscopy

(f) More emphasis on case detection rather than cure

(g) Poor organisational support

(h) Multiplicity of treatment regimes, especially among private practitioners

(j) Poor integration of the program with general health services

(k) Low level of awareness among patients about various aspects of the disease

(l) Non availability of trained staff

Based on these findings Govt of India, with the help of World Bank, revised the strategies and objectives in 1997, adopting DOTS (Directly Observed Treatment Short course), as advocated by WHO.

The objectives of Revised National Tuberculosis Control Program (RNTCP) were :

(a) Achieve at least 85% cure rate of infectious cases through supervised Short Course Chemotherapy involving peripheral health functionaries.

(b) Augmentation of case finding activities through quality sputum microscopy to detect at least 70% estimated cases.

(c) Involvement of NGOs, Information, Education and Communication and improved operational research.

The revised strategy was introduced in the country as a pilot project in 1993. The pilot Project showed that the new strategy was feasible and acceptable to project staff and patients. The average cure rate achieved was more than 80% and the proportion of sputum positive cases rose to more than 50% of all cases found (24). It is envisaged, under the National Health Policy – 2002, to reduce the mortality due to tuberculosis by 50%, by the year 2010 (16).

Progress of RNTCP

In 1992, National level review of existing NTP concluded that efforts so far had not made any significant impact, leading to launch of RNTCP in 1993, with DOTS as the main strategy. World Bank granted a loan of US $ 142 million to Govt of India to implement RNTCP in at least one third of the country. Till 1998, only 2 percent of the total population of India was covered by RNTCP. During the later half of 1998, large-scale expansion of the program was undertaken and by 1999 RNTCP had expanded 7 folds to become the second largest such program in the World. By Mar 2001, more than one third of the country (430 million population in 190 districts) was covered by the RNTCP. More than 200 tuberculosis control societies had been formed in states and more than 1.5 Lakh health workers including 10,000 doctors & 3000 laboratory technicians had been trained till Mar 2001 using high quality modular training materials. More than 1400 supervisors were deputed to ensure the quality of diagnosis & treatment. By 2005, 1065 million population in 607 districts of more than 22 states was fully covered under RNTCP. The program had finally achieved case detection rate of 72% as against the global target of 70% and treatment success rate of more than 85%.

Under RNTCP, patients presenting themselves with symptoms suspicious of tuberculosis are screened through 3 sputum smear examinations. Revised program began initially in health institutions having X-ray facilities and extended to other centres. Supervision and monitoring were strengthened under the new scheme. Supervisory teams per 5 lakh population in urban areas and per 3 lakh population in rural areas are positioned, each consisting of a MOTC (Medical Officer Tuberculosis Control), STLS (Senior Tuberculosis laboratory Supervisor) and STS ( Senior Treatment Supervisor).

Important definitions under RNTCP (23) :

(a) **New Case** : A tuberculosis patient who has never taken antitubercular drugs or has taken antitubercular drugs for less than one month.

(b) **Case (Pulmonary), Smear positive** : TB patient in whom at least 2 initial sputum smear examinations (direct smear microscopy) are positive for AFB.

Or

TB patient with one sputum examination positive for AFB and radiological abnormalities consistent with active TB, as determined by treating physician.

Or

TB patient with one sputum examination positive for AFB and culture positive for M. tuberculosis.

(c) **Case (Pulmonary), Smear negative** : TB patient with symptoms suggestive of TB with at least 03 sputum examinations negative for AFB and radiographic abnormalities consistent with active pulmonary TB, followed by decision to treat the patient with full course of ATT.

Or

Diagnosis based on positive culture for AFB but negative sputum examinations.

(d) **Chronic case** : A TB patient who remains smear positive for AFB even after completing a re-treatment regime.

(e) **Cured** : Initially smear positive patient who completed treatment and had at least two negative sputum examinations, one of which should have been on completion of treatment.

(f) **Defaulted** : A TB patient, who at any time after registration, has not taken ATT for 2 months or more consecutively.

(g) **Died** : TB patient who died during treatment, irrespective of the cause.

(h) **Extrapulmonary Tuberculosis** : TB of any other organ other than lungs. However, a patient diagnosed with both pulmonary and extra-pulmonary TB is classified as pulmonary case.

(j) **Failure** : Smear positive patient who is tested smear positive at 5 months or later after starting ATT. Failure also includes initially smear negative patients who turned smear positive anytime during treatment.

(k) **Relapse** : A TB patient declared cured under RNTCP, but who reports back to health services and is found to be bacteriologically positive.

(l) **Treatment after default** : A patient who received ATT from any source for one month or more and who re-starts treatment after defaulting, i.e. after a gap of two months or more consecutively.

(m) **Transferred in** : A TB patient who has reported to a Tuberculosis Unit / district after starting treatment in another unit where he / she has been recorded.

(n) **Transferred out** : A TB patient who has been transferred to another TU / district and his treatment results are not known.

(o) **Treatment completed** : Sputum positive case who has completed treatment , with negative smear results at the end of initiation phase but none at the end of treatment.

Or

Sputum negative patient who has received full course of ATT and has not become smear positive at the end of treatment.

Or

Patient with extra pulmonary TB who has received full course of ATT and has not become smear positive at the end of treatment.

(p) **Tuberculous infection** : Presence of viable, multiplying and virulent tubercular bacilli within cells or tissues of human being without any manifestation of clinical symptoms.

DOTS is a community based tuberculosis treatment and care strategy which combines the benefits of supervised treatment, and the benefits of community-based care and support.

It has two phases :

(a) Intensive phase during which all the doses of chemotherapy are given supervised

(b) Continuation phase during which patient collects drugs from the center on a weekly basis and must present the empty blister pack of the drugs consumed at the time of the next week's collection. The first dose of the continuation phase must be administered under direct observation.

DOTS ensures high cure rates through its three components

(a) Appropriate medical treatment

(b) Supervision and motivation by a health / non-health worker,

(c) Monitoring of disease status by the health services.

DOTS will be administered by peripheral health staff such as MPWs, or through voluntary workers such as teachers, anganwadi workers, dais, ex-patients, social workers, etc. They will be known as DOTS 'agent' and will be paid incentive/honorarium of Rs 150 per patient completing the treatment.

The five components of DOTS are as under :

(a) Case detection with help of microscopy with provision for multi-tier cross checking and quality assurance of sputum smear.

(b) Regular and uninterrupted supply of medicines in colour-coded, patient-wise boxes.

(c) Direct observation by an observer (health workers or community volunteers) while the patient is on chemotherapy.

(d) Systematic evaluation and monitoring to ensure cure.

(e) Political will, thereby ensuring financial support and sustainability of the program. (25)

## National AIDS Control Program (26, 27)

With the spread of AIDS from one country to another it became necessary to initiate a National AIDS Control Program (NACP) in India. The Government of India in 1985 constituted a task force to look into this matter. It began by pilot screening program of high-risk population. National AIDS Control Program was launched in 1987. From 1987 to 1992, surveillance activities were undertaken in 55 cities in 3 states, with program implementation being left to the states without much central guidance. In the year 1992, Ministry of Health and Family Welfare set up National AIDS Control Organization (NACO) as a separate wing to implement and monitor various components of the program. The government launched a five-year HIV/AIDS Control Project (Phase-I) from September 1992 to September 1997 as 100% centrally sponsored project for all states and union territories. The project was later extended to March 1998.

The national strategy has the following important components: establishing of surveillance centres to cover the whole country; identification of high risk groups and their screening; issuing specific guidelines for management of detected cases and their follow-up; formulating guidelines for blood banks, blood product manufacturers, blood donors, and dialysis units; information, education and communication activities by involving mass media; research; reduction of personal and social impact of the disease; control of sexually transmitted diseases and condom promotion.

### NACP Phase I (1992 – 1999)

The aim of first phase of NACP was to prevent further transmission of HIV, to decrease morbidity and mortality associated with the infection and to minimize the social and economic impact of the epidemic.

### NACP Phase – II (1999 – 2001)

The National AIDS Control Program Phase – II was launched on 15 Dec 1999. It was implemented by NACO

with support from World Bank, USAID and the Department for International Development (DFID). NACP Phase II had features that brought about a paradigm shift in the nation's response to prevention and control of HIV/AIDS at all levels. Based on the epidemiological data obtained from annual sentinel surveillance, the country was divided into three categories,

(a) Maharashtra with prevalence of 2-2.4 percent in the age group 15-49 years,

(b) Andhra Pradesh, Karnataka, Manipur, and Tamil Nadu with a prevalence of 1-2 percent in the 15-49 age group, and

(c) The rest of the country where the prevalence less than 1% in same age group. The goal was to achieve zero level of new infection of HIV by the year 2007.

The objective under the second phase was to restrict future spread of HIV infection to less than 5% in Maharashtra, less than 3% in Andhra Pradesh, Karnataka, Manipur, and Tamil Nadu and less than 1% in rest of the country.

The objective was to be realized by focusing on targeted intervention by

(a) Raising the level of awareness on STD/HIV in rural areas and other vulnerable groups of population;

(b) Encouraging health seeking behaviour in general population for reproductive tract infections RTI and STDs;

(c) Making people aware about the services available in the public health system for the management of RTI/STD;

(d) Provision of facilities for early detection and prompt treatment

(e) Implementing focused IEC strategy.

**NACP Phase II achieved certain important aims, as under**

(a) Shifted focus from raising awareness to changing behaviour through interventions, particularly for groups at high risk of contracting and spreading HIV.

(b) Supported decentralisation of service delivery to the states and municipalities and a new facilitating role for NACO. Program delivery was made flexible, evidence-based, participatory and relied on local program implementation plans;

(c) Protection of human rights by encouraging voluntary counseling and testing and discouraging mandatory testing;

(d) Support structured and evidence-based annual reviews and ongoing operational research; and

(e) Encouraged management reforms, such as better managed State level AIDS Control Societies and improved drugs and equipment procurement practices. These reforms were proposed with view to bring about a sense of ownership of the program among the States, Municipal Corporations, NGOs and other implementing agencies.

**National AIDS Prevention and Control Policy (NAPCP) 2002 (27)**

The NAPCP was announced in 2002 with the aim to achieve zero transmission level of HIV by 2007. It adopted the following strategies :

(a) Interrupting the transmission of HIV by generating awareness among high risk groups and providing them with necessary skills and tools for protecting them from getting infected, mainly as under :

(i) Control of Sexually Transmitted Diseases (STDs) among sexually active and economically productive population.

(ii) Promoting condom usage among especially high risk groups as a means to protect them from HIV infection.

(b) Generating a positive socio-economic environment to enable infected individuals to manage the problem.

(c) Improving the health delivery system for PLWA, in hospitals as well as in community, through domiciliary care.

**NACP Phase III (28)**

Expert opinion is that India's AIDS epidemic is still at relatively early stage, which provides an opportunity for preventing infection rates from rising. Accordingly, Phase III of NACP (2006 – 2011) has been formulated to achieve the following goals :

(a) Preventing new HIV infections in high risk groups and general population through targeted interventions among high risk groups and intensified interventions among general population.

(b) Ensuring care, support and treatment to higher proportions of people living with AIDS (PLWA).

(c) Strengthening the prevention program in terms of infrastructure, systems and trained manpower at district, state and national level.

(d) Strengthening the strategic information and management system at national level.

Program framework for NACP III

Program framework for NACP III consists of

(a) Creating an enabling environment by introducing reforms in legal procedures and policies and structural constraints that impede interventions aimed at marginalized populations such as commercial sex workers, IV drug users and MSM groups

(b) Implementation of strategic communication by developing the existing IEC strategy towards holistic and strategic approach for high level advocacy, creating an enabling environment, bringing about behaviour change and social mobilisation at all levels

(c) Greater involvement of PLWA as resources for appropriate and effective response. PLWA should be incorporated into NACP III for ensuring access to prevention, care, support and treatment services

(d) Tackling the gender and socioeconomic issues such as gender inequalities, socioeconomic status, occupation, education, ethnicity and age.

Objectives of NACP III

NACP III is being implemented with the following objectives :

**Objective 1**

**Prevention of New Infections**

Estimates of 2004 indicate that 0.9% of Indian adult population (between 15-49 years) is presently infected with HIV. Thus nearly 99% Indian population is presently uninfected and should be targeted with effective preventive strategy. This is proposed to be achieved by :

(a) **Intensive coverage of High Risk Groups through targeted interventions** : Surveys conducted under NACP II indicated presence of high risk groups in all parts of the country and a focused strategy was launched to raise their awareness, motivating them to adopt safe behaviour, improving their access to preventive services and tools such as condoms. NACP III will aim at increasing the coverage of such services especially for high risk groups, identified as sex workers and their clients, transgender population, men having sex with men (MSM) and IV drug users in urban and rural areas. The 'bridge population', identified as truck drivers, street children, prison inmates and migrant workers would also receive special attention under NACP III. The essential elements of target interventions proposed under NACP III are access to behaviour change communication, prevention services such as condoms, STI services, needles and syringes, treatment services in form of STI clinics, drug substitutions for IV drugs, antiretroviral therapy and creation of an enabling environment under all project sites.

(b) **Intensification of interventions among general population** : Although 99% of Indian population is not infected, a high level of vulnerability exists, especially among young people, women, migrant workers and marginalized populations. NACP III aims at reducing risk, vulnerability and stigma through increased awareness and targeted behaviour change. The program is considered to be effective when 99% of population can recall three modes of HIV transmission and two methods of prevention. This is to be achieved through increased awareness through communication, social mobilisation & advocacy and through integration and expansion of integrated HIV related services like HIV counseling, testing, STI treatment, PPTCT and post exposure prophylaxis at sub district hospital, community health centres and PHCs.

(c) **Sexually Transmitted Diseases (STD) Control Program (29)** : Evidence suggests that likelihood of contracting HIV infection is 8-10 times higher in presence of other STDs, particularly genital ulcers. In view of the established relationship between HIV and STIs, Min of Health & Family Welfare adopted a policy of integrating HIV/AIDS and STD control within the existing health care system. Under the program, emphasis is given to comprehensive treatment of STIs at primary health care level and integration of non-stigmatised services with greater accessibility and acceptability by patients and community, while maintaining confidentiality and privacy of the patients. NACO took over the STD control program (in operation since 1946) in 1992 and made it an integral component of AIDS control policy. After overcoming the shortcomings of the erstwhile STD contol program (like poor community acceptability, poor accessibility, stigma), NACP III continues to provide STI services based on syndromic approach, with the aim to improve etiological management of STIs. The broad objectives of STI control program under NACP III are to reduce STD infections, thereby controlling HIV transmission by minimizing a risk factor and to prevent short and long term morbidity & mortality due to STDs. This is to be achieved through the following strategies :

(i) Development of adequate & effective program management by strengthening existing STD clinics, appointing STD program officers in State AIDS Control Societies and identification of district nodal officers who would supervise working of STD clinics.

(ii) Promotion of IEC activities for prevention of transmission of STD & HIV infections in form of activities to educate people for responsible sexual behaviour, safer sex and greater condom usage.

(iii) Improving case management including diagnosis, treatment, counseling, partner notification and screening for other diseases, in form of two sets of guidelines for PHC level and for referral of STD specialists.

(iv) Increasing access to health care for STD by strengthening existing STD clinics, increasing health seeking behaviour through IEC & NGOs and establishing First Referral Units in collaboration with Dept of Family Welfare.

(v) Creating facilities for diagnosis & treatment of asymptomatic infections by providing trained lady medical officer and sensitizing community through Family Health Awareness Campaigns for early detection and referral to PHCs.

(d) **Voluntary Counseling and Testing (VCT)** : VCT specifically involves increasing availability and demand for voluntary testing including joint

testing of couples, training grassroot health workers in HIV counseling and providing counseling through blood banks and through STI clinics. Under NACP III, it is envisaged that at least one voluntary testing centre would be established in every district. Pretesting counseling (before HIV testing) essentially prepares an individual for undergoing HIV test, identifying high risk behaviour by the individual and changing his/her high risk behaviour. Post test counseling helps the client to understand the importance and meaning of negative or positive HIV test, benefits of changing the high risk behaviour and constructively handling the marital and sexual needs.

(e) **HIV testing** : Under the present HIV testing policy of Govt of India, there is no rationale for mandatory HIV testing of any individual. It is established that any form of mandatory testing usually drives 'underground' those who are at highest risk due to stigma & discrimination and is thus counter-productive in the long term. According to present HIV policy, HIV testing is carried out on voluntary basis with adequate pretest and post-test counseling. Govt of India has formulated a comprehensive HIV testing policy, in accordance to WHO guidelines, which states that :

(i) No individual shall be made to undergo any form of mandatory HIV testing.

(ii) HIV testing shall not be imposed as a precondition to employment or for providing health care facilities during employment.

(iii) Adequate facilities for voluntary testing with pre-test and post-test facilities will be made available throughout the country in a phased manner, so as have at least one HIV testing centre in every district.

(iv) Disclosure of HIV status to spouse of the person will depend entirely on willingness to part with such information. However, all efforts should be made so that the individual voluntarily shares such information with family, to ensure proper home based care.

(v) In case of marriage, when one partner insists on knowing the HIV status of other partner, HIV testing should be arranged by contracting partner to the satisfaction of person concerned.

(vi) Different testing strategies are to be adopted under different circumstances, as under :

- **Mandatory testing** : Screening in blood banks for blood safety. However, testing in all blood banks will be undertaken on collected blood samples in an unlinked & anonymous manner so as to only identify the status of blood sample and not of the donor.
- **Unlinked and anonymous testing**: To be undertaken for epidemiological surveys and HIV surveillance to monitor the trend of HIV infection in community.
- **Voluntary and confidential testing** : To be undertaken as confirmatory testing for subclinical infections / clinical management and as voluntary testing.
- **Need based testing**: To be undertaken with explicit consent, for research purposes, after ensuring all ethical considerations.

For screening of donated blood, a single test by either Rapid or ELISA method is enough to eliminate possibility of HIV infected blood. For epidemiological surveys, the same procedure is adopted with one or two of Rapid / ELISA / Simple which has high sensitivity. In such cases, testing is unlinked and anonymous and result is not given to the person. For clinical management and for confirmation of HIV status of individuals who voluntarily asks for it, testing is done by at least two ELISA and one Rapid/Simple test using different antigen preparation. The result of HIV testing in such cases has to be disclosed only after proper pre-test and post-test counseling of the concerned individual.

(f) **Prevention of Parent to Child Transmission (PPTCT)**: Various studies have indicated that chemoprophylaxis (in the form of Nevirapine) before delivery in case of HIV-infected pregnant woman significantly reduces mother-to-child transmission rate from 33% to 8.4% at birth or 10.1% at age of two months. The intervention cost has been worked out to Rs 175 per woman, which is a very cost effective method to prevent perinatal HIV infection. NACP III envisages that antenatal clinics will be used for imparting HIV education to pregnant women through trained counselors. Special emphasis would also be given to drug prophylaxis linked with infant feeding, nutritional support and contraception. Drug regimes used for chemoprophylaxis would be modified according to emerging evidence of efficacy of the drugs.

(g) **Occupational Health and HIV/AIDS** : NACP III has addressed the issue of expanding HIV/AIDS response at work place. Under NACP III, specific guidelines have been formulated in collaboration with employers, workers organisations, ministries and civil society, with the aim to strengthen response to HIV and mitigate the effect of the disease at work place. The key areas for intervention at work place are prevention of HIV/AIDS, management & mitigation of impact at work place, care & support for infected workers and reducing stigma and discrimination at work place.

(h) **Universal Protection & Post Exposure Prophylaxis (PEP)** : Under NACP III, health care workers will be provided specific protection against occupational exposure to HIV. NACP III recommends following measures after occupational exposure

(i) Rapid testing facility for HIV testing.

(ii) Exposure with HIV should be considered a medical emergency.

(iii) Chemoprophylaxis should be started within 4 hours after exposure.

(iv) Chemoprophylaxis should be reviewed on 1, 3 and 6 month interval.

(v) Under NACP III, only following drugs are approved for post exposure prophylaxis :

- Zidovudine – 300 mg twice daily for 4 weeks.
- Lamivudine – 150 mg twice daily for 4 weeks.
- Indinavir – 800 mg thrice daily (only as part of expanded regime)
- Saquinavir – 600 mg thrice daily.

(j) **Blood Safety Program** : In India, blood banking infrastructure is highly decentralized and there is acute shortage of trained manpower, equipment and financial resources necessary to provide the desired quality of blood. In addition, there is often shortage of blood which encourages private blood banks with inadequate infrastructure and quality control.

Blood safety has remained an integral part of NACP since its inception and NACP III has included the objectives of

(i) Ensuring organized blood banking services at State / District level

(ii) Educating & motivating community about importance of voluntary blood donation

(iii) Enforcing quality control for all units of blood to be infused.

**To achieve the above objectives, NACP III has formulated certain strategic plans as under :**

(a) Strengthening National Blood Transfusion Services.

(b) Ensuring adequate blood supply to all blood transfusion centres.

(c) Ensuring safety of blood and blood products.

(d) Developing facilities for production of blood components from whole blood.

(e) Developing facilities for plasma fractionation

(f) Strengthening quality control of blood and blood products.

(g) Undertaking research on blood transfusion services.

(h) Strengthening effective management, monitoring and evaluation of blood transfusion. NACP III emphasizes on establishing HIV testing facilities, provide for testing of other blood transmissible diseases and modernization of blood banks.

**The Hon' Supreme Court ruling on Blood Transfusion Services** : The Hon' Supreme Court of India in a landmark judgment, issued certain directives on 04 Jan 1996, as under :

a) To establish forthwith a National Council of Blood Transfusion at Central, State and UT level as a society registered under Societies Act 1860 with funds provided by central / state / UT govt.

b) To license all blood banks.

c) To stop professional blood donation.

d) To grant 100% Income Tax exemption to any individual who makes donation to national / state blood councils.

e) To consider feasibility of separate legislation for regulating collection, processing, storage, distribution and operation of blood banks in the country.

**National Blood Policy (30)** : The Hon' Supreme Court's ruling of 1996 helped in phasing out unlicensed blood banks by May 1997 and abolished professional blood donation in the country by December 1997. Mandatory testing for HIV, Syphilis, Malaria, Hepatitis B & C helped in checking transmission of blood borne infections. The National Blood Policy has been laid down to ensure easy accessibility and adequate supply of safe blood & blood components and to ensure blood transfusion under supervision of trained health care workers.

(k) **Condom Promotion Program** : In India, heterosexual transmission constitutes the major transmission route of HIV and condom usage remains the single most effective and practical method to prevent HIV transmission. Accordingly, Condom Promotion Program under NACP III proposes that there should be no moral, religious or ethical inhibition in promoting condom usage among sexually active individuals, especially those who practice high risk behaviour. Under NACP III, it is envisaged to convince people to use condoms not only for family planning but also as the best preventive measure against HIV, convince commercial sex workers and their clients to use condoms as a means to prevent sexually transmitted diseases including HIV and to make available low cost, good quality condoms to people all over the country easily at the time and place where they will need them. The objective of Condom Promotion Program is to ensure easy access to acceptable, good quality and affordable condoms with the view to promote safe sex. The following are used as indicators for success of Condom Promotion Program under NACP III :-

(i) Percentage of persons who report easy availability of condoms within 500 meters of the place where they need them.

(ii) Percentage of persons reporting consistent use of condom in sexual encounters with non-regular partners in last 30 days.

(iii) Percentage increase in number of non-traditional outlets for condoms, like post offices, shopping malls etc.

**University Talk AIDS Project (UTA)** : UTA Project began as

early as Oct 1991 with partnership between National Service Scheme (NSS), Dept of Youth Affairs & Sports and NACO. The project aims to generate awareness among students on HIV related issues through seminars, talks, workshops and written material. The program also deals with related issues pertinent to youth like drug abuse, relationships, courtships, marriage and thus aims to enhance life style skills among the youth.

Objective 2

Care, Support and Treatment

NACP III has incorporated comprehensive community and home based care, psychosocial support to HIV infected individuals and households and aims to ensure accessible, affordable and sustainable treatment to infected individuals. To achieve the above objectives, NACP III has adopted the following strategies :

(a) Treatment for opportunistic infections (OI) previously available at district level would be now available at CHC and PHC levels. Drugs would be given free at all govt hospitals and few NGOs with good track record in providing HIV care would also be incorporated for treating OI. NACP III also proposes close linkage between NACP and RNTCP since tuberculosis remains the most common and most lethal opportunistic infection among HIV infected individuals.

(b) Anti retroviral therapy to as many infected individuals has been attempted under NACP III. NACP III proposes to enhance the service through private-public partnerships and through community partnership and ownership. Serpositive women who have participated in PPTCT program, children below 15 years with HIV/AIDS, PLHA referred under targeted interventions (such as for commercial sex workers, truck drivers or migrant workers) and AIDS patients getting treatment from govt ART centres will be given priority for ART. It is proposed that by 2010, as many as 1,84,000 individuals would be on ART.

(c) NACP III also proposes to establish DNA PCR facility for diagnosis of HIV in children through selected national referral centres, to meet the requirement due to increasing number of infected children.

Objective 3

Capacity Building

Under NACP III, capacity building at national, state and district levels is envisaged through multiple strategies to meet the fast evolving challenges of HIV epidemic in the country. Possible centres for imparting training, identified by a multidisciplinary standing committee (including an epidemiologist, economist, microbiologist and public health, marketing, communication specialists among others) will identify training needs at various levels and also help States to plan their training. In addition, capacity building under NACP III will include issues of program management, finance and procurement of infrastructure, human resource and medicines at various levels. Recruitment of staff in NACO would be demand based and all staff would receive refresher training periodically. Specialised areas such as program management & implementation, finance and procurement etc will receive special attention under the program. The district planning under Rural Health Mission will attempt to integrate HIV related services into the general health services. Cross linkages with other relevant programs like RNTCP & RCH would be established for optimum outputs. NACP III also makes an attempt to co-ordinate various programs being implemented by different agencies, thereby ensuring joint analysis of results and sharing, monitoring and evaluation of progress.

Objective 4

Monitoring & Evaluation

**HIV Surveillance**

Effective and accurate HIV surveillance is essential to monitor progress of the control program. NACP III undertakes HIV surveillance with the objective to estimate incidence, prevalence, morbidity and mortality due to HIV and also to identify behavioural and biological markers on progress of preventive program.

**HIV Sentinel Surveillance**

HIV Sentinel Surveillance is undertaken every year jointly by NACO and Min of Health & Family Welfare since 1998 with the aim to update HIV estimates for the country. Under this program, HIV prevalence in the country is estimated based on HIV prevalence recorded at designated sentinel surveillance sites (such as STD clinics, de-addiction centres and intervention centres for female sex workers) for different risk groups. Women attending antenatal clinics are taken to be representative of the general population. Blood samples collected (between 01 Aug – 31 Oct) by unlinked anonymous method are tested at regular intervals annually and the data is used for epidemiological analysis and estimation of HIV prevalence in the country.

**High Risk Behaviour Surveillance Survey (BSS)**

BSS is undertaken to provide behavioural measurement for recording trends of high risk behaviour among selected population groups. A set of 9 indicators, as under, were used on three occasions to assess the trends.

(a) Knowledge indicators

  (i) Proportion of respondents who know 2 acceptable ways to prevent STDs.

  (ii) Proportion of respondents who know that condoms prevent STDs.

  (iii) Proportion of respondents who know 2 acceptable ways to prevent HIV.

  (iv) Proportion of respondents who know that condoms prevent HIV.

(b) Behaviour Indicators

  (v) Proportion of respondents who report heterosexual intercourse with non-regular

partner in the last year.

(vi) Proportion of respondents who report condom usage during last sexual intercourse with non-regular partner in the last year.

(c) Prevalence of Urethritis

(vii) Proportion of male respondents who report symptoms of urethritis during last one year.

(viii) Proportion of male respondents who sought treatment from qualified medical practitioners for urethritis in the last year.

(d) Appropriate perception of risk indicators

(ix) Proportion of respondents with high risk behaviour who perceive that they can get infected with HIV.

## National Program for Control of Blindness (31)

The national program for control of blindness was launched in the year 1976 as a 100% centrally sponsored program and incorporates the earlier trachoma control program started in the year 1963. The various activities of this program include establishment of Regional Institute of Ophthalmology, upgradation of ophthalmology departments of medical colleges and district hospitals, development of mobile eye units, recruitment of required ophthalmic manpower and provision of various ophthalmic services. NPCB initially laid down the goal of reducing prevalence of blindness to less than 0.3% by 2000 as compared to 1.49% in 1986-89. The program failed to achieve its targets due to various reasons and 10th Five Year Plan reformulated the targets as

(a) To reduce prevalence of blindness to 0.8% by 2007

(b) Increase cataract surgery rate to 450 per lac population

(c) Improve visual outcome of cataract surgery by performing IOL implantation in > 80% by 2007

(d) Develop 50 pediatric ophthalmology units in the country

(e) Provide facilities for early diagnosis & treatment of glaucoma and diabetic retinopathy

(f) Setting up 20,000 vision centres in the country

(g) Develop 25 fully functional eye bank

(h) Develop human resource and institutional capacity.

**Initial strategies under NPCB were:**

(a) Strengthening of service delivery

(b) Developing human resources for eye care

(c) Promoting out-reach activities and public awareness

(d) Developing institutional capacity.

Due to failure to achieve targets, strategies were revised to include:

(a) Strengthening services for other causes of blindness like corneal blindness (requiring transplantation), refractive errors in school children, improving follow -up services for cataract operated persons and treating other causes of blindness like glaucoma.

(b) Shift from eyecamp approach to fixed facility approach and from conventional surgery to IOL implantation.

(c) Strengthen participation of voluntary organisations in the program and to earmark geographical areas to NGOs and govt.

(d) Enhance coverage in tribal and underserved areas.

Under NPCB cataract operations using IOL implants are conducted, with minimum annual target for cataract surgeries set at 400 per lac population. NGOs are encouraged to organize eye camps in remote areas along with District Health Services. Augmentation of infrastructure in form of construction of eye wards, operation theatres and dark rooms have been undertaken in 7 states, assisted by World Bank. NPCB also envisages training to surgeons for IOL implantation. Other important issues addressed by NPCB are school eye screening program (where refractory errors among school children are confirmed by ophthalmic assistants and corrective spectacles are prescribed), collection & utilization of donated eyes (where more than 20,000 donated eyes are collected and utilized every year), control of Vitamin A deficiency (where 2 lakh IU of Vitamin A solution is given to every child every 6 months till the age of 6 years. This component, included under CSSM program ,is now an integral part of RCH program), control of trachoma (where chemotherapeutic intervention is undertaken to reduce severity, lower incidence and reduce prevalence of trachoma in community). Under NPCB, an ophthalmic assistant is placed at PHC/CHC level for implementation of program strategies.

The program aims to improve the physical, technical and managerial capabilities of non-profit institutions to provide high quality cataract treatment in situ or in camps. The program is implemented through a combination of service delivery models – Medical Colleges, district hospital, base hospitals, community health center, primary health centers, camps in fixed facilities, camps in improvised facilities and if necessary in private facilities in collaboration between the central government, state government and non-government organizations.

The program intends to strengthen medical colleges and Regional Institutes of Ophthalmology to train ophthalmologists and selected health professional on cataract diagnosis, screening, surgery and follow-up care and it will provide managerial training for central and state project coordinators and other project staff requiring managerial and administrative skills training.

**Infrastructure Development**

At the apex, a National Institute of Ophthalmology (Dr Rajendra Prasad Centre for Ophthalmic Sciences, AIIMS, New Delhi), has been established with 10 other Regional Institutes of Ophthalmology for manpower development, research and referral services. In addition 82 Medical Colleges have been upgraded, out of which 39 medical colleges have been designated as training centres for paramedical ophthalmic assistants. So far 166 eye banks

have been developed in the government and non-government sector, 445 district hospitals have been equipped for ophthalmic services. The concept of District Blindness Control Society was first developed in five pilot districts. Based on the success of these societies, as many as 512 District Blindness Control Societies have been formed under the chairmanship of District Collector. These societies have multidisciplinary structure with representatives from government, non-government and private sector.

**Vision 2020 – The Right to Sight**

Launched in early 1999 in Geneva by WHO – The Right to Sight has as its goal the elimination of avoidable blindness by the year 2020. While adopting the basic strategy of providing comprehensive eye care as an integral part of the primary health care system, 'Vision 2020' includes three major components: specific disease control, human resource development, and infrastructure and appropriate technology development. In the first five-year, disease control efforts will focus largely on cataract, trachoma, onchocerciasis, avoidable causes of childhood blindness, uncorrected refractive error, glaucoma and diabetic retinopathy. Human resource development under the program includes augmentation of middle level ophthalmic personnel. Proposed infrastructure development under NPCB includes establishing 20 centres of excellence, 200 training centres, 2000 service centres and 2000 vision centres. As VISION 2020's mission statement emphasizes, "Our mission is to eliminate the main causes of blindness in order to give all people in the world, particularly the millions of needlessly blind, the right to sight".

## National Iodine Deficiency Disorders Control Program (NIDDCP) (32, 33)

India commenced a 100% centrally sponsored National Goitre Control Program in 1962, based on iodized salt, after successful trials in Kangra Valley in Himachal Pradesh. At the end of four decades, the prevalence of the disease still remains high. In retrospect, it became clear that the failure was mostly due to operational and logistic difficulties. That is, the production of iodized salt did not keep pace with the requirement. Operational difficulties such as inadequate production of iodized salt and continued sale of un-iodized salt in endemic areas resulted in this program having little impact on the goitre problem in the country. Reassessment of the magnitude of the problem by ICMR showed that the problem was not restricted to the goitre-belt as was thought earlier, but is extremely prevalent in other parts of India as well (e.g., Gujarat, Punjab, Maharashtra, Madhya Pradesh, Andhra Pradesh and Kerala). Similarly, the iodine-deficiency manifestations were not limited to endemic goitre and cretinism but to a wider spectrum of disability including deaf-mutism, mental retardation, and various degrees of impairment of intellectual and motor functions. It is estimated that nearly 200 million persons are exposed to the risk of IDD, of which 61 million are having goitre, 2.2 million are cretins and 6.6 million have mild neurological disorders.

In 1992, the program was renamed National Iodine Deficiency Disorders Control Program (NIDDCP) and nation-wide, rather than area-specific use of iodized salt was promoted. It was decided as a national policy to fortify all edible salt in a phased manner by end of 8th plan. The essential components of NIDDCP are use of iodized salt in place of common salt, monitoring and surveillance, manpower training and mass communication.

**Goals of 10th Five Year Plan** (34) : Under the 10th Five Year Plan, specific goals were laid down to achieve universal access to iodized salt, generate district-wise data on consumption of iodized salt and reduce prevalence of iodine deficiency disorders in the country to less than 10% by 2010. In order to achieve these goals, a survey conducted estimated that nearly 200 million people in India are at risk of iodine deficiency disorders. NIDDCP envisages that only iodized salt would be available in the country. To achieve this, sale of non-iodized salt has been banned in 26 states and 7 UTs under PFA Act 1954. Recently central govt has issued complete ban on non-iodized salt throughout the country. Guidelines for quality control for iodated salt have been laid down. Min of Health & Family Welfare has issued notification banning sale of non-iodized slat for direct human consumption in the entire country, effective from May 2006.

## Universal Immunization Program (35, 36, 37, 38)

Experience with small pox eradication program proved that immunization was the most powerful and cost effective weapon against vaccine preventable diseases. In 1974, WHO launched the "Expanded Program on Immunization" (EPI) against 6 diseases which were common during childhood, viz. diphtheria, pertussis, tetanus, polio, tuberculosis, and measles. From the beginning of the program UNICEF has been providing significant support to EPI.

Government of India launched its EPI in 1978 with the objective of reducing mortality and morbidity resulting from vaccine-preventable diseases of childhood, and to achieve self-sufficiency in the production of vaccines. This program was revised (with focus on infants and pregnant mothers) and renamed as Universal Immunization Program (UIP) 1985. It had two vital components: immunization of pregnant women against tetanus and immunization of children in their first year of life against the six target diseases. Measles vaccine was also included under UIP in 1985. UIP was merged with Child Survival and Safe Motherhood (CSSM) program in 1992 and later became part of RCH program in 1997. The aim was to achieve 100 per cent coverage of pregnant women with 2 doses of tetanus toxoid (or a booster dose), and at least 85% coverage of infants with 3 doses each of DPT, OPV, one dose of BCG and one dose of measles vaccine.

The immunization services are being provided through the existing health care delivery system (i.e. MCH centres, Primary Health Centres, and subcentres, hospitals, dispensaries, and ICDS units). There is no separate cadre of staff for UIP since it is an integral part of RCH.

Although the target was 100% immunization, no country has ever achieved "universal" immunization in children.

"Universal" immunization is therefore best interpreted as implying the ideal that no child should be denied immunization against tuberculosis, diphtheria, whooping cough, tetanus, polio and measles. It is, however, generally accepted that when immunization coverage reaches a figure of 80% or more, then disease transmission patterns are so severely disrupted as to provide a degree of protection even for the remaining children who have not been immunized, because of "herd" immunity. It is also important that children are immunized during the first year of life and that levels of immunization are sustained so that each new generation is protected.

**UIP under RCH** : It is envisaged that that under RCH II the immunization program shall be further strengthened. Immunisation coverage will be enhanced for underserved communities, for which Dept of Family Planning has formulated a strategic plan for UIP for the period 2004-2009.

The success of UIP can be measured in terms of burden of vaccine preventable diseases (VPD) in community. UIP has contributed significantly to bringing down infant mortality rate (IMR) from 104 per 1000 live births in 1984 to 60 infant deaths per 1000 live births in 2003. There were certain constraints in UIP under RCH I such as irregular coverage, poor cold chain system, poor implementation, poor staffing & training, poor vaccine supply and poor maintenance of equipment. These have been addressed under RCH II by laying down six goals as under :

(a) Provisioning of safe and efficient immunsation to all infants and women at district level.

(b) Global polio eradication, reduction in mortality due to measles and elimination of neonatal tetanus.

(c) Provisioning of adequate and assured funding for the program.

(d) Reduce social and cultural barriers to immunization services and increase demand for immunsation in community by means of IEC activities.

(e) Introduction of new and underutilized vaccines against diseases which are prevalent in India, like Hepatitis B, Japanese Encephalitis (JE) etc.

(f) Accurately monitor use of immunization services, antigen coverage and drop rates among community

**Urban Measles Campaign** : Measles is highly contagious viral disease, generally occurring in overcrowded living places with poor ventilation, poor living conditions and poor vaccine coverage. By 2000, 63 cities were covered under the Measles vaccination drive initially launched by UNICEF. Presently under the program, the aim to vaccinate all children below the age of 3 years. Under the UIP, MMR can be administered upto the age of 5 years, although ideal age is 15 months.

**Elimination of Neonatal Tetanus** : Neonatal tetanus still contributes significantly to infant mortality in many areas in the country. Fortunately, NNT can be prevented by immunizing all women in reproductive age group by tetanus toxoid. The National Program of Elimination of Neonatal Tetanus under RCH has laid down the following objective of reduction of incidence of NNT to less than 1 per 1000 live births by 2000 (now extended to 2009) through immunizing all pregnant women by two doses of TT, promoting "The Five Cleans" (clean hands, clean surface, clean blade, clean stump and clean tie) during delivery, provisioning of disposable delivery kits and accurate community based surveillance of NNT.

Elimination of NNT is defined as incidence of less than 1 case per 1000 live births in any given geographical area. The state of Andhra Pradesh was the first to be certified in Nov 2003 by a team of National & International experts to have eliminated NNT. With the aim to eliminate NNT from the entire nation by 2009, intensive measures were initiated in all parts of the country.

**National Immunisation Schedule** : Vaccination against TB, polio, tetanus, diphtheria, pertusis and measles is recommended under the routine immunization schedule, as under :

| Age | Vaccines |
|---|---|
| At Birth | BCG, OPV (zero dose) |
| 6 weeks | DPT, OPV, Hep B (first dose) |
| 10 weeks | DPT, OPV, Hep B (second dose) |
| 14 weeks | DPT, OPV, Hep B (third dose) |
| 9 months | Measles |
| 15-18 months | MMR (only in Delhi / New Delhi) |
| 16-24 months | DPT (first booster), OPV |
| 24 months | Typhoid (only in Delhi/New Delhi) |
| 4-5 years | DT (booster), OPV (only in Delhi / New Delhi) |
| 10-16 years | TT |
| Pregnant women (un-immunised) | 2 doses of TT at interval of 1 month |
| Pregnant women (immunized) | 1 booster dose of TT |

Other vaccines recommended by Indian Academy of Pediatrics (IAP) but not included under the National Schedule are as under. These are optional for those who can afford the cost of the vaccines :

| Age | Vaccine |
|---|---|
| 6 weeks | HiB (first dose) |
| 10 weeks | HiB (second dose) |
| 14 weeks | HiB (third dose) |
| 12 months | Chicken Pox, Influenza |
| 18 months | HiB (booster) |
| 24 months | Hep A, Meningococcal meningitis |
| 30 months | Hep A |
| 5 years | Typhoid, Meningococcal meningitis |

## Polio Eradication Program (39)

World Health Assembly of WHO passed a resolution in May

1988 to eradicate Poliomyelitis from the World by the year 2000 and accordingly, all nations launched a concerted drive against Polio. The Americas were declared Polio-free in 1994, followed by Western Pacific in 2000 and Europe in 2002.

Pulse polio program was launched in India in 1995. Under this program, children less than five years of age are given additional oral polio drops every year on fixed National Immunisation Days (NIDs).

Pulse Polio Immunisation means administration of oral polio to all children 0-5 years of age in the country on a single day, regardless of any previous immunisations. Polio vaccine is usually given as two rounds about 4 to 6 weeks apart during low transmission season of polio; i.e. during winter months, with the aim to replace wild polio virus with vaccine virus in community. The doses of OPV during PPIs are extra doses which supplement and do not replace the doses received during routine immunisation services. The children including 0-1 year old infants should receive all their scheduled doses and PPI doses. There is no minimum interval between PPI and scheduled OPV doses.

For India to progress towards the goal of eradication of wild polio virus, it is important to identify poorly vaccinated areas, to determine primary reasons for poor coverage of immunisation and to use this information to ensure high coverage of subsequent supplementary door-to-door immunisation rounds. Now it is clear that PPI campaign using only booth- based approach is not sufficient to interrupt the wild poliovirus transmission in the areas where it is mostly persistent. A recent action research on PPI non-acceptors showed that 10-15 percent of eligible children were missed in earlier PPIs. An area in which wild poliovirus transmission has recently occurred is by defintion an area of low immunisation coverage and area of poor surveillance.

Presently, the basic strategies being followed to eradicate polio from the country are :-

(a) Routine immunization of all infants with at least 4 doses of trivalent OPV.

(b) Pulse Polio Immunisation (PPI) Program through National Immunisation Days (NIDs) wherein additional doses of OPV, 4-6 weeks apart, are administered to all children upto 5 years of age. Intensified Pulse Polio Immunisation (IPPI) is being undertaken in the form of house to house search and vaccination of unvaccinated children after the "booth days".

(c) Surveillance for Acute Flaccid Paralysis (AFP), defined as "any child upto 15 years of age who has sudden onset of flaccid paralysis or paralytic illness in any individual in absence of any obvious reason and where polio is suspected to be the underlying cause". The surveillance program incorporates the following components :

(i) Establishment of AFP Reporting Units, in the form of hospitals, pediatricians, doctors & health/medical care establishments in government and private sector. These reporting units send a weekly report to District Immunisation Officer (DIO).

(ii) Notification of AFP cases to DIOs, immediately on occurrence, following which investigation is undertaken.

(iii) Investigation of AFP cases is to be undertaken within 48 hrs of notification by DIO / SMO, wherein, after confirming the diagnosis of AFP, the child is clinically examined and detailed history is recorded on Case Investigation Form (CIF).

(iv) Collection and transportation of two stool specimens (at least 24 hrs apart) from AFP case is undertaken within 14 days of onset of paralysis. About 8 gms of stool is collected, labeled and transported (in clean, dry, screw-capped, non-sterile bottle without any preservative or transport media) under "reverse cold chain" to a designated national laboratory for identification and isolation of the polio virus.

(v) Outbreak Response Immunistaion (ORI) is organized in community after occurrence of any AFP case. All children below 5 years of age are administered one dose of OPV irrespective of their previous immunization status, through a door-to-door coverage round. The ORI round is to be organized at the earliest after occurrence of AFP case and if travel history of the case is suggestive, ORI should also be conducted at other places of stay of the AFP case.

(vi) Active case search in community is to be conducted by house-to-house search, conducted along with ORI. The case definition to be used in case search is "Flaccid paralysis in a child between 0-15 years of age with onset within last 60 days."

(vii) 60 day follow up examination by DIO is undertaken through re-visit and re-examination of every AFP case 60 days after onset, to confirm residual weakness. A child is said to have residual weakness if the child has any one sign out of weakness, asymmetric skin folds, difference in left/right mid arm/mid thigh circumference.

(d) Extensive house-to-house immunization in form of Mopping up campaigns, under which extra rounds of door-to-door immunization is undertaken with or without fixed booths. This is usually undertaken before onset of summer and rainy months, when residual polio virus in community is likely to appear again in community.

An important improvement in PPI since 1998 has been incorporation of vaccine vial monitor (VVM). Colour monitors or labels are put on vaccine bottles. Each label has a circle of deep blue colour. Inside it is a white square

which changes colour and gradually becomes blue like that of surrounding circle if the temperature is not maintained and then the vaccine should be considered ineffective. Thereby, the health worker can easily ascertain that the vaccine being given is effective or not. This mechanism has been made mandatory in all vaccine procurements since 1998.

**Actions to be taken on Occurrence of AFP Case**

(a) Admission to Hospital : The patient should be immediately admitted to hospital and isolated.

(b) Disinfection : Concurrent disinfection should be carried out.

(c) Notification should be carried out as per existing orders.

(d) Attendants should wear gowns and wash hands after handling patients.

(e) Contacts : Close contacts should be kept under surveillance for 14 days and should not be exposed to violent muscular effort, trauma and inoculations.

(f) Water and Food Sanitation : The clarified water should be superchlorinated before supply. Food sanitation should be kept at highest standard.

(g) Flies : They should be destroyed by use of insecticide sprays and breeding should be prevented by proper disposal of garbage.

(h) Oral Vaccine : Mass vaccination should be organised to achieve the most rapid and complete immunization of epidemiologically relevant groups, particularly younger children.

## National Guinea – Worm Eradication Program (14, 43)

India launched its National Guineaworm Eradication Program in 1984 with technical assistance from WHO. From the very beginning the program was integrated into the national health system at village level through primary health care. With well defined strategies, an efficient information and evaluation system, intersectoral coordination at all levels and close collaboration with WHO and UNICEF, India was able to significantly reduce the disease in affected areas. The last Guinea worm case in the country was reported in August 1996 from Jodhpur (Rajasthan). The country has reported zero cases since then. In February 2000, the International Commission for the Certification of Dracunculiasis Eradication recommended that India be certified free of dracunculiasis transmission and subsequently India was declared to "Guinea Worm Disease free" on 15 February 2001.

## Japanese Encephalitis Control Program (14, 44, 45)

Japanese encephalitis (JE) is a disease with high mortality rate and those who survive do so with various degrees of neurological complications. JE has been reported in the country since mid fifties. With increasing development of irrigation projects and changing pattern of water resource management there has been a progressive increase in number of States reporting JE in India. Twelve States/Union territories have reported outbreaks of JE in the last decade and 378 million population is exposed to the risk of JE. States of Andhra Pradesh, West Bengal, Assam, Tamil Nadu, Karnataka, Bihar and Uttar Pradesh are reporting maximum number of cases.

A task force has been constituted at National level for control of JE, which reviews the situation and control strategies from time to time. Technical support for prevention, control and investigation of outbreaks is provided under National Vector Borne Diseases Control program (NVBDCP), with separate budget allocation of funds for JE control, including training and IEC under NVBDCP.

**The Strategies for Control of Japanese Encephalitis:**

(a) Surveillance activities through sentinel sites.

(b) Early diagnosis & treatment at PHCs, CHCs and tertiary hospitals.

(c) Behaviour Change Communication (BCC) for early reporting & personal protection.

(d) Integrated vector control measures in the form of antilarval measures, space spraying in animal dwellings and fogging when outbreaks are imminent.

(e) Training of medical & nursing staff.

(f) Efforts to develop a safe and standard vaccine.

Under the program, vaccination with killed JE vaccine is not recommended for control of an outbreak. Primary immunization (not included under the program) in the form of 2 doses of 1 ml (0.5 ml for children upto 3 years) each is to be given subcutaneously at 7-14 days interval. Booster dose of 1 ml is to be given after one year, with re-vaccination after 3 years. Vaccination is considered as a very cost-effective method to permanently control JE at community level.

## Kala-Azar Control Program (14, 46)

Kala-azar (Visceral leishmaniasis) continues to be a serious public health problem in several states in the country. Available data indicates that Kala-azar is endemic in 32 districts in Bihar, 4 districts in Jharkhand, 11 districts in West Bengal and 2 districts in UP, with an estimated 129 million people at risk. Periodic outbreaks of Kala-azar with increase in morbidity and mortality continue to occur in these states. Over 90% of the reported cases and over 95% of the reported deaths are from Bihar. Over two thirds of the cases in Bihar are reported from 7 districts. National Health Policy 2002 has laid down the goal of elimination of Kala Azar by 2010.

The Government of India is implementing a Centrally Sponsored Scheme for control of Kala-azar in Bihar and West Bengal. Following reported increase in the number of cases and deaths due to Kala-azar in 1989-91, an intensive program for containment of Kala-azar was launched in 1992.

The strategy for control of infection includes interruption of transmission through residual indoor insecticide spraying, early diagnosis with RK 39 Rapid Detection Kits, prompt treatment with oral Miltefosine, intensive IEC activities for sustained behaviour change, capacity

building in form of infrastructure and training, close monitoring & evaluation and Operational Research.

After 1993-94, financial aid was provided to Bihar and West Bengal to control Kala Azar, along with chemicals for residual spray and drugs (Sodium stibogluconate and Pentamidine isothionate). The program was operational on cost sharing basis till 2000-2001, with centre providing the chemicals and drugs and states providing the expenses for spray operations and other strategies. However, since 2003-2004, the program is being implemented as a 100% centrally funded program.

## Dengue Fever Control (14, 47)

Dengue outbreaks have been reported from urban areas from all states. All four types of dengue viruses exist in India. The vector *Aedes aegypti* breeds in peri-domestic fresh water collections and is found both in urban and rural areas. Dengue outbreaks occur both in urban and rural areas. Dengue fever occurred in Kolkata from Jul 1963 to Mar 1964 and since then more than 60 outbreaks have been reported from all other states in the country, including the outbreak in North India in 2006.

All areas in the country have been found to be susceptible to Dengue outbreaks because extensive breeding exist in all urban areas (in form of desert coolers, water storage tanks, wells & fountains, tyre dumps, junk cans and uncleared garbage dumps) and absence of any *Aedes* Control Program in the country.

Since there is no specific treatment for Dengue or effective vaccine available, the control strategy is based primarily on surveillance through sentinel sites, early reporting and prompt case management, vector control through reduction, personal protection, community mobilisation and intersectoral co-operation. There is no separate funding for Dengue control at present in the country and resources under NVBDCP are utilized for various control & prevention activities.

## National Cancer Control Program (14, 48, 49)

In India, Cancer is among the top ten leading causes of death, with over 2.5 million cancer cases at point of time and 7 lakh new cases and 3 lakh deaths occurring every year. Tobacco- related cancers (cancer of oral cavity & lung) and cancer of cervix form more than 50% of overall cancer burden in the country. Current projects indicate that cancer burden in India will double by 2026 due to continued use of tobacco, increasing longevity and greater exposure to environmental carcinogens. Changing dietary patterns (high calorie, high fat intake) and lower parity is likely to result in increasing incidence of breast cancer among women.

The Cancer Control Program was initiated in 1975-76 as a 100% centrally funded Central Sector project. It was renamed as National Cancer Control Program in 1985 and revised in 2004. The objectives of the program are

(a) Primary prevention of cancers through health education

(b) Secondary prevention by early detection & diagnosis (especially of cervical, breast & oropharyngeal cancers)

(c) Strengthening of existing cancer treatment facilities

(d) Provide palliative care for terminal stage cancer patients

(e) Research and training.

At present there are 24 regional cancer research centres, whose main functions are detection & treatment of cancers, after care and rehabilitation, education & training, cancer registration, research and coordination with medical colleges and general health care system. In addition, National Cancer Control Program aims to establish Oncology wings in all medical colleges of the country. The District Cancer Control Program for preventive health education, early detection, palliative care, training and coordination was launched in 1990-91 in collaboration with Regional Cancer Centres.

**National Cancer Registry Program** : Cancer registration consists of scientifically and accurately collecting, compiling and recording data on malignant cancers, which may be either hospital based or population based. National Cancer Registration Program was launched by ICMR in 1982 to provide accurate and reliable data on cancer prevalence & incidence. At present, there are 5 urban population-based cancer registries (Delhi, Mumbai, Bhopal, Bangalore & Chennai) and 1 rural registry at Barshi in Maharashtra. 6 hospital-based cancer registries are maintained at Chandigarh, Dibrugarh, Thiruvananthapuram, Bangalore, Mumbai and Chennai. A total of 3.3% of Indian population are covered by these cancer registries, which has been expanded by six additional population-based registries in North Eastern States and one rural registry at Ahmedabad.

## National Mental Health Program (14, 50)

It is estimated that 10 to 15% of the population suffer from mental health problem. The National Mental Health Program (NMHP) was initiated by the Government of India in 1982 with the objective of improving mental health services at all levels of health care (primary, secondary and tertiary) for early recognition, adequate treatment and rehabilitation of patients with mental health problems within the community and in the hospitals. The strategies to achieve these objectives were integration of mental health care with primary health care, providing tertiary care centers for treatment of mental illnesses and minimizing stigma and discrimination against mentally ill individuals through regulatory mechanisms like State Mental Health Authority. The Mental Health Act, 1987, which came into force with effect from April 1993, requires that each State/UT set up its own State level Mental Health Authority as a Statutory obligation. Majority of the States/ UTs have complied with this and have formed a Mental Health Authority.

During the eighth plan, NIMHANS Bangalore developed a district mental health care model in Bellary district with the following aims:

(a) To provide sustainable basic mental health services to the community and to integrate these services with health services;

(b) Early detection and prompt treatment of patients;

(c) To provide domiciliary mental health care and to reduce patient load in mental hospital;

(d) Community education to reduce the stigma attached to mental illness

(e) To treat and rehabilitate patients with mental problems within their family setting.

During the ninth plan period the experience gained in implementing mental health care both in Central and State sector will be utilized to provide sustainable mental health services at primary and secondary care levels and to build up community support for domiciliary care. IEC on mental health especially prevention of stress-related disorders through promotion of healthy lifestyles and operational research studies for effective implementation of preventive, promotive and curative programs in mental health through existing health infrastructure will receive due attention.

The thrust areas for mental health during 10th Five Year Plan are :

(a) District Health Progamme in an enlarged and more effective form would be covering the entire country.

(b) Modernization of mental hospitals in order to modify their present custodial role.

(c) Upgrading department of Psychiatry in medical colleges and enhancing the psychiatry content of the medical curriculum at the under-graduate level.

(d) Strengthening the Central and State Mental Health Authorities with a permanent secretariat.

(e) Research and training in the field of community mental health, substance abuse and child/adolescent psychiatric clinics.

## National Diabetes Control Program

The National Diabetes Control Program was included as a pilot program in the Seventh Five-Year Plan during 1987 in two districts in Tamil Nadu and one district in Jammu & Kashmir. Several states initiated district diabetes control program as part of State Plan scheme during the Eighth Plan period. Experience gained in implementing the district diabetes control program during Seventh and Eighth Plans have shown that integrated treatment of diabetes mellitus, hypertension and heart disease within primary and secondary care level is possible, provided functional linkages between these and tertiary care centres are developed and utilised. During the Ninth Plan period these experiences were utilised to develop integrated program of non-communicable diseases prevention, detection and management program at primary and secondary care level in all districts.

Initially, the objectives of National Diabetes Control Program were :

(a) Identification of high risk subjects & early intervention in form of health education

(b) Early diagnosis and appropriate management of cases,

(c) Prevention, arrest or slowing of acute metabolic as well as chronic cardiovascular-renal complications of the disease

(d) Providing equal opportunities for education and employment for diabetic patients

(e) Rehabilitation of partially or totally handicapped diabetic patients.

Recently, ICMR has initiated and is managing the National Integrated Disease Surveillance Project, focusing on risk factors for non-communicable disease like cardiovascular diseases, diabetes mellitus, cancers, obesity etc.

## National Water Supply and Sanitation Program (51)

The National Water Supply and Sanitation Program was initiated in 1954 with the object of providing safe water supply and adequate drainage facilities for the entire urban and rural population of the country. In 1972 a special program known as the Accelerated Rural Water Supply Program was started as a supplement to the national water supply and sanitation program. In spite of increased financial outlay during successive five-year plans, only a small dent was made on the overall problem. During the fifth plan, rural water supply was included in the Minimum Needs Program of the State Plans. The Central Government is supporting the efforts of the States in identifying problem villages through the Accelerated Rural Water Supply Program. A "problem village" has been defined as one where no source of safe water is available within a distance of 1.6 km or where water is available at a depth of more than 15 metres or where water source has excess salinity, iron, fluorides, arsenic, etc or where water is exposed to the risk of cholera.

Despite financial constraints, the government is committed to provide safe drinking water to all the villages. The latest assessment indicates that safe water is available to about 85% of the total population and 16% population has access to adequate sanitation facilities (out of which 2% are in rural areas).

## Minimum Needs Program

The minimum needs program was introduced in the first year of the fifth plan (1974-78). The objective of the program is to provide certain basic minimum needs and thereby improve the living standards of the people. It is the expression of the commitment of the government for the "social and economic development of the community particularly the underprivileged and underserved population". The program includes the following components:

(a) Rural Health

(b) Rural Water Supply

(c) Rural Electrification

(d) Elementary Education

(e) Adult Education

(f) Nutrition

(g) Environmental improvement of urban slums

(h) Houses for landless labourers

## 20-Point Program

In addition to the five-year plans and programs, in 1975, the government initiated a special activity. This was the 20-point program – described as an agenda for national action to promote social justice and economic growth.

On August 20, 1986, the existing 20-point program was restructured. Its objectives are spelt out by the government as "eradication of poverty, raising productivity, reducing inequalities, removing social and economic disparities and improving the quality of life".

At least 8 of the 20 points are related, directly or indirectly, to health. These are:-

| | |
|---|---|
| Point – 1 | Attack on rural poverty |
| Point – 7 | Clean drinking water |
| Point – 8 | Health for all |
| Point – 9 | Two-child norm |
| Point – 10 | Expansion of education |
| Point – 14 | Housing |
| Point – 15 | Improvement of slums |
| Point – 17 | Protection of the environment |

## Integrated Child Development Services (ICDS) (52)

The ICDS scheme was initiated by the then Ministry of Social and Women's Welfare on 02 Oct 1975, in pursuance of the National Policy for children. The Ninth Five Year Plan aimed to universalise ICDS, i.e. cover the whole country. The beneficiaries of ICDS are :

(a) Children below 6 years
(b) Pregnant and lactating women
(c) Women in the age group of 15-44 years
(d) Adolescent girls in selected blocks

The ICDS seeks to lay a solid foundation for the development of the nation's human resource by providing an integrated package of early childhood services. These consist of:

(a) Supplementary nutrition
(b) Immunization
(c) Health check-up
(d) Medical referral services
(e) Nutrition and health education for women
(f) Non-formal education for children up to the age of 6 years
(g) Care of pregnant and nursing mothers

Under the 10th Five Year Plan, the objectives emphasized are (53) :

(a) Achieve optimum intra-familial distribution of food by strengthening the food and nutrition component.
(b) Reach the children in 6-36 month age group, pregnant and lactating women
(c) Weighing all vulnerable population & put on treatment within 3 months
(d) Universal screening every quarter to identify causes for growth hindrance
(e) Interventions, including take home food supplements
(f) Identifying and treating health problems associated with severe malnutrition
(g) Training and supervision

The administrative unit of an ICDS project is the "community development block" in rural areas, the "tribal development block" in tribal areas and a group of slums in urban areas. The rural/urban project has a population of 1 lac and a tribal project about 35,000. The number of villages in the rural project may be 100 while in tribal areas it may be only 50. The focal point for the delivery of integrated early childhood services under the ICDS scheme is the trained local woman known as the Anganwadi worker. Other functionaries are the Child Development Project Officer, who is in charge of 4 Supervisors and 100 Anganwadi workers.

**Nutritional Program for Adolescent Girls :** The 10th Five Year Plan and Nutritional Policy proposed a nutritional program for girls weighing less than 35 Kg and for pregnant women weighing less than 45 Kg and below poverty line, who would get ration of Rs 6/- per month in form of wheat or rice, through the Public Distribution System.

**Scheme for Adolescent Girls in ICDS : Kishori Shakti Yojana :** The adolescent girls need appropriate nutrition, education, health education, training for adulthood, training for acquiring skills as the base for earning an independent livelihood, training for motherhood, etc. Similarly on the other side their potential to be a good community leader has to be realized. A scheme for adolescent girls in ICDS was launched by the department of Women and Child Development, Ministry of Human Resource Development in 1991. All adolescent girls in the age group of 11-18 years (70%) receive the following common services:

Watch over menarche

(a) Immunization
(b) General health check up once in every six months
(c) Training for minor ailments
(d) Deworming
(e) Prophylactic measures against anaemia, goiter, vitamin deficiency, etc.
(f) Referral to PHC/District hospital in case of acute need

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Col RajVir Bhalwar

# National Health Policy, National Population Policy and National Rural Health Mission

## National health policy – 2002

National health policy (NHP) was first enunciated in 1983, and since then there have been marked changes in the determinant factors relating to the health sector. Some of the policy initiative outlined in the NHP-1983 yielded results, while in several other areas, the outcome was not as expected. Government initiatives in the public health sector have recorded some noteworthy successes over time. Smallpox and Guinea Worm disease have been eradicated from the country. Polio is on the verge of being eradicated. Leprosy, Kala Azar, and Filariasis can be expected to be eliminated in the foreseeable future. There has been a substantial drop in the total fertility rate and infant mortality rate. The success of the initiatives taken in the public health field are reflected in the progressive improvement of many demographic, epidemiological and infrastructural indicators over time. Accordingly, the NHP – 1983 was revised and a new, extensive NHP was enunciated by the Govt of India in 2002.

### Objectives

The main objective of this policy is to achieve an acceptable standard of good health amongst the general population of the country. The approach would be to :

(a) Increase access to the decentralized public health system by establishing new infrastructure in deficient areas, and by upgrading the infrastructure in the existing institutions.

(b) Overriding importance would be given to ensuring a more equitable access to health services across the social and geographical expanse of the country.

(c) Emphasis will be given to increasing the aggregate public health investment through a substantially increased contribution by the Central Government. It is expected that this initiative will strengthen the capacity of the public health administration at the state level to render effective service delivery.

(d) The contribution of the private sector in providing health services would be much enhanced, particularly for the population groups which can afford to pay for services.

(e) Primacy will be given to preventive and first-line curative initiative at the primary health level through increased share of allocation.

(f) Emphasis will laid on rational use of drugs within the allopathic system, and also increased access to tried and tested systems of traditional medicine will be ensured.

Within these broad objectives, NHP-2002 will endeavour to achieve the time-bound goals mentioned in Box-1. On a short term basis, within the context of the NHP, the Important health related targets for the tenth five year plan (2002 – 2007) are :

Box - 1 : NHP Goals to be achieved by 2000-2015.

| | |
|---|---|
| Eradicate Polio and Yaws | 2005 |
| Eliminate Leprosy | 2005 |
| Eliminate Kala Azar | 2010 |
| Eliminate Lymphatic Filariasis | 2015 |
| Achieve Zero level growth of HIV / AIDS | 2007 |
| Reduce Mortality by 50% on account of TB, Malaria and Other Vector and Water Borne diseases. | 2010 |
| Reduce Prevalence of Blindness to 0.5% | 2010 |
| Reduce IMR to 30/1000 and MMR to 100/Lakh. | 2010 |
| Increase organization or public health facilities from current level of <20 to >75%. | 2010 |
| Establish an integrated system of surveillance, National Health Accounts and Health Statistics. | 2005 |
| Increase health expenditure by Government as a % of GDP from the existing 0.9% to 2.0%. | 2010 |
| Increase share of Central grants to Constitute at least 25% of total health spending. | 2010 |
| Increase State Sector Health spending from 5.5% to 7% of the budget | 2005 |
| Further increase state health spending to 8% | 2010 |
| | |

(a) To achieve growth rate of GDP @ 8%.

(b) Reduction of Poverty ratio to 20% by 2007 and to 10% by 2012.

(c) Universal access to primary education by 2007.

(d) Reduction in decadal rate of population growth, between 2001 to 2011 to 1.62%.

(e) Increase in literacy rate to 72% within the plan period and to 80% by 2012.

(f) Reduction of IMR to 45 per 1000 by 2007 and to 28 by 2012.

(g) Reduction of MMR to 20 per 1000 by 2007 and to 10/1000 by 2012.

(h) All villages to have sustained access to portable drinking water by 2012.

(j) Cleaning of all major polluted rivers by 2007 and other notified striations by 2012.

### Major Strategies of NHP-2002

(a) Financial Resources

It is concerning that Public Health expenditure has declined from 1.5% of GDP in 1990 to 0.9% of GDP in 1999. Given the extremely difficult fiscal position of the State Governments, the Central Government will have to play a key role in augmenting public investments. It is planned, under the policy, to increase health sector expenditure to 6 percent of GDP, with 2 percent of GDP being contributed as public health investment, by the year 2010. The State Governments would also need to increase the commitment to the health sector. In the first phase, by 2005, they would be expected to increase the commitment of their resources to 7percent of their budget, and in the second phase, by 2010, to increase it to 8 percent. With the stepping up of the public health investment, the Central Government's contribution would be 25 percent from the existing 15 percent by 2010.

(b) Equity

To meet the objective of reducing various types of inequities and imbalances, i.e., interregional; across the rural – urban divide; and between economic classes – the most cost-effective method would be to increase the sectoral outlay in the primary health sector. Such outlets afford access to a number of individuals, and also facilitate preventive and early stage curative initiative, which are cost effective in recognition of the public health principle, NHP-2002 sets out an increased allocation of 55 percent of the public health investment for the primary health sector, the secondary and tertiary health sectors being targeted for 35 percent and 10 percent respectively, for strengthening existing facilities and opening additional public service outlets, consistent with in the norms for such facilities.

(c) Delivery Of National Public Health Programmes

The policy envisages a key role for the Central Government in designing national programmes with the active participation of the State Governments. Also, the policy ensures the provisioning of financial resources, in addition to technical support, monitoring and evaluation at the national level by the Centre. However, to optimize the utilization of the public health infrastructure at the primary level, NHP-2002 envisages the gradual convergence of all health programmes under a single field administration. Vertical programmes for control of major diseases like TB, Malaria, HIV/AIDS, as also the RCH and Universal Immunization Programmes, would need to be continued till moderate levels of prevalence are reached. The policy also envisages that programme implementation be effected through autonomous bodies at State and district levels.

The policy envisages that apart from the exclusive staff in a vertical structure for the disease control programmes, all rural staff should be available for the entire gamut of public health activities at the decentralized level, irrespective of whether these activities relate to national programmes or other public health initiatives. It would be for the Head of the District Health administration to allocate the time of the rural health staff between the various programmes, depending on the local need.

(d) The State Of Public Health Infrastructure

The policy envisages kick-starting the revival of the Primary Health System by providing some essential drugs under Central Government funding through the decentralized health system. It is expected that the provisioning of essential drugs at the public health service centre will create a demand for other professional services from the local population, which in turn, will boost the general revival of activities in these service centers.

This policy recognizes the need for more frequent in-service training of public health medical personnel, at the level of medical officers as well as paramedics. Such training would help to update the personnel on recent advancements in science, and would also equip them for their new assignment. When they are moved from one discipline of public health administration to another.

Global experience has shown that the quality of public services is closely linked to the quantum and quality of investment through public funding in the primary health sector. Therefore the policy, while committing additional aggregate financial resources, places great reliance on the strengthening of the primary health structure for the attaining of improved public health outcomes in an equitable basis. Further, it also recognizes the practical need for levying reasonable user-charges for certain secondary and tertiary public health care services for those who can afford to pay.

(e) Extending Public Health Services

State Governments may consider the need for expanding the pool of medical practitioners to include a cadre of licentiates of medical practice, as also practitioners of Indian Systems of Medicine and Homoeopathy. Simple services / procedures can be provided by such practitioners even outside their disciplines, as part of the basic primary health services in under-served areas. Also, NHP-2002 envisages that the scope of the use of paramedical manpower of allopathic disciplines in a prescribed functional area adjunct to their current functions, would also be examined for meeting simple public health requirements.

(f) Role Of Local Self-Government Institutions

NHP-2002 lays great emphasis upon the implementation of public health programmes through local self-government institutions.

(g) Norms For Health Care Personnel

Minimal statutory norms for the development of doctors and nurses in medical institutions need to be introduced urgently under the provisions of the Indian Medical Council Act and Indian Nursing Council Act, respectively. The policy also envisages the setting up of a Medical Grants Commission for funding new Government Medical and Dental Colleges in different parts of the country. To enable fresh graduates to contribute effectively to the providing of primary health services as the physician of first contact, this policy identifies a significant need to modify the existing curriculum. A need-based, skill-oriented syllabus, with a more significant component of practical training would make fresh doctors useful

immediately after graduation.

(h) Need For Specialists In Public Health And Family Medicine

In order to alleviate the actual shortage of medical personnel with specialization in the disciplines of public health and 'family medicine', the policy envisages the progressive implementation of mandatory norms to raise the proportion of postgraduate seats in these disciplines in Medical Training Institutions, to reach a stage wherein 1/4th of the seats are earmarked for these disciplines. It is envisaged that in the sanctioning of post-graduate seats in future, it shall be insisted upon that a certain reasonable number of seats be allocated to public health and family medicine. Since the public health discipline has an interface with many other developmental sectors, specialization in public health may be encouraged not only for medical doctors, but also for non-medical graduates from the allied fields of public health engineering, microbiology and other natural sciences.

(j) Use Of Generic Drugs and Vaccines

NHP emphasizes the need for basing treatment regimens, in both, the public and private domain, on a limited number of essential drugs of a generic nature. This is a pre-requisite for cost effective public health care. In the public system, this would be enforced by prohibiting the use of proprietary drugs, except in special circumstances.

(k) Urban Health

NHP-2002 envisages the setting up of an organized urban primary health care structure. The structure conceived under NHP-2002 is a two-tiered one; the primary center is seen as the first-tier, covering a population of one lakh, with a dispensary providing an OPD facility and essential drugs, to enable access to all the national health programmes, and a second-tier of the urban health organization at the level of the Government general hospital, where reference is made from the primary centre.

(l) Mental Health

NHP-2002 envisages a network of decentralized mental health services for ameliorating the more common categories of disorders.

(m) Information, Education And Communication (IEC)

NHP-2002 envisages an IEC policy, which maximizes the dissemination of information to those population groups which cannot be effectively approached by using only the mass media. The focus would therefore be on the inter-personal communication of information and on folk and other traditional media to bring about behavioral change.

(n) Health Research

The policy envisages an increase in Government funded health research to a level of 1 percent of the total health spending by 2005; and thereafter, up to 2 percent by 2010. Domestic medical research would be focused on new therapeutic drugs and vaccines for tropical diseases, such as TB and Malaria, as also on the sub-types of HIV / AIDS prevalent in the country.

(o) Role of The Private Sector

In principle, this policy welcomes the participation of the private sector in all areas of health activities – primary, secondary or tertiary.

(p) National Disease Surveillance Network

This Policy envisages the full operationalization of an integrated disease control network from the lowest rung of public health administration to the Central Government by 2005. The programme for setting up this network includes components relating to the installation of data-base handling hardware; IT inter-connectivity between different tiers of the network; and in-house training for data collection and interpretation for undertaking timely and effective response. This public health surveillance network will also encompass information from private health care institutions and practitioners. It is expected that real-time information will greatly strengthen the capacity of the public health system to counter local outbreaks of seasonal diseases.

(q) Health Statistics

The policy envisages the compilation of estimates for the incidence of the common diseases – TB, Malaria, and Blindness – by 2005. The policy proposes that statistical methods be put in place to enable the periodic updating of these baseline estimates through representative sampling, under an appropriate statistical methodology. The policy also recognizes the need to establish, in a longer time-frame, baseline estimates for non-communicable diseases, like CVD, Cancer, Diabetes; and accidental injuries, and communicable diseases, like Hepatitis and JE. NHP-2002 envisages that, with access to such reliable data on the incidence of various diseases, the public health system would move closer to the objective of evidence-based policy-making.

## National population policy (NPP) - 2000

In 1952, Indian became the first country in the world to launch a national program, emphasizing family planning to the extent necessary for reducing birth rates "to stabilize the population at a level consistent with the requirement of national economy". After 1952, sharp declines in death rates were, however, not accompanied by a similar drop in birth rates. The National Health Policy, 1983, stated that replacement levels of fertility rate (TFR) should be achieved by the year 2000.

On 11 May 2000 India had 1 billion (100 crore) people, i.e., 16 percent of the world's population on 2.4 percent of the globe's land area. If current trends continue, India may overtake China in 2045, to become the most populated country in the world. While global population has increased threefold during 20$^{th}$ century, from 2 billion, the population of India has increased nearly five times from 238 million (23 crores) to 1 billion in the same period. India's current yearly increase in population of 15.5 million is enough to neutralize efforts to conserve the resource endowment and environment.

The National Population Policy 2000 (NPP 2000) affirms the commitment of government towards voluntary and informed choice and consent of citizens while availing of reproductive health care services, and continuation of the target free approach in administering family planning

services. The NPP 2000 provides a policy framework for advancing goals and prioritizing strategies during the next decade, to meet the reproductive and child health needs of the people in India, and to achieve net replacement levels (TFR) by 2010. It is based upon the need to simultaneously address issues of child survival, maternal health and contraception, while increasing outreach and coverage of a comprehensive package of reproductive and child health service by government, industry and voluntary non-government sector, working in partnership.

**Objectives**

The immediate objective of the NPP 2000 is to address the unmeet needs for contraception, health care infrastructure, and health personnel, and to provide integrated service delivery for basic reproductive and child health care. The medium-term objective is to bring the TFR to replacement levels by 2010, through vigorous implementation of inter-sectoral operational strategies. The long-term objective is to achieve a stable population by 2045, at a level consistent with the requirements of sustainable economic growth, social development, and environmental protection.

**Targets**

In pursuance of these objectives, the following National Socio-Demographic Goals to be achieved in each case by 2010 are formulated :

(a) Address the unmet needs for basic reproductive and child health services, supplies and infrastructure.

(b) Make school education up to age 14 free and compulsory, and reduce drop puts at primary and secondary school levels to below 20 percent for both boys and girls.

(c) Reduce infant mortality rate to below 30 per 1000 live births.

(d) Reduce maternal mortality ratio to below 100 per 100, 000 live births.

(e) Achieve universal immunization of children against all vaccine preventable diseases.

(f) Promote delayed marriage for girls, not earlier than age 18 and preferably after 20 years of age.

(g) Achieve 80 percent institutional deliveries and 100 percent deliveries by trained persons.

(g) Achieve universal access to information / counseling, and services for fertility regulation and contraception with a wide basket of choices.

(j) Achieve 100 percent registration of births, deaths, marriage and pregnancy.

If the NPP - 2000 is fully implemented, we anticipate a population of 1107 million (110 crores) in 2010, instead of 1162 million (116 crores) projected by Technical Group on population Projections.

**Major Strategies in NPP - 2000**

(a) Decentralized Planning and Program Implementation.

(b) Convergence of Service Delivery at Village Levels.

(c) Empowering Women for Improved Health and Nutrition.

(d) Meeting the Unmet Needs for Family Welfare Services.

(e) Focus on Under-Served Population Groups.

(i) Urban Slums.

(ii) Tribal Communities, Hill Area Populations and Displaced and Migrant Populations.

(iii) Adolescents.

(f) Diverse Health Care Providers.

(g) Collaboration with and Commitments from Non-Government Organizations and the Private Sector.

(h) Mainstreaming Indian System of Medicine and Homeopathy.

(j) Contraceptive Technology and Research on Reproductive and Child Health.

(k) Providing for the Older Population.

(l) Information, Education and Communication.

**Operational Strategies**

(a) Utilize village self help groups to organize and provide basic services for reproductive and child health care, combined with the ICDS scheme.

(b) Implement at village levels a one-stop integrated and coordinated service delivery package for basic health care, family planning and maternal and child health related services, provided by the community and for the community.

(c) Wherever these village self-help groups have not developed for any reason, community midwives, practitioners of ISM, retired school teachers and ex-defense personnel may be organized into neighborhood groups to perform similar functions.

(d) At village levels, the Anganwadi centre may become the pivot of basic health care activities, contraceptive counseling and supply, nutrition education and supplementation, as well as pre-school activities. The Anganwadi centers can also function as depots for ORS/basic medicines and contraceptives.

(e) A maternity hut should be established in each village to be used as the village delivery room with storage space for supplies and medicines. It should be adequately equipped with kits for midwifery, ante-natal care, and delivery; basic medication for obstetric emergency aid; contraceptives, drugs and medicines for common aliments.

(f) Trained birth attendants as well as the vast pool of traditional dais should be made familiar with emergency and referral procedures.

(g) Provide wider basket of choices in contraception, through innovative social marketing schemes to reach household levels.

## National Rural Health Mission (NRHM)

The NRHM was launched on 12April 2005 by the Hon'able Prime Minister. NHRM would strive to achieve a set of Core and supplementary strategies to meet its goal of providing effective health care to the rural population especially the disadvantaged groups including women and children. Initial focus would be on 10 high priority states and to increase public health expenses from 0. 9% to 2. 3% of GDP.

### Core Strategies

The main focus in NRHM would be on the following issues :

(a) Decentralized village and district level health planning.

(b) Appointment of Accredited Social Health Activist (ASHA):- The selection criteria would be "women, resident of the concerned village, married / widow / divorced, 25-45 years age, formal education up to 8th, to be selected out of a panel by village health and action committee of Gram Sabha. Norm would be 1 per 1000 population, but this norm may be changed for different areas. No pay of honorarium but she will be given compensation for various health and sanitation services provided. They will be given a kit of suitable drugs. They would be guided by Anganwadi Workers (AWW) and ANM. In 4 years, 2.5 lakh ASHAs will be deployed.

(c) Strengthening the public health service delivery system particularly at village, primary and secondary level, by developing and implementing the Indian Public Health Standards; Developing CHCs as the First Referral Units (FRUs) by providing special care in Med, Surg, Obs & Gyn, and Pediatrics. Presently minimum standards of Indian Public Health for CHCs have been developed; later they will be developed for PHCs & subcentrie also.

(d) Mainstreaming of AYUSH (Indian Systems of Medicine).

(e) Improved management capacity to organise health systems and services in public health.

(f) Emphasizing evidence based planning and implementation.

(g) Prompting non-profit factor to increase social participation, promoting health behaviors and improving intersectoral convergence.

### Supplementary Strategies

(a) Regulation of private sector to improve equity and reduce "out of pocket" expenses.

(b) Foster Public – Private Partnership (PPP) to meet national public health goals.

(c) Re-orientation Of Medical Education (ROME).

(d) Raising health security / insurance for the poor.

### Organisational Stucture :

**Central level** – Mission steering group under Minister of H & FW.

**State level** – State Health Mission under CM.

**District level** – District Health Mission under Chairman Zila Parishad and covered by District Head of Health Department. It will control, manage and guide all public health institution in the dist & sub-dist level.

### Indian Public Health Standards (IPHS) in CHCs

As of Sept 04, there were 1, 42, 655 sub centres, 23, 109, PHCs and 3, 222 CHCs functioning. Each CHC is supposed to cover 1, 20, 000 population (80, 000 in hilly / tribal / difficult areas). Bureau of Indian Standards (BIS) has standards for 30 bedded Hospitals. These are at present not achievable as they are very resource intensive. Present IPHS standards for CHCs reflect requirements for the minimum functional grades. Further up-gradation will be proposed after these minimum requirements have been met.

The salient features of IPHS for CHCs include.

(a) Care of routine and emergency cases in Surg, Med and Obstetrics.

(b) 24 hrs delivery services including normal and complicated deliveries.

(c) Full range of FP services including laparoscopy.

(d) New born care, routine & emergency care of such children.

(e) Adequate surveillance under all national health programs.

(f) Referral Transport.

(g) Essential Lab Services.

(h) Blood Storage Services.

Specialists suggested at CHC level are Medical, Surgical, Obs-Gynae, Paediatrics, Anesthesia & Public Health manager. 1 Ophthalmologist for every 5 CHCs is also suggested. In addition, support staff is to be strengthened by addition of a Public Health Nurse (PHN) and one Auxillary Nurse Midwife (ANM) in all these CHCs in addition to the existing 21 to 22 support staff.

In addition norms for physical infrastructure for clinical services, support services, ancillary services and administrative services have also been specified.

A list of equipment needed at the CHC has been made. SOPs and standard treatment Guidelines (STGs) for management of routine and emergency cases have been made. A list of essential and emergency drugs for CHC has also been developed and Rogi Kalyan Samitee (Patient Welfare Committees) have been organised.

NRHM has been launched in 18 states, including 8 European Action Group (EAG) states (Raj, UP, MP, Bihar, Orissa, Uttaranchal, Jharkhand, Chattisghad), 8 North Eastern States, and 2 Northern states of Himachal & J&K.

### Progress Under NRHM

(a) State Health Missions have been constituted in all states.

(b) Total 3 lakh ASHAs selected till date.

(c) 2. 05 lakh ASHAs trained.

(d) ASHA training modules developed and revised.

(e) State / Distt. / Block level training completed.

(f) Over 1100 management professionals (CA/MBA) appointed in program management units (PMU) to support the programme management. This is being planed at the level of the block also.

(g) RCH- II launched and under implementation.

(h) IMCI started in 25 states.

(j) Legal changes brought about to allow ANMs to dispense medication and MBBS doctors to dispense anesthesia.

(k) JE vaccination initiated in 11 districts in 4 states and 93 lakh children immunized.

**References & Further Suggested readings**

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# Health Care

## Introduction

The term health care can evoke different meanings in different persons depending on one's perspectives. An industrial worker may think of health care as the treatment of loose motions with home remedies and a day off from work. To a surgeon, it may focus on the next patient being prepared for appendectomy. A public health administrator may consider it to be the immunization campaign scheduled for the next week, to the finance minister of a government, it may mean the health benefits package under planning to benefit a needy community. A town councilor may see it as the need to control the rising budget for purchase of medicines for the dispensaries in the municipality. Thus health care includes the systems of individual arrangements and social institutions through which health services of a personal nature are provided, organized, financed and controlled. It will refer to all types of personal health services provided to individuals by physicians, dentists, nurses, pharmacists and other health personnel. It includes promotion of health and prevention of disease, primary cure, diagnosis and treatment, rehabilitation and long term care. They are organized and financed under personal, private or public auspices (1).

## Evolution of health care

Till the turn of the 19th century, the western system of health care was being provided for the large numbers of ill persons unable to afford private treatment, by religious or philanthropic institutions or individuals who were motivated primarily to provide relief to the suffering of diseased persons, besides by governments. Knowledge of causes of disease and therapy were rudimentary as per current standards. Institutions were thus established for the poor and needy diseased persons who could not afford personal care for diseases. The stress was on Hospices for providing nursing care and relieving pain and sanatorium for convalescence. Initially, when the exact causes or sites of disease were ill-understood, attention was directed to amelioration of symptoms; i.e. medical care was 'symptom centered'. Later when the pathological changes in organs came to be understood, medical care became 'disease centered'. With the discovery of micro organisms as the cause of the pathological changes in organs and pathogenesis of the diseases, attention came to be fixed on to particular pathogens; first the animate and later, in course of time, the inanimate pathogens. Recognition of the fact that disease results from the interaction between the host and aetiological agent, and that its severity depends upon the reaction of the host as much as upon the quantitative and qualitative invasiveness of the aetiological agent, shifted the attention from disease to the sick person himself. The medical care then became 'patient centered' rather than 'disease centered'. In recent years, it has been appreciated that disease is an outcome of multiple factors favourable to the specific aetiology, to be found in the environment as an outcome of inter-relation between the host, environment and specific aetiology leads to recognition of the necessity of medical care of 'the individual within his community and environment' (2,3).

Disease exhibits what is called the 'iceberg' phenomenon. Ill people who actually seek cure represent only a small portion of the afflicted section of the whole community, like the visible portion of the iceberg. The submerged portion represents the vast section, which, owing to the environmental similarity with that of the overt portion, is vulnerable to the same pathogenic process. Thus apparent disease is a pointer to the existence of the vulnerable section, submerged in the community. Therefore, a study of individuals within the community and environment is important to uncover the submerged portion, along with the socio-economic and environmental factors favouring ill health (4).

Researchers in the field of diagnostics and therapeutics working in different parts of the world but primarily in Europe & America, started providing breakthroughs in the understanding and management of disease. Some of the discoveries were however expensive and the benefits could be availed by few. An appreciation by corporate world, that the diseased persons would be willing to pay for services provided, lead to setting up of hospitals on a corporate basis. The health care provided was of increasingly high quality but at a very high individual cost, beyond the reach of the multitude. Systems of provision of health care through purchasing health insurance by individuals was gradually established in the affluent nations. However, the increasing costs of medical care started becoming unaffordable even by affluent nations. It was gradually realized that preventing the onset of disease could be ensured by bringing about changes in the environment in which man lived and worked. Thus sowing the seeds of the new science of Public Health Care. (5,6 )

Rapid strides were made by nations in Europe and America during the 19th & 20th century in providing public health services to improve the health of its citizens. However, a realisation set in after the First World War and reinforced by events of the Second World War, that nations could not insulate their citizens or communities their members, if poverty and disease continued to flourish in populations, communities or nations in their immediate or even distant neighbourhood. No nation could also consider providing all facilities required to protect its citizens from acquiring diseases unilaterally and cooperation with other nations was necessary. Thus began the internationalization of public health. Developed nations organized themselves into groups for the collective good of their citizens to make concerted efforts to improve the state of health of their citizens. They also started providing aid or donations to those nations who were perceived to be of strategic importance to them in order to assist these nations to

improve their own public health services. In this respect, the league of Nations after the First World War and United Nations after Second World War, and their respective organs like WHO & UNICEF, were the organizations established to provide international cooperation, expertise and assistance to the member states. More and more nations, small or big, specially those which attained "freedom" from their erstwhile colonial masters in the 20th century, also joined these international organizations and provided a truly international spectrum to health care activities. The World Health Organisation (WHO), the health organ of United Nations spearheaded the international health activities and devised various strategies to enable developing countries with poor socio-economic profile, to provide a minimum level of health care to their citizens. "Health for all by year 2000" was the culminating strategy in recent years in this respect.( 7,8,9,10 )

Rapid progress by countries of the world was made on control of communicable diseases with simple and highly effective public health strategies like immunization and environmental sanitation under the umbrella of international institutions with the active collaboration of national governments. Increasing affluence of individuals and communities lead to adoption of certain ways of living, later broadly classified as "lifestyle", associated with this affluence by more and more individuals and communities. The increasing incidence of non-communicable diseases like hypertension, diabetes and coronary heart diseases were thus evidenced specially in these parts of the world. Improved methods of studying diseases through epidemiological methods identified the concept of "lifestyle" as the major aggravating factor causing this "epidemic" even in some not affluent countries which were still struggling to control communicable diseases. A new concept of "primordial prevention" to prevent the emergence of "risk factors" by means of public awareness campaigns to advocate healthy "lifestyle" over a period of decades, specially in the affluent societies and nations, along with vastly improved diagnostic and therapeutic measures have to some extent controlled the mortality, morbidity and disability associated with these diseases. (11,12,13 )

It was also realized that health could not be assured only by the medical fraternity. The relationship between health and economic status is well known. One of the principal impediments to economic development in many of the poorest developing countries is the widespread debility of the population due to extensive malnutrition and chronic impairment. Improvement in standards of living and working, which had many dimensions like education, social empowerment, sustainability of environment, industrialization and many others, were not only inevitably linked to disease but un-separable for the achievement of health and necessitated activities by all concerned for the achievement of "health" by all countries of the world as defined by WHO. The emphasis in the field of health care thus shifted from promising and committing necessary state level actions to provide primary health services for all citizens by member nations of United Nations under the "Health for All" campaign, to commitments by nations to implement as far and as quickly as possible, the expanded and comprehensive "Millennium Development Goals" which were inclusive of all those sectors of government and all organizations private & public who impacted on health. ( 14,15)

The realisation that governmental resources were inadequate to provide all necessary services to its citizens, that certain institutions in the private sector, called "voluntary health agencies" were already providing some of the desired services and the need to harmonize and synergize all actions to meet the determined goals and objectives in the stipulated time frame have lead to better appreciation for a public private partnership for the provision of services aimed at achieving "health" for all citizens of the world. ( 15,16,17)

### Concepts of Health Care

#### Health

WHO has defined health as "a state of complete physical, mental and social well being and not merely the absence of disease". This definition is utopian but can be attempted to be achieved. Control of disease, the causation of disease besides aspects of equality and human rights will need to be addressed to achieve the stated objective of health(18)

#### Public Health

The four major public health strategies for influencing health are preventing disease and promoting health, improving medical care, promoting health enhancing behaviour and controlling the environment. Public health considers medical care to be one means of protecting and improving the health of people. Curative services, however generally receive funding priority over preventive services on the grounds of urgency curative services cater for the immediate felt needs of the clientele while preventive services provide for the future which at times is not understood or appreciated by the clientele (19). Detailed discussion on Public Health have already been made in the "Curtain Raiser" chapter of this book.

#### Comprehensive health care

The concept of comprehensive services to cater for the needs of any human being from his "womb to tomb" was first used in 1946 in the Indian context by the "Report of the Health Survey and Development Committee" popularly known as "Bhore Committee" which assessed the health conditions and health institutions existing in British India. The recommendations of this document, available to India on achieving freedom, were loftily accepted as the benchmark for planning norms of public health but have been unable to be fully implemented even till date. This has been mainly due to the population growth outstripping the infrastructure provisions during successive five year plans of the government. (20)

#### Basic health services

In 1965, WHO UNICEF defined basic health service as a network of coordinated, peripheral and intermediate health units capable of performing effectively a selected group of functions essential to the health of an area and

assuring the availability of competent professional and auxiliary personnel to perform these functions. (21)

### Primary health care

In order to provide a minimum essential level of health care to the vast populations living in developing countries by their governments, appropriate technology was recommended to be utilised along with community participation to be provided to all the citizens. The concept of primary health care emanated from an important WHO conference held at Alma Ata ( USSR) in 1978. Primary health care is essential health care made universally accessible to all individuals and acceptable to them, through their full participation and at a cost the country can afford. (22,23)

### "Health for All by year 2000"

This slogan coined during the Alma Ata conference of WHO was coined to ensure achievement of an acceptable level of health throughout the world in the foreseeable future. It did not mean that all citizens of the world would be healthy but that they would have access to primary health care. It was aimed to achieve the stated goal by using the primary health care approach. Countries have committed resources to provide primary health care. However access to such services has remained a problem due to various operational and other factors. (15,24)

### Millennium Developmental Goals

A review of the state of health of the world population and affluence or lack of it resulted in world leaders adopting the United Nations Millennium Declaration in 2000, which committed them to pursue policies to ensure the development of their people and poverty eradication. These are now popularly referred to as the "Millennium Development Goals" and cater for aspects of poverty alleviation, overcoming illiteracy, provision of gender equality, providing access to clean water and reversing activities leading to environment degradation besides health related matters like reduction of maternal and child morbidity and mortality and control of communicable diseases. (25,26)

## Health Care in India

India under British rule had not reaped the benefits of industrialization which had affected positively the living standards of citizens of the ruling nation, enriched by raw materials forcibly taken away at very cheap rates from India and other colonies. Measures to provide health care in India were restricted to soldiers of the British army and civilians residing in and around the areas occupied by the ruling elite. It was only towards the end of British rule that concern for the common man was voiced by successive committees and commissions enquiring into the state of health of Indians. India became a free country in 1947 with a democratically elected government and adopted the constitution to become a Republic in 1950. The political leadership of this nascent democracy was fired with a zeal to provide radical change in the shortest possible time to the oppressed, impoverished, illiterate people lacking the basic amenities conducive to health. They chose a socialistic system of government to achieve these lofty ideals and copied from USSR to "plan" development activities with the meager resources available. To provide employment, food and other amenities, the route of planned industrialization through establishment of public sector industries and a command economy were visualized. The planning system was drawn up by the Planning Commission headed by the Prime Minister. Planning was for a period of 5 years commensurate possibly with the tenure of democratically elected governments. Stress on health sector was planned in consonance with the projections of health infrastructure made by the Bhore Committee and the realisation of need to attain population stabilization. India consciously chose to provide a system of socialized medicine which entailed upon the government to provide free health care services to all citizens. Health was placed on the "concurrent" list of subjects in the constitution with the basic responsibility resting with respective state governments to provide health care facilities. The role of the central government was to guide, coordinate and facilitate the activities of state governments and interact with international agencies in this respect. (21, 27, 28 )

However, the path to provision of an improved health care was adversely influenced by the need to finance the process of national integration, three major wars with our neighbours, the ever increasing needs of a burgeoning population, fledgling industry and over dependence on agriculture which had been rendered inefficient by persistent lack of modern inputs and strategies besides going through phase of land reforms. An impoverished yet proud nation hesitated to seek assistance from affluent nations from whose influence the nation had recently unshackled itself because this would have implied political aligning with these countries. Many methods, strategies and concepts were propagated by these countries as solutions to the ills of countries like India, based on their limited experiences. Some of India's academicians, technocrats and administrators who were deputed for training at institutions in developed countries on scholarships, fellowships, etc in fields of health and health related aspects received training on these aspects but attempts to replicate western models in India blindly, usually failed as they were not suitable to our needs.

However, the progress of the country in achieving for its citizens improvements in the sphere of health since attaining Independence though slow, has certainly been positive even though not as impressive as would have been hoped by the founding fathers. Indians on an average today, live better, eat more and nutritiously, have better chance of surviving to old age( life expectancy at birth increasing from 37 years in 1951 to 62 in 2001) and even poorly performing indicators of health like maternal mortality and infant mortality ( halved from 146 per 1000 live births in 1951 to 40 in 2004 ) have certainly shown a significant improvement. (29,30)

As a growing economy, India is fast learning to understand and address its problems. The Planning Commission in its approach paper to the 11$^{th}$ plan 2007-2012 has identified the need for a faster and inclusive growth. In this aim for all round development,

programmes like Sarva Shiksha Abhiyan and Rural Health Mission, which have been focused mainly on rural India, have been highlighted to provide the desired results by providing improved access and availability of quality health care, sanitation and nutrition (31) .

## Medical Care Of Armed Forces Personnel

In the Armed forces integration is inherent in its organization and administration of medical care is necessarily comprehensive. Services have no control over the individuals' heredity, intra-uterine life, prenatal hazards and life upto the age of recruitment. At the time of recruitment, however, a selection choice is available when persons with apparent or latent but detectable hereditary or acquired defects are eliminated. A medically suitable, probably a little undernourished but potentially sound bodied person, capable of being moulded into a fit serviceman, with adequate reserve against stress and strain of service, can thus be selected. The further responsibility of building up his health is that of the Armed Forces. In the process the recruit has to surrender some of his individual characteristics nurtured by parents and community from his very birth and assimilate certain unfamiliar new characteristics required for leading a close community life under regimentation, various disciplinary restrictions, and quite often, very strenuous, hazardous and emotionally stress producing life conditions. In order to enable him to withstand the metamorphosis from a civilian individual to a physically, mentally, emotionally and socially fit soldier, and thereafter to maintain his qualities at a high standard of fitness, the care of serviceman is well planned.

### Organization

In the Armed Forces "HEALTH" embraces all aspects which prevents disease and promotes physical, mental, and fighting fitness amongst all ranks and ensures their welfare and high morale. The important means to achieve positive health are provision of adequate and healthy accommodation, food and feeding arrangements, water and milk supplies, living and working conditions, clothing, environmental control and sanitation, personal care and health education of troops. Health and well being of personnel is the responsibility of the commanders. Medical services advise the commanders at all levels on all matters concerning health care and carry out treatment of ailments upto their rehabilitation. The Director General Armed Forces Medical Services (DGAFMS) is the head of Armed Forces Medical Services, and is responsible to the Ministry of Defence for overall medical need of the Armed Forces. The Director Generals of Medical Services (DGsMS) of Army, Navy and Air Force are the medical advisers to the respective Chiefs of Staff of the Army, Navy and Air force and are responsible for the day to day administration and proper functioning of the medical services under their control. The DGAFMS is kept informed of all general policies, decisions and directives issued by the three service headquarters (HQ). He is kept informed by the DGsMS regarding the planning of hospitals & research developments. A representative of DGAFMS attends all meetings and discussions where matters of medical policies and planning are under consideration by the three services. The important aspects of organization, charter of duties and functions of the armed forces medical services are enumerated in the Regulations for the Armed Forces Medical Services (RMSAF). **(32)**

In addition to provision of basic preventive, promotive and curative services, various National Health Programmes are also adopted in the Armed Forces in close coordination with the Central and State Health Services. The medical organization at the respective Service Headquarters coordinates all the personal care requirements, which include :

(a) Health care of troops and their families.
(b) Provisions of medical treatment and remedial regime.
(c) Advising on accommodation, nutrition, food, milk and water supply in Armed Forces.
(d) Health education of troops.
(e) Environmental control.
(f) Research on health and medical care, including matters affecting morale, fighting and functional efficiency of Forces.
(g) Health statistics.
(h) Medical categorization.
(j) Pathology services.
(k) Scrutiny of fatal case documents.
(l) Training of medical officers and paramedical personnel.

The various institutions involved in the planning, coordination and administration of the armed forces medical services include office of DGAFMS, Medical Services Advisory Committee and Armed Forces Medical Research Committee. Armed forces provide comprehensive health care in a three tiered format with single medical officer - Regimental medical officer (RMO) or a medical officer from the affiliated medical unit, designated as authorized medical attendant (AMA), providing primary health care at the unit level ; cases needing hospitalization or specialist attendance are referred to a field ambulance from an operational army area or to a peripheral or sub-zonal hospital in peace areas where secondary care can be provided. In case of necessity of highly skilled care, patients are referred to tertiary care centres located at zonal or command hospitals either through the intermediate channel of evacuation or even directly. The aspects of public health care are administered mainly through Station or Field Health Organisation ( SHO / FHO) who also coordinate provision of health care of the families of serving personnel through Maternal and Child Health (MCH) services and School health services. Ex-servicemen and their families are provided medical care through Ex-servicemen Contributory Health Services (ECHS) and also through military hospitals restricted to facilities locally available.

### Medical Services Advisory Committee

Medical Services Advisory Committee (MSAC), which consists of DGAFMS as the Chairman & the three DGsMS as members, is the highest policy making body as far as medical services are concerned. It deals with and decides all matters which have an inter services bearing. The proceedings of the Committee are approved by the Chiefs of Staff committee. The DGAFMS has therefore a dual role. In inter service matters, the chairman, MSAC is responsible to Chiefs of Staff Committee. In other aspects of his duties he is directly responsible to Ministry of Defence. Some of the important matters which are referred to MSAC for decision are :

(a) Initial training of AMC officers at Army Medical corps Centre & School.

(b) Specialist training & specialist pool, selection of officers for courses in India and abroad, study leave, grading/classification, appointment of advisors and consultants.

(c) Policy regarding ante-date of commission

(d) Policy regarding inter service transfer/attachment of officers and their deputation to other medical institutions.

(e) Recommendation for the appointment of honorary surgeons to the President and the grant of honorary commissions to civilian medical practitioners.

(f) Selection of officers to fill up appointments in the inter service organisations such as Armed Forces Medical Stores Depots (AFMSDs). However, the administration of AFMC is the sole responsibility of DGAFMS.

(g) Preparations and maintenance of regulations.

(h) Any other matter having inter service bearing.

**Armed Forces Medical Research Committee**

Armed Forces Medical Research Committee (AFMRC) was constituted under the Defence Research & Development Council in November 1963 with DGAFMS as chairman. The three DGsMS, DGHS (AF), Senior Consultants Medicine & Surgery, Scientific Adviser to Ministry of Defence, Commandant AFMC and other co-opted members or nominated representatives from ICMR, DRDO organisations etc. are members. Additional DGAFMS ( Medical Research ) is member secretary of AFMRC. In this connection, collaboration is maintained with the following organisations controlling health related activities in the country :

(a) Indian Council of Medical Research (ICMR)

(b) Council of Scientific and Industrial Research (CSIR)

(c) Medical Council of India.

(d) Directorate General Health Services.

(e) Planning Commission

(f) Indian standards Institute

The terms of reference of AFMRC are as follows :

(a) The Armed Forces Research Committee is under the Defence Research & Development Council & functions under its general authority & guidance.

(b) All medical research problems, before being taken up for investigations, are submitted to the Armed Forces Medical Research Committee which makes recommendations regarding the choice of problems and allotment there of to institutions for progress of research. Decisions on such recommendations are taken by or under the authority of the Defence Research and Development Council.

(c) The Armed Forces Medical Research Committee is responsible to over see the progress of medical research authorised by the Defence Council & such recommendations from time to time as may be necessary for the consideration of the Defence Research Development Council.

**Functions of DGAFMS**

The DGAFMS functions directly under the Ministry of Defence for the following :

(a) Convenor as well as the chairman of the boards for recruitment of medical, dental and nursing officers for three services of the Armed Forces.

(b) Terms and conditions of service of all categories of officers (medical, dental and nursing).

(c) Release, recall, invalidment, retirement, pension & gratuities of all categories.

(d) Reserve of officers for the three services.

(e) Maintenance of personal documents of Medical, Dental and Nursing officers. He records his remarks on the technical and professional capability of all officers of the rank of Colonels and above ( and equivalent rank in other services).

(f) Provisioning, procurement, storing including reserve, and issue of medical and dental equipment and stores as required by the three services.

(g) Standardization and development of medical, dental and non-medical equipment with a view to their inclusion in equipment tables.

(h) Arrange trials of stores and equipment in hospital and other units; convening equipment and scales panel committee meetings, preparations of medical scales and equipment tables publication of PVMS.

(j) Control and Supervision of AFMSDs and Artificial Limb Centre (ALC).

(k) Administration of AFMC and other research and training establishments attached to the institution. The Institute of Aviation Medicine will, however, be under direct control of DGMS(Air Force).

(l) Selection and appointments of instructional staff for above institution from the panels of the suitable names submitted by DGsMS.

(m) Inter service attachment or transfer of medical officers to meet the requirement of each service from the panels of names given by the DGsMS.

(n) Coordination, planning, directions and developments of research work carried out in AFMC and the institutions under the control of three services headquarters. The DGAFMS is be the Chairman of the Armed Forces Medical Research Committee and is guided by the direction given by the research & development council.

(o) Coordination of statistical works in the three services & compilation of annual reports including Annual Health Report of the Armed Forces.

(p) Recording recommendation on purely medical aspect of the cases for claims for disability pension for service personnel.

(q) Issue of technical & medical instructions on matters concerning three services.

(r) Rendering technical & medical guidance to Director General Ordanance Factories.

(s) Liaison with the Director General Health Services, the Defence medical organisations of foreign countries and the research institutions in India and abroad.

(t) DGAFMS is the Chairman for Selection Board for promotion of AMC, AD Corps and MNS to the rank Colonel & equivalent rank in the Navy & Air Force. He is member of Selection Board for promotion to the rank of Brigadier & above (equivalent rank in other services,) including the appointment of DGsMS in three services.

**Nutrition of Troops**

Nutrition is an important means of promotion and maintenance of health. However, its total organization is not the direct responsibility of the Medical Services. Ration scales are drawn up or amended by the respective service HQs in consultation with their Medical Directorates. Policy matters regarding ration scales are dealt with on an inter-services basis by the Armed Forces Health Sub Committee (AFHSC) of the Medical Services Advisory Committee (MSAC).

Research in food and food technology is usually carried out by the Defense Research Organization, routine inspection of food stuffs is carried out by Food Inspection Organization functioning under the Director General Supplies and Transport (S&T Directorate, Army HQ). A senior medical officer of the Army Medical Corps, a specialist in Preventive and Social Medicine is the head of the food inspectorate and is designed as the 'Deputy Director General Food Inspection' (DDGFI). He acts as the medical adviser in respect of assessment of nutritional values of food, and serves as the link between the Army Service Corps (ASC) and office of DGMS(Army) at the Army HQ. The DGsMS are consulted regarding nutritional aspect of the ration scales and foodstuffs included in them. The respective technical staff officers viz. Dir MS(H) for Army, Director (H) for Navy and Director (H) for Air Force, act as advisers to their DGsMS on these matters. DGAFMS is consulted on any matter regarding nutrition, ration or foodstuff problem common to all the three services. He may also order any research to be carried out on these matters through ADGAFMS(MR), R&D Organization and DGsMS.

**Health Statistics**

All statistical work pertaining to hospital based data in the Army for recording compilation and interpretation of medical data related to morbidity and mortality is carried out by the 'Management Information System Organization (MISO)' under the General Service (GS) Branch of Army Headquarters. One AMC officer, a specialist in Preventive and Social Medicine, oversees all the aspects pertaining to patient related data. These data are generated from the formatted reports received from hospital and other medical units concerned with patient care and after compilation, tabulation and analysis are provided to DGMS(Army). Computerisation of system of reporting has assisted in faster data management, analysis and feedback to the environment in the recent past. In the Navy and Air Force this task is done at their Medical Directorates. The Central Diseases Registry (CDR) is functioning in the Department of Community Medicine (PSM) of Armed Forces Medical College (AFMC). At present, it maintains records of all HIV/AIDS cases and cases of High Altitude Pulmonary Oedema. More diseases can be brought under registry/surveillance as per requirement of DGAFMS.

**Medical Boards and Fatal Documents**

Medical categorization( including invalidation) and scrutiny of the fatal case documents are important activities of the technical administration of health services. These functions are carried out by the medical staff posted at various HQs in the chain of command of the three services. The medical categorization ensures that a person with a disease or disability is kept under surveillance, there is continuity of remedial measures and provision of sheltered employment conditions away from possible hazards, which may aggravate the disease or disability. It also ensures that the task or work does not suffer due to the handicap of the performer.

Invalidation out of service of an unfit person, ensures primarily the fitness for combat and other duties of the armed forces personnel by eliminating the unfits or misfits and secondarily avoids the exposure of the disabled to the aggravating hazards associated with service conditions.

Scrutiny of the fatal case documents is a form of medical audit which brings out the lacunae in the comprehensiveness of health care, deficiencies in the curative regimes or even the restorative care. In these activities the specialists( including senior specialists like advisers and consultants) and senior administrative medical officers play a vital role. Corrective actions wherever required including professional counseling to the treating doctors or administrative officers are initiated by the appropriate medical administrative authorities.

**Pathology Services**

The Armed forces Pathology Services carry out all the clinical pathological examinations including biopsy examination of tissues, special diagnostic skin tests,

autopsies and histopathological examinations both for diagnostic and medico-legal purposes, public health examinations such as examinations of water and milk supplies and wall scrapings or samples for insecticides. Additional DGMS(H, PS & IT) at the Army HQs is adviser to the DGMS on aspects of Health, Hospital services and pathology services. At the peripheral levels there are hospital laboratories of varying capabilities depending on the size of the hospital where they are located. In addition to these, there are Departments of Pathology, Microbiology and Biochemistry at AFMC which are responsible for academic and research activities besides provision of pathology services to dependent clientele.

**Health Services**

Army

DGMS (Army )is responsible for all matters regarding health of the troops and their families to the Chief of Army Staff. The health services in the Army are the responsibility of the Addl DGMS (H, PS & IT) at the Army Headquarters. He is the head of the professional or technical section of Medical Directorate and is responsible for advising the DGMS on the health of the troops, the promotion and maintenance of positive health and prevention of illness. Addl DGMS (H, PS & IT) has two specialists, Director MS (PS) and Director MS (H) on his staff to assist him. The Senior Advisers in various specialities are available for consultation on matters pertaining to their respective specialities. All matters regarding health of troops, accommodation, clothing, nutrition, comprehensive medical care, control of communicable and some non-communicable diseases, pathology services, scrutiny of fatal case documents, medical examination and medical boards, entitlements of military and civilian personnel to medical care from Army sources and research, in fact all professional matters are dealt with by this section of the Medical Directorate. At the Command and Corps level the specialist in PSM, designated as Assistant Director of Health (ADH) and at the Area and Divisional level as Deputy Assistant Director of Health (DADH) are responsible to their administrative medical heads for all the duties of this section. Health activities are coordinated and executed by SHO / FHO as well as by Senior Executive Medical Officer (SEMO) where SHO / FHO are not available. The responsibilities in operational areas & peace areas are slightly different as follows :

**Field / Operational Areas**

In the operational areas, Deputy Director Medical Services (DDMS) of a Corps and Assistant Director Medical Services (ADMS) of a Division are responsible to their respective commanders for the medical administration and to the Major General(Medical ) of the Command for all medical, technical and administrative matters. Commanding Officer (CO) Field Ambulances (fd amb) works under the overall supervision, guidance and administrative command of the ADMS who is the 'Commander' of all medical units in the field formation. Conventionally each Division has two fd ambs. Each of these fd ambs are asked to provide medical and health cover, including establishing of Advanced Dressing Stations (ADSs) and Forward Surgical Centres (FSCs) to earmarked brigades / divisional troop units within the Division. The CO of the Fd Amb providing medical care to the respective Bde/ Div Tps unit is also designated as the SMO of that particular Bde/ Div Tps unit for all health related activities.

**Peace Areas**

In each large garrison station there is a hospital (Army, Navy or Air Force). Generally CO of the miltary hospital is the SEMO. (This concept does not exist in Navy & Air Force).However the DDMS/ADMS is empowered to nominate any medical officer to perform the duties of SEMO of a part or the whole of the military station. The SEMO is responsible to advise the local station Commander on all matters regarding health and sickness among troops and their families in the garrison or station and is the head of all the local medical establishments. He is also the Health Officer of the Cantonment and adviser to the Cantonment Board on all health matters. OC SHO, a specialist in PSM, assists in the comprehensive health care of troops and their families in station and in the Cantonment area. SEMO is responsible for all the local medical administrative and technical matters to the DDMS of the “Area HQ” and for administration of the hospital to the local Commander. AO 165/79 may be referred for detailed account of duties and responsibilities of various administrative and health authorities in relation to health of troops and their families.(33)

Navy

The Director Medical Services (Health) at the Naval HQ is responsible to the DGMS (Navy) on all matters concerning the Health of Naval personnel. DGMS (Navy) is responsible to Chief of Naval Staff (CNS) on all matters pertaining to health. At the Command level, the Command Medical Officer (CMO) is responsible to the Flag Officer Commanding in Chief (FOC-in-C) on matters pertaining to preventive, promotive and curative aspects of health care. He is assisted by the Staff Officer - Health (SO(H)) in exercising control and coordination of health related activities of ships /establishments in the area of responsibility. The Principal Medical Officer (PMO) of the ship / establishment (besides being the equivalent of RMO in the case of ships /establishments posted only single MO ) is the adviser to the Commanding Officer on all matters pertaining to health, hygiene and sanitation. Naval shore establishments have SHOs of varying size depending on the work load, similar in organization and function, to those in the Army. The SHO is responsible for ALL health promotional and hygiene activities in a station. They also provide pest control services to the ships of the fleet when located at a port station.

Air Force

The Director Medical Services (Health) at the Air HQ is the adviser to the DGMS (Air) on all matters affecting the health of air force personnel. DGMS (Air) in turn is responsible for the same to the Chief of Air Staff (CAS). Principal Medical Officers (PMOs) of all the Operation, Training and Maintenance Commands are similarly responsible to their own Air Officer Commanding in Chief

(AOC-in-C) and also to DGMS (Air). They are assisted by Deputy PMOs who are specialists in Preventive Medicine or Aviation Medicine. Operational Commands have both these specialists while other commands have either of them. There is a SHO of varying capability ( large, medium or small ) at all permanent IAF Stations. These organizations work directly under the supervision of the SMO or MO of the Stations. In large stations a specialist in PSM is in charge of this unit. The SHOs in other stations are functioned by medical personnel below officer rank (PBOR), who are trained in health and sanitation, under the overall command of SMO/MO of the station.

**Station Health Organization**

The Station Health Organisation (SHO) is a unit responsible for coordination and provision of public health services to the units located in the military station where they are located. Station Health Organisation (Large) is authorised at selected military stations based on garrison strength or on medical operational requirement. The erstwhile Station Health Organisation medium, small and unclassified authorised to smaller military stations have been merged with the local hospital with a view to reduce costs but their function is as before with direct control by CO of the hospital in his role as SEMO. They now function as the Health Section of the hospital. SHOs are responsible for the maintenance of healthy conditions of environmental sanitation, vector control including anti-malaria measures and disease prevention and control in the station. The OC of SHO (Large) is a classified or graded specialist in PSM who also functions as the Assistant Health Officer (AHO) of the Cantonment, when so formally appointed by the Command HQ. He is responsible to the Health Officer for the health of civilians and sanitation within the cantonment and to the SEMO for the health and sanitation within the Armed Forces lodger units and establishments in the garrison station. The OC SHO works in close collaboration with the Cantonment Board Authorities.

Functions of the OC SHO

The functions of the OC SHO are comprehensive and include inspectorial, advisorial, administrative and executive aspects of health care delivery. The detailed description is available in RMSAF & Army Order 165 / 79 which may be referred to. An outline description is as follows :

(a) OC SHO has four-fold functions to perform and his time is proportionately divided into the duties required of him to fulfill these. For all these four-fold functions he is responsible to the SEMO in station. In order to carry out these functions properly, the OC SHO is required to keep a close liaison with local civil health authorities and is also required to participate in all the National/local health programs that are carried out under their auspices.

(b) As AHO of the Cantonment, his duties are concerned with maintenance of health of civilian population with the main objective of keeping in check all the influences which might jeopardize the health of troops garrisoned in and around the cantonment and embrace the environmental sanitation; quality control of food, milk, water supply, disposal of sewage, sullage, refuse and industrial waste; control of communicable diseases; supervision of health of workers employed under the cantonment board; execution of health programmes as directed from time to time; licensing of catering establishments and market including hawkers; enforcement of cantonment regulations regarding abatement of public nuisance and environmental insanitation in commercial, industrial, residential and trade districts. On all these matters he is expected to render a monthly report for deliberation of the Cantonment Board of which the Health Officer (SEMO) is an important member.

(c) As MO in charge of the Cantonment General Hospital (CGH) he works under the administrative jurisdiction of the Cantonment Board. This hospital is intended to diagnose and treat the civilians in the Cantonment and serves as a 'pulse' of the health of the civil population. In order to extend the medical facilities and also get a better picture of the health, there may be established some outpost dispensaries or health centers. As a part of the professional supervision of the CGH the MO in charge is also responsible for general organization and administration of the hospital and execution of all instructions regarding the establishment, equipment and functioning of the hospital and has to make the annual budget of the hospital. The staff of the hospital is responsible to him for their duties, general conduct of professional work and holding charge of the equipment. Some of the cantonment hospitals have vastly extended their scope and provide much more specialized facilities.

(d) As SEMO's adviser on all matters regarding health of the troops, it is his responsibility to have a first hand knowledge of influences which might adversely affect the health of troops in station so that the SEMO is in a position to appropriately advise the OC Station, who is also the Chairman of the Cantonment Board. For fulfillment of this function, his duties include :

(i) Regular inspection of the garrison and unit lines;

(ii) Control and prevention of communicable diseases among troops.

(iii) To ensure proper execution of anti-malaria, anti-rodent and anti-fly measures.

(iv) To ensure safe water and milk supply; disposal of sewage and waste matters.

(v) Inspection of licensed catering establishments for permitting them to be put 'In bounds' for troops, and also periodical inspection to keep them on the approved list.

(vi) To maintain, interpret and report the vital and health statistics in respect of troops in the garrison.

(e) He is also to inspect the schools established for the children of service personnel.

(f) The OC SHO should carry out surveys on ailments found to be locally prevalent among troops, families or civilians in the cantonment, and garrison or neighbouring areas and submit them through the SEMO to higher medical authorities

(g) As OC of the unit, he is responsible for its administration and supervision of the work of the staff.

(h) As the permanent secretary of Station Health Committee he is required to correlate all the information available to him from the four-fold functions described above. The information is then presented comprehensively to the Station Health Committee, the inferences relevant to the health and well being of the troops are drawn and action to safeguard them against untoward influences are recommended. The committee consists of the Station Commander as the Chairman and OsC units in the station as members. The Garrison Engineer or his representative, the Supply Officer or his representative and the Cantonment Executive Officer are the co-opted members of this committee. The representative of local civil health authorities are also invited to attend the meeting. The Committee meets once a quarter or more often to discuss relevant health matters. The OsC units are then required to carry out the decisions taken at the committee meeting. The records are maintained and action pursued by the OC Station Health Organization in his capacity as the secretary of the Committee.

**Health Organization in Field Formation**

(a) DDMS Corps has an ADH as his adviser and assistant in all matters of health of troops in the formation and the lower formations. A FHO and Fd Amb are allotted to Corps HQ. Field Health Organisation (FHO) with all combatant manpower, is authorized for a Corps, to provide hygiene services along the line of march. During peace time they provide similar services as an SHO in certain stations where they are located. The role of FHO and health section of Fd Amb is to reinforce the existing sanitary resources in the field formations or its part deployed under such conditions, which threaten outbreaks of communicable diseases. The decision to deploy these units or their part in various location or formations is left to the DDMS Corps as advised by his ADH. He coordinates the matters on health of troops in the whole formation and its component formations.

(b) In a Division, the DADH advises and assists the ADMS at the Divisional HQ. The health section of a Fd Amb in a division provides the technical element consisting of two health assistant of rank of JCO / NCO. These personnel monitor the environmental aspects specially quality of water and vector control activities by units in their respective area of responsibility. They also assist the DADH in organizing health promotion activities. Normally, their requirements at particular places, sub-formations or units is assessed by the DADH, and decided upon by the ADMS. The Fd Amb is instructed to locate these personnel according to requirements. The detailed charter of their activities are as follows :

(i) Supervisory and Inspectorial

- Environmental sanitation measures in and around the units/sub-units, such as disposal of waste matter and pest control measures particularly against mosquitoes, house flies, bedbugs, mites, ticks and rats.
- Purification, chlorination, storage and distribution of water supply.
- Ration supplies, fresh, dry and tinned for their wholesomeness.
- Sanitary vigilance in civil areas around camps in collaboration with the local health authorites.
- Control measures against communicable diseases.

(ii) Instructional

- Assist DADH/SMO in conducting health courses for Regimental Officers, JCOs, NCOs and OR

(iii) Executive

- Technical assistance to rectify sanitary defects in the unit lines.
- Carry out disinfection and disinfestation whenever required.
- Periodic collection and dispatch of water, milk and food samples as and when required to laboratories for examination. This should also be done while establishing new water points.
- Assist DADH in collection of statistical data on health of troops by maintaining records and preparing periodical reports and returns.
- Help units in conduct of control measures in case of outbreak of communicable diseases, and high incidence of other preventable diseases.
- Assist units in implementation of national health Programs in the formation.
- Help DADH in carrying out investigations / health surveys when required.

**Unit Health Establishment**

The responsibility of maintaining hygiene and sanitation

in the unit and health of troops rests with CO of the unit with expert advice and assistance of the RMO. The principal means of preventing diseases are the maintenance of effective sanitation and personal care and hygiene. Therefore, knowledge of elementary hygiene, sanitation and the best means of preserving them are incumbent on all ranks. The unit health establishment enabling the OC to carry out his responsibilities for maintaining the effective fighting strength consists of the RMO, the unit hygiene officer, the unit hygiene and sanitation squad, and the medical section (consisting of dual tasked band personnel /stretcher bearers in infantry / mechanized infantry units ), AMC nursing assistants manning the MI Rooms/RAP and Battle Field Nursing Assistants (BFNAs) who are personnel of the unit trained in first aid duties. In a regimental training centre depending on its strength, there may be two or more RMOs, of who one can be graded/ classified specialist in Preventive and Social Medicine.

Duties of Unit Hygiene and Sanitation Squad (34)

In army units, a unit hygiene and sanitation squad is required to provide hygiene and sanitary activities in the unit area as per Army order 25 / 2004 /DGMS. A regimental officer is detailed by name to act as Hygiene and Sanitation Officer of the unit. The unit hygiene officer is mainly required to carry out the duties concerning maintenance of environmental sanitation, personal hygiene of all ranks and hygiene of cookhouses, dining halls and messes in the unit. He should be properly trained for these duties under local arrangements by the SEMO/SMO. He is also responsible to ensure that all the unit health documents, other than those that are to be maintained by RMO are upto date. A unit hygiene and sanitation squad consisting of 4 NCOs and 6 OR ( for major units) and 2 NCOs and 3 OR ( for minor unit) with 100% reserve are required to be trained by the RMO / under the arrangement of SEMO to carry out out the sanitary duties in a unit. The duties of the unit hygiene and sanitation squad are as under :

(a) Supervision of the sanitation of cookhouses, wet canteens, aerated water factory including proper disposal of waste products.

(b) Spraying of insecticides within unit lines.

(c) All anti-mosquito, anti-fly measures and anti-rat duties

(d) Supervision of personal anti-malaria measures.

(e) Acting as sanitary police to ensure general cleanliness and disinfection.

(f) Daily supervision of the water supply and its purification for drinking purposes.

(g) The care of all apparatus and stores connected with water supply of the unit

(h) Chlorination or superchlorination and testing for chlorine contents.

## Regimental Medical Officer (RMO)

He is the first medical officer in the chain of medical echelons through which a patient is passed from the time of contracting illness or sustaining injury. In order to perform his duties effectively, the RMO will have to be always abreast in his professional knowledge besides being conversant with rules, regulations, orders and instructions regarding all health matters and be able to apply his professional and administrative acumen for the attainment of optimal health of the troops who are placed under his care. As a practitioner of preventive and social medicine, he is required to perform the duties as laid down in RMSAF para 103 to 116 and AO 165/79. The unit MI Room functions as a miniature health center for the unit. All medical officers nominated by the SEMO / SMO to be in medical charge of units without RMOs (AMA) will also perform all these duties. These are briefly as under :

(a) He will be in medical charge of all personnel of the unit and the families entitled for medical attendance. He will advise the OC unit on all sanitary and medical matters pertaining to health of the troops.

(b) He will conduct morning sick parade at the MI Room/RAP at an hour fixed in consultation with OC unit and SEMO. Usually the sick parade is held at the time of the first duty parade of the day viz. physical training He should treat minor ailments in the MI Room and refer other cases to hospital for admission/investigation/consultation by specialists. He enters on "sick report book"- AFMSF -44 prepared in duplicate by the unit, the diagnosis of each case reporting sick, and the disposal of the case in the column of remarks in the following terms :

(i) Medicine and duty' (M&D) meaning treatment and return to duty.

(ii) Attend 'A' meaning attend for treatment as ordered and to perform ordinary regimental duties.

(iii) Attend 'B' meaning attend for treatment as ordered and to perform light duties only.

(iv) Attend 'C' meaning attend for treatment and to be excused all duties.

(v) 'Hospital' meaning admitted to hospital.

(vi) 'Duty' meaning reported sick unnecessarily without enough cause.

(c) He will carry out a detailed annual medical examination of all JCOs and OR and keep a record thereof in accordance with AO 3/ 2001.(35)

(d) He will carry out quarterly medical examination of all low medical category personnel and monthly medical inspection of all food handlers and keep a record of such examination.

(e) He will examine all men going out on Posting/Course and all men returning to the unit from temporary duty course, leave and hospital

(F) He will visit unit-run schools and carry out examination of school children and hygiene inspection of school premises.

(g) He will impart health education to the troops given regularly and repeatedly throughout the year. Unit

cinemas whenever available should display health education slides. Notice boards in unit lines should display salient features about major diseases and their preventive measures.

(h) He will arrange with CO of unit, training of requisite number of men in first aid, hygiene sanitation, water and anti-mosquito duties.

(j) He will be responsible for carrying out all preventive inoculations and vaccinations of all ranks, civilian employees and families under his charge.

(k) He will inspect every portion of the unit line including family quarters, cook houses, JCOs Mess, Officers Mess, clubs, institutes and civilian quarters within unit lines and report in writing of the defects to CO with remedial measures and suggestions. These will be recorded in a sanitary diary once a month.

(l) He should examine all families within three days of their arrival in station and ensure their immunization is completed and any disease/defect is attended to.

(m) He should execute all health programmes, surveys and studies as per national or regional health programmes or as per directions of medical authorities at local or higher armed forces headquarters and render reports as required.

(n) He should ensure that medical stores and equipments for RAP authorized vide RME scale, 37/64 as amended, are in perfect working order and should be checked once a month for any shortages, discrepancies or defects. He should ensure that replacement is demanded promptly from the medical units on which dependent. Equipment and material required for MI Room but not ordinarily authorized may be obtained on loan and kept in the MI Room. Outfit First Aid on sliding scale on authorized number of vehicle vide Medical Scale, IAF (M) 37/68 as amended, should be maintained.

(o) Ordnance stores authorized as per WET, medical comforts for patients as per Standard Ration Scales (SRS) and stationery articles from the unit should be obtained regularly.

(p) He should maintain an emergency cupboard for prompt attention of the emergencies on the lines laid down for Hospital MI Room in accordance with MAI 25/63.

(q) He should maintain the following registers in the unit :

(i) Barrack treatments, admission and discharge register

(ii) Infectious Disease Notification Register.

(iii) Malaria Register.

(iv) Register of water tested for free chlorine,

(v) Low medical category personnel register,

(vi) Record of health education lectures.

(vii) Record of eligible couples.

(r) He will advise the unit to maintain following records/registers according to existing orders :

(i) STD Register

(ii) Inoculation and Vaccination Register.

(iii) Yearly Medical Inspection Register.

(iv) Insecticide Spray Records.

(v) Sanitary Diary.

(vi) Blood Donors Panel Register

(vii) Register showing nominal roll of all ranks trained in hygiene and sanitation and water duties.

(s) He will maintain health records and charts, graphs or histograms of daily sickness, hospital admissions and incidence of infectious diseases.

(t) He will submit reports and returns to SEMO on health of the troops as required. Any case of infectious disease or unusual sickness is to be reported to SEMO without delay.

(u) With the concurrence of the CO unit he may be called upon to :

(i) Work in local military hospitals as and when required by the SEMO/ADMS to enable him to remain in touch with clinical procedures and hospital practice.

(ii) Visit the patients sent in for admission by him to follow up their diagnosis, treatment, progress and disposal;

(iii) Attend clinical meetings/ discussions and other professional training arranged by the SEMO.

**Summary of Duties of RMO**

- Advise CO on all health matters
- Immunisation
- Medical attendance of patients
- Supervise med, ord and other stores of RAP
- Med exam annual, food handlers, others
- Med exam of families
- Health education
- Maintain Records unit & MI Room
- Monthly Sanitary Round
- Other duties assigned CO /SEMO

## Health Education

Besides providing curative services as far as is possible within the constraints at the periphery, the medical officers (RMO / AMA) are principally concerned with

provision of preventive & promotive activities aimed at ensuring maintenance of good health by the troops and their families living with them in the military stations. The aspects of provision of health education to all ranks and their families, provision of maternal and child health care including family planning services, immunization and school health care services need to be appreciated by all personnel involved in the provision of health services.

It must be emphasized that personal habits contribute to the achievement of positive health, morale and well being and also reduce vulnerability to disease, both communicable and non-communicable. When men live in a closed community life they need to be more particular in practicing healthy habits to protect themselves and the community in which they live. Provided all the facilities to live healthy are offered, personal care demands active cooperation and action by the individuals themselves. This depends upon their will, efforts and education. Therefore, rationalization of his life pattern by health education is needed.

Health education as defined by National Conference of Preventive Medicine in USA is “a process that informs, motivates and helps people to adopt and maintain healthy practices and lifestyles, advocates environmental changes as needed to facilitate this goal and conducts professional training and research to the same end”. A more meaningful and dynamic definition arose from the Declaration of Alma Ata which defined health education as “ a process aimed at encouraging people to want to be healthy, to know how to stay healthy, to do what they can individually and collectively to maintain health and to seek help when needed”. Health education in the armed forces is necessary to enable the personnel to observe their own health care; get over wrong beliefs and replace them with rational ones; acquire correct and adequate knowledge regarding health and means of its promotion and maintenance; prevent ailments and take early care; convert illness consciousness into health consciousness for making 'health' their valued asset (37,38).

The conventional regimental method of enforcement of orders and instruction prove temporarily successful but do not yield lasting results. Health education sows healthy habits more permanently among the personnel and their families. Order and instructions regarding health are useful to a limited extent only because the code of conduct laid down through them is without the consent, knowledge or conviction of personnel. They do bring about some modification but do not necessarily produce a permanent change in the habits of personnel. As soon as laxity in enforcement of regulations occurs the disease rates rise. If personnel are induced by health education to incorporate these habits as a permanent component of their behaviour pattern, this laxity may not occur.

The serviceman's education also benefits his children in improving their health and inculcating healthy habits from the very childhood. It benefits the community when the serviceman returns to his rural environments and presents people an example of healthful living, thus, becoming a nucleus to spread the message of healthy living. Knowledge is very important, but merely imparting knowledge is not fruitful unless the attitude is favourable. That also may not make persons adopt healthy habits and surrender wrong beliefs unless motivation is created and group acceptance is ensured. After motivation has been created the newly acquired beliefs and practices should become permanent habits. Further, the 'felt needs' created have to be first fulfilled, and the habits made part of the whole culture-pattern, which is the end result of health education. Beliefs and practices acquired by people through past generations cannot be readily removed by implementing new ones unless they are willing to accept them and make these a part and parcel of their culture pattern. The benefits of the new habits over the older ones must be experienced by the people so as to take root.

The task of health education in an armed forces unit can be carried out by the RMO/ AMA, regimental officers and JCOs or paramedical personnel. It however demands patience, perseverance and hard work. It needs preplanning which includes preparation and use of appropriate audiovisual aids like charts, graphs, flash cards, film charts, pictures, posters and so on. Cinema films and filmstrips are very good adjuncts. Audiovisual aids should be simple and in a language easily understandable by the targeted audience. Group discussions help in convincing the personnel and families of the advantages and rationality of the new practices and beliefs and habits. The set hours for such education should be included in the formal training programme of the unit. But opportunities offer themselves to educate people during morning sick parade, health inspections, unit sanitation and hygiene inspections, during informal gathering, immunization and so on.

A high standard in the provision of health environments, sanitary facilities, catering arrangements, water supplies, living accommodation and so on provide an actual life experience of high educative value. Childbirth offers good opportunity for introducing the subject of family planning besides aspects of child rearing. Outbreak of diseases offers good opportunities though, at an avoidable health price to educate personnel and commanders on the necessary preventive measures.

The aspects which have been identified for health education activities are based on common experience of subjects which are of utmost importance for the achievement of health. The subjects include the following :

Personal Hygiene

The aspects of personal hygiene which are reinforced during health education are :

(a) Regular bowel habits are important for maintaining good health. It is cultivated by regularity in its act. It is necessary on the part of unit administration to provide enough sanitary facilities in the form of clean, well constructed, sanitary or deep trench latrines with adequate privacy to encourage personnel to use only the authorized latrines every time. Irregularity of bowel habits is often due to inadequacy or

unsuitability or lack of privacy and cleanliness of latrines. Moreover, such conditions also oblige personnel to foul the grounds near about the camp causing insanitary conditions, fly breeding, spread of intestinal diseases like viral hepatitis A, dysentery and ankylostomiasis. Personnel should also be educated and habituated to make use of latrines and not indulge in indiscriminate defaecation. Similarly adequate urinals of proper standards design should be provided by the unit and made use of by the personnel.

(b) A daily bath is the chief means to maintain a healthy skin and avert communicable skin disease. Excessive use of soap is not always good. After bath the body should be dried by rubbing with a moderately rough towel, such as the one provided as issue in the Armed forces. Adequate provision for washing and bathing should be made. Daily bath is beneficial not only for the cleanliness of the skin but brisk rubbing of the skin activates the surface circulation. This stimulates the cutaneous nerve ending making them more responsive, and clears the sweat and sebaceous pores. An elastic, clean healthy skin surface is an efficient safeguard against adverse effects of extremes of heat and also cold. The invigorating effect of a bath is due to stimulation of steroid secretions brought about by the mild stimulus produced by sudden contact of skin with water, cold in summer and hot in water. Cold and hot water baths respectively cool down the body in summer and warm it in winter.

(c) Hair should be washed regularly, if not daily, and properly groomed; they should always be kept cut short to avoid dirt accumulating in it and also for aesthetic reasons. Nails accumulate dirt and pathogenic organisms and introduce them to one's food if hands are not washed properly and in the skin if one happens to scratch it. They should be kept cut short.

(d) Teeth should be brushed preferably after every meal, but at least after the last meal of the day. A proper brush should be used for cleaning the teeth. The habit of using a toothpick is not good as it harms the teeth and gums.

(e) Eyes should not be rubbed too often or wiped with dirty hands. A clean handkerchief should be used for wiping the eyes and another one for clearing the nose, and while sneezing or coughing. Spitting indiscriminately or coughing, sneezing without use of handkerchief are bad habits, which help to spread the respiratory infection. Such habits must be discouraged. Fingers should not be used to clean nose and ears. It is bad habit and may damage the eardrum or nasal mucosa. The nose should not be blown too violently as it results in driving the mucous or serous discharge up the eustachian tube and may even rupture the ear drum.. All ranks must shave daily preferably with their own individual safety razor. Community shaving by a barber may cause HIV infection, Hepatitis B or fungal infections.

(f) Clothes must be washed and dried regularly; facilities must be provided to enable them to do so. They should not use each other's clothing, socks, shoes or boots or bed linen and blankets. As tobacco or betel chewing is not a usual habit in the Armed Forces, the habit of spitting can easily be curbed.

(g) Clean bowels, a good shave, brisk physical exercise, a good bath, brisk rubbing of the skin with a rough towel, a good nutritious breakfast and clean teeth and mouth in the morning before starting daily routine enhances efficiency in work.

### Food Habits

This indicates the habit of eating adequate nutritionally balanced food at fixed times, from healthy sources where it is well and hygienically cooked, preserved, protected and served. It should be eaten in sanitary surroundings without fly or dust nuisance or bad odours. It should be served by hygienic food handlers in a hygienic manner. Starvation does not harm a man as much as eating indiscriminately from unhygienic sources. Eating over and above the usual requirements even after starvation, also causes harm. Overeating harms more persons than under eating, especially among those above 35 years age. Hands and mouth should be washed before and also after eating. Over-consumption of oils, vanaspati or pure ghee is not beneficial as is usually believed. Service rations are well balanced and the various scales provide adequate quantities of calories and all nutrients to the servicemen for the particular area, types of activities and functions they are intended for. It is important that unit catering should be wholesome and sumptuous so that eating outside the unit is not felt necessary by personnel.

### Water Discipline

Water should be consumed in adequate quantity and from an authorized or a known safe source. Slackness in adhering to this habit may cause outbreak of gastrointestinal diseases. All ranks going out on patrol, convoy duties, tracking, route marches, on exercises, manoeuvers, reconnaissance, movement by transport or railway journeys should be habituated to carry full water bottles, individual water sterilizing outfits and to strictly adhere to the rules of water hygiene and discipline. Arrangements should be made to facilitate these habits and personnel should be trained to make use of the equipment given to them for water purification. It is quite impossible to train personnel to go without water, and any attempt to do so inevitably inflicts injury on the individual. The belief that soldiers can be hardened by forcing them to go short of water when undergoing training is irrational and dangerous. For troops undertaking hard work in hot weather, an ample supply of pure cool drinking water is essential to maintain fitness and to prevent effects of heat. True water discipline is enduring thirst and drinking when necessary from authorized sources, and when there is acute shortage of safe water, drinking only when ordered; it does not mean unnecessary water deprivation.

Water should be replaced when one has lost about 1.5 litre.

Regular Exercise

The aspects which need consideration are as follows :

(a) Human body requires regular exercise. Physical inertia leads to obesity, low catabolism, muscular laxity, low threshold for exercise, low vital capacity, low cardiac tolerance and low threshold for physical and emotional stress.

(b) Physical activity is a stimulus to the growth of children and adolescents and promotes mental relaxation in adults. It produces and enhances resistance against coronary disease, frost bite, trench foot, respiratory infection, prevents obesity, mental and physical lethargy. Exertion should, however, not be so excessive as to cause extreme fatigue as, like all stimuli, it becomes a stress-producing factor if it is excessive. It should be enough to produce pleasant fatigue demanding relaxation. Stage of recovery should follow exertion-causing fatigue.

Relaxation and sleep

Relaxation and sleep are necessary for recovery of the body from fatigue by eliminating biochemical products and physical and mental exertion. Sleep should be sound without any artificial aids. A sound sleep is ensured by freedom from ill health; good feeding and enough physical and mental exercise; comfortable thermal environments and freedom from pests like bedbugs, mosquitoes, sandflies, rats and so on; comfortable garments must therefore be provided to ensure sound sleep in barracks. Men should get used to sleeping with open windows and uncovered faces. In winter, reliance must be put on adequate clothing and blankets for warmth while sleeping than on closed doors and windows and artificial heat from fireplaces. A direct draught should, however, be avoided and guarded against. Enough rest and sleep are very necessary for accuracy in work, avoiding accidents, including traffic accidents and greater output of work. Some recruits like to huddle together under common blankets in winter. This habit spreads respiratory disease like meningitis, influenza and common cold. Provision of charpoy for each person, mosquito net, sufficient warm clothes and adequate blankets is to be made.

Leisure

Guidance in proper leisure time activities enable improvement in lifestyle and reduction of mental stress. The aspects to be considered are as follows :

(a) Recreation by inducing personnel to get interested in healthy outdoor or indoor games, recreational outings, visits to places of historical, cultural and religious interests, hobbies like painting, music, photography or handicraft, and other pastime engagements for using leisure in healthy pursuits produces a healthy attitude to life, inhibits temptation to indulge in unhealthy activities, aimless loitering, promiscuous tendencies, quarrelsome behaviour and provides relaxation without lethargy. All facilities should be provided and men should be induced to take full advantage.

(b) Religious, ethical and moral teachings keep the mind of people geared to healthy thought and action, provide a strong inhibiting factor in unhealthy pursuits like promiscuity and alcoholism or heavy smoking habits.

(c) General education, high degree of professional efficiency achieved by constant professional training and basic military training, a high standard of self discipline achieved without fear of punishment, and a high physical standard achieved by regular exercise, produce high resistance against unhealthy pursuits, habits and tendencies. All officers and JCOs should be educated to understand and practice these principles.

Smoking and Drinking

Excessive alcohol consumption has been traditionally associated with armed forces personnel possibly due to easier availability of alcohol and conditions of service life. Consumption of tobacco specially smoking has also been associated with armed forces personnel. The harmful effects of tobacco are well documented.

The policy adopted in respect of alcohol consumption and tobacco smoking in Armed Forces is one of moderation and of discouraging habitual or heavy indulgence. Neither of them have got any nutritional or health producing values and heavy indulgence has definite unhealthy effects, In order to discourage consumption of alcohol, an allowance in lieu of issue of alcohol in kind has been introduced. The token small amounts ( 60-120ml) issued 2-3 times a week at present for recreational purposes are not expected to produce addiction or lead to regular or heavy indulgence and are considered to be tolerable when issued under supervision within those limits. Medical officers should, however, always emphasize the uselessness and bad effects of immoderation in their use. The younger officers should be made a special target of such education as they are vulnerable to get addicted, need more nutrition which is likely to fall short of requirement due to heavy alcohol drinking; have to work harder to be alert and provide a good example to their troops. They are on their lowest rungs of their career and hence need guarding against bad habits. Medical officers themselves should provide good examples in this respect.

The aspects needing highlighting in this respect are as follows :

(a) Value of alcohol from the physiological and psychological point of view is not subject to a difference of opinion. It has some food value in the sense that yields energy. In any form it is definitely not essential for nutrition. It has an energy value of 25 to 29 Kj per ml. The addition of about 1.6 Mj from 60 ml. of rum is not significant.

(b) The psychological stimulant effect of the alcohol

in moderate doses as is issued to our troops at present, has been accepted over the ages. Alcohol produces a sense of well being and 'will do more' in our troops employed under adverse conditions. It is at present issued for this purpose to troops, more as a psychological booster than for any other reason.

(c) If alcohol is consumed in excess it may produce deleterious effects on the tissues particularly the liver, heart and central nervous system such as cirrhosis, peptic ulcers, delerium, tremor, psychosis, lowering of rational thinking, delayed reaction time increased irritability, lack of concentration and so on. These effects are mainly due to resultant avitaminosis from lack of proper diet of confirmed alcoholics or improper absorption as a result of chronic alcoholic gastritis. The troops should therefore, be educated in these aspects of alcohol consumption. The example set by regimental officers and JCOs in moderation, temperance or abstinence goes a long way to educate the OR, making them habituated to moderations.

(d) Heavy smoking is another harmful habit. Like drinking, this habit also often starts as a social accompaniment for relaxation under tense condition, for masking shyness or diffidence, as an escape from realities of life stress, or from the false beliefs in their beneficial values. The temporary relief is followed by irritation or lack of concentration and craving for further smoking. Just like tobacco chewing or alcohol drinking, this leads to compulsive smoking and then to addiction. Excessive smoking, especially if started in early life, causes increased incidence of lung cancer. It leads to a higher incidence of ischaemic heart disease, peptic ulceration, gastric carcinomatosis, tobacco amblyopia and tremors. Nicotine causes powerful vasospasm, thrombotic tendencies and reduced cardiac dynamics. Chronic bronchitis and pharyngitis are its constant accompaniments and dental staining is often seen. These points should be brought out to discourage troops from indulging in heavy smoking.

(e) It is said that the personality make up of people who take to heavy smoking and drinking is basically vulnerable to stress producing factors and hence smoking and drinking aggravate the fundamental effect of stress on such persons. Smoking causes increased vulnerability to frostbite due to vasospasm induced by it, and once it has set in, smoking should be prohibited. Withdrawal symptoms or denial of smoking to a person used to it are similar to withdrawal of any other substance of addiction i.e. restlessness, irritability, lack of concentration, delayed reaction time and delayed cerebration.

Family Welfare

Care of wife and children is the personal responsibility of each person; and a serviceman is not an exception to this. The welfare and health of the family affects the health, efficiency, wellbeing and morale of the troops directly and indirectly. Unit administration has a moral and ethical responsibility to ensure the welfare of all families in station. Medical Officers should educate and guide them and unit Commanders should arrange for proper facilities. Habits of the parents are likely to be picked up by the progeny, hence the personnel and their wives should practice correct health habits. Immunization schedule as mentioned in Chapter IX should be followed in case of children of all service personnel. Antenatal care, maternity, postnatal care, child welfare and family planning facilities should be provided under station and or unit arrangements. School health care should be provided to all children attending Armed Forces, Station or Regimental Schools. Families therefore, require health education to be able to gain from the comprehensive health care facilities made available.

**Suggested Subjects of Health Education**

- Personal hygiene
- Food habits
- Water discipline
- Regular Exercise
- Relaxation & sleep
- Leisure
- Smoking & Drinking
- Family welfare & Family planning

Family Planning

Family limitation is the greatest need at present from the national, community, family and individual point of view. For Armed forces personnel family planning and limitation of progeny is of vital importance because of the peculiar nature of their service requirements, condition and commitments. At least for half of their career, with the exception of extremely few categories, they have to remain away from their families and entrust their wives with all the burden of bringing up, education, and looking after the illness and other problems of children. This entails an extraordinary strain on wives besides the maintenance of a double establishment. If the serving person has to give his best to the service, he should remain free from the worries of his family while away from them (or living with them). It is therefore necessary that the size of the family should be small and manageable and within his means. All ranks should, therefore, be educated in rational beliefs and practices of planning and limitation of families. It is the responsibility of the RMO as well as the regimental officers to help the personnel in acquiring the knowledge and means to practice limitation and planning of the family.

## Health Care for Special situations

**During Moves** (34, 39, 40)

Care of personnel during a move is much more taxing than when they are static under well-controlled environmental living and working conditions. Movement in Armed forces is undertaken for administrative, logistic, strategic or operational purpose. It is accomplished by marching, by mechanical transport, by railway journey, by sea or air. The special taxing conditions during moves, depending on the mode of progression, are concerned with extra energy requirements, change in atmospheric, biological, physiological, physical and psychological environments, loss of sleep, change in body metabolism consequent upon the change in environs and mode of life, depletion of nutrition due to difficulties in food supply and water supply, difficulty in maintaining personal hygiene and environmental sanitation and so on. All the modes of movements require pre-planning and utmost care to ensure that personnel do not suffer from ill effects due to these conditions and arrive at their destination in a fit state to undertake further administrative or operational tasks without much delay or lack of efficiency. Trekking back to the base during withdrawal operations adds to all other stress producing factors. The various requirements and management of a move by marching, road transport, and railway are briefly described for the usual situations involved in the Army ; ie. Move by marching, move by rail, move by mechanical transport. The details need to be clearly understood by the medical officers required to plan provision of medical care during these moves which are as follows :

Marching

This is normal activity of troops undertaken for administrative logistic, tactical, strategic, operational and training purposes. Marching comprises orderly walking, wearing certain clothes in definite fashion, carrying a certain load disposed on the body in a particular manner, and moving together as a body of men at a regulated pace. It is interrupted by 'halts', the number and duration of which are directed by strategy. Further, this exertion may be prolonged for hours and days after physical and mental strain e.g. withdrawal operation in retreat. In short, marching is a community form of exertion. Training in the practice and habits of walking is, however, a prerequisite in every case. The aspects which need to be considered are as follows :

**Training for Marching**

Training for prolonged marching must be gradual and must be on full rations. Any attempt to force men in this preliminary training or train them to endure on inadequate rations will only result in a breakdown. Officers are responsible for instructing their men in march discipline, the care of their feet, personal cleanliness, water discipline and in march sanitation. The medical officer should give them technical advice on the physiology and hygiene of the march. He should also ensure that water duty personnel and the sanitary squads are thoroughly familiar with their duties, which will be required of them on the line of march.

**Preliminary Preparations**

A rapid survey of men should be made by the medical officer before the marching starts to eliminate those who are likely to be unfit to carry out the march. Only men who are in sound health should be allowed to start. Inspection of their feet, socks and boots is the duty of the platoon/ sub unit commanders in collaboration with the medical officer. Water trucks and receptacles for carrying water and all water bottles and cooking arrangements for the march should also be included within the inspection by the medical officer. Each person should know the route proposed to be followed and arrangement to keep in contact with and recovery of stragglers should be made. Alternative or escape routes, own camp positions and modes of communication when segregated must be known. Emergency and survival rations must be given to each individual and composite pack rations kept in reserve.

**Start**

The best time to start a day's march is the time at which the soldier would normally start his day's work in that particular season and climate. Marching in the very early mornings should be avoided as far as the military situation permits, as they involve much loss of sleep and greatly increase energy expenditure. The tactical situation may make it necessary to undertake a series of night marches. However, they cause considerable strain and result in loss of manpower and efficiency. In extremely hot weather the march should be finished before the worst heat of the day, by starting earlier in the morning, if necessary. Apart from this, the time to start should be late enough to allow men a reasonable night's sleep. This should always be impressed upon the force commander by the medical officers. Military necessity must of course govern the situation and each case must be considered on its merit. Before the march starts a light breakfast and hot sweet tea should always be issued.

**Rate**

The most economic rate with minimum energy wastage for the fully laden, trained infantry man on a fair, flat road is 90 metres in a minute with a pace of 75 cm. At this rate and including the usual allowance of a ten minutes halt for an hour marching, 5 km an hour for a smaller formation than a brigade and 4 km an hour for a division may be taken as very good marching on fair roads. In hilly or broken country the rate will be less. At altitudes above 3000 m the rate will be progressively reduced due to hypoxia. A faster rate either by increasing the number of paces per minute or the length of pace, become rapidly and progressively less economic and throws a strain on the troops and reduces their operational efficiency,

**Halts**

A halt of 10 min should be made at the end of the first 2 km for adjustment of equipment, and thereafter a 10 min halt every hour should be allowed. This is physiologically necessary. Long halts for an hour or more should always be allowed when the days march exceeds 25 km. At this halt the troops should be given a substantial meal. At every halt, short or long, every man should take off his equipment, lie down and raise his feet.

**Distances**

The distance covered is determined by the load, the climate conditions, the terrain or condition of the route, and the training and health of troops. For seasoned troops marching on six successive days, a speed of 24 km a day is good and 32 km a day very good. 'Forced marching ' at faster speed than this is only possible with a small number of specially picked tough and trained troops. One day's rest a week is essential. It is physiologically and psychologically much healthier to march 140 km in six days, with one day's rest than to cover that distance by continuously marching for seven days without rest. Forced marching leads to a great wastage from exhaustion and sickness and the tactical or strategic advantage contingent upon it may not, out weight the loss. But if the military situation demands a forced march, medical authorities should advise the force Commander on all possible steps to minimize the anticipated man power loss. The most important of these measures are the provision of full scale rations, an ample water supply, minimum load carriage and ensuring restful night's sleep.

**Load**

The physical stress associated with marching while carrying loads can lead to injuries besides fatigue. The aspects which need to b considered are as follows :

(a) Bones and ligaments take the main brunt of load during the static load carriage, but the main strain of energy expenditure during dynamic load carriage falls on the muscular system. The more the energy expended on carrying excessive loads the less there will remain to be expended on the distance marched and in fighting. Therefore, all possible means should be adopted to economize in muscular energy.

(b) For comfortable carriage, the body and the load carried on it should form one unit. In order to achieve even distribution and optimum stability and support, the load should be close to the body and over its centre; if loosely disposed, this causes friction and instability. If the load is further away from the body, the support has to be broad-based which causes more expenditure of muscular energy.

(c) A single load evenly distributed between the two shoulders and suspended by strapplings to the shoulders can be advantageously carried on the back, but large and irregular size loads are difficult to carry by this method. The load must be compact, preferably in an oblong cube shaped package.

(d) The weights of loads carried by infantry have varied considerably at different periods. Rationally the weight of load should have an optimum ratio with the body weight. A load of about 30 per cent of the body weight can be carried with most economical energy expenditure by an infantry soldier i.e. approximately 21 kg. For a man weighing 70 Kg., the effective maximum should be about 45 per cent viz. 32 kg for the same man. With loads of over 45 per cent of the body weight, the amount of energy expended increases to three times the increased load.

**Physiological Consideration**

The important physiological aspects which must be considered while planning the medical cover during marching are :

(a) The optimum body temperature for the efficient performance of muscular exercise is 38°C, above, which muscular efficiency becomes impaired; and if it continues to rise, heatstroke may result. The total body heat produced by a trained, physically fit, infantry soldier marching with full equipment on a level ground is 360 Kcal (1506Kj) per hour. Allowing for the heat of metabolism approximately 1000 Kcal (4184 Kj) of heat is required to be dissipated from his body during a straight forward march of 25 km over level ground at the atmospheric temperature of 21°C. As evaporation of approximately 2 ml of sweat dissipates one Kcal (4.184 Kj) of heat, the evaporation of about 2 litres of sweat is necessary to dissipate the excess heat. Heat produced will increase above 1500 Kcal (6276 Kj) in an untrained, unsuitably clad, tired person with sore feet, marching on a rough and hilly terrain with more than 18 kg of load and the speed above 90 m a minute. In addition as the atmospheric temperature rises above 21°C the evaporation of progressively increasing amounts of sweat from the skin is necessary to prevent a rise in body temperature.

(b) The total loss of water from the body will be at least 5 litres when the atmospheric temperature is 32°C, and 12 litres when it is above 40°C. Although the total water content of the average man's body is about 40 litres, a considerable portion of it cannot be drawn upon for the dissipation of heat without damage to the tissue structure. When he loses three litres, physical inefficiency becomes marked, and the loss of more than four litres brings him near to dehydration. Therefore in marching at an atmospheric temperature of over 38°C without water replacement, there is a risk of precipitation of heat effects. During 25 km march with the atmospheric temperature at 32°C, water should be consumed at the midday halt and when the atmospheric temperature is over 40°C it should be consumed at every halt.

(c) Physically fit, suitably clad, seasoned soldiers when adequately fed and supplied with water, suffer little ill effects from marching even in the hottest weather, if the march is not unduly long and the relative humidity not usually high. The amount of sweat produced does not necessarily indicate the amount evaporated.

(d) When the temperature and relative humidity are 32°C and 90 per cent respectively, an individual whose body is bathed in sweat is evaporating much less sweat from his skin than one with the

dry body when the temperature is 45°C and the relative humidity 20 per cent. The critical factors therefore are the high relative humidity with high dry bulb temperature.

(e) When the dry bulb temperature is above 38°C with the relative humidity above 85 per cent, there is a very real danger of a number of cases of heat exhaustion and heat stroke occurring among even the fittest marching soldiers.

(f) Under all the above conditions marches should be short, halts frequent, equipment and clothing light, drinking water liberally supplied and the worst heat of the day avoided.

(g) Evaporation of sweat is less in a humid and still atmosphere; therefore a hot and airless day is less suitable for marching.

(h) Effects of the heat are much more likely to occur among those who are over fatigued, debilitated and in poor physical condition.

(j) Profuse sweating also causes depletion of salt. While undertaking a 25 km march under atmospheric temperature of 40°C maximum a man loses about 15 to 20 g of salt. When undertaking hard work or longer marches in hot humid weather more salt may be needed.

(k) Also refer to humidity temperature chart in Chapter-II to determine heat risk of exercising/marching during hot weather.

(l) In mountain terrain at high altitude, the tactical and operational marches undertaken for long range patrol or tracking have some different physiological considerations as follows :

(i) The troops may be required to ascend a height above 3000 m and upto 6000 m ASL. Troops not fully acclimatized to high altitude are liable to suffer from altitude sickness and even pulmonary oedema. The danger lies in the possibility of its being mistaken for ordinary exhaustion and the real condition thus unknowingly progressing into irreversible physical breakdown and death. The progress of walking and its rate progressively diminishes at successive higher altitude. The danger is more for apparently stout or sturdy people who try to overdo the task of climbing with heavier loads.

(ii) The other danger is that of exposure to severe cold with blizzard, especially when swollen feet due to prolonged walking induce personnel to remove the boots and socks. Loss of water is caused by exhaling moisture saturated air at body temperature while inhaling cold air without much moisture. These conditions must be guarded against and personnel trained to recognise their importance and likelihood of danger.

(iii) For long range patrols, trekking and manoeuvers, oxygen cylinders may have to be carried.

(iv) Other side effects of marching in mountains terrain are foot injuries due to twisting, running or jumping and several injuries due to falls or land slides.

(v) Leeches in foot hills at lower altitudes may cause minor nuisance and snow or rain may retard the progress.

(vi) First aid equipment is always necessary while marching in mountainous terrain.

**Sanitary Arrangements**

Normally all people should have defaecated before the march begins. At short halts all that can be done is to ensure that those who must defaecate excavate, a shallow hole in the ground in which they deposit their faeces, afterwards covering them with earth, At a long halt, shallow trench latrines are dug by the battalion sanitary personnel who should always proceed with the advance party and leave detachment behind to cover the trenches and mark them properly for the succeeding trackers to be aware of the latrine area. Disposal of other waste matters should be carried out by burning or burying in shallow trenches.

**Personal Hygiene**

Men should get facilities each day for washing and changing. If it is not possible to wash the socks worn during the day's march, they should be turned inside out and hung up to dry in the sun. In hot weather, a campsite which allows washing arrangements should be chosen. At the same time the dangers of bathing in rivers or lakes which are polluted with sewage should be remembered. The danger of scrub typhus should be borne in mind when selecting resting sites, campsites and washing places.

**Procedures on Arriving at Camp**

On arrival at camp the men should get hot sweat tea. After tea, the necessary camp work should be performed and the men should attend to their personal hygiene. Finally the main meal of the day, which should be hot and substantial, should be served, but the issue of this should not be delayed too long, otherwise men who are overtired are apt to go to rest without food. In order to avoid a muscle bound condition men should not rest immediately but carry out light tasks or walk about for some time before lying down for complete rest. After the march is over for the day, the platoon commanders should carry out an inspection of boots, socks, feet and general condition of persons. The Medical Officer should assist in it and thoroughly examine the cases requiring his attention.

**Duties of Medical Officer on March**

The normal position of the unit Medical Officer is at the rear of the column so that he can attend to men who fall out. He should, however, once in each hour to go to the head of his battalion and allow it to march past him. By watching the appearance of the men as they file past him and speaking to each Company Commander, he can

guage the effect of the march on the men and supply his battalion commander with vital information. At halts he should attend to any minor ailments. At the long halt he should help the unit hygiene officer to select a site for the shallow trench latrines and ensure the refilling and purification of water in the water vehicles and containers. Immediately after the last short halt of the march, he should proceed forward to the site of the camp or billets and satisfy himself that sufficient latrines and urinals are ready for the immediate needs of his unit. He should also satisfy himself as to the suitability of the proposed sources of water supply.

**Care of Feet**

The soldier marches on his feet. It is obvious therefore that he must ensure adequate care of his feet and condition them to be able to bear with the physical stress of marching. The aspects needing consideration are as follows :

(a) Hardening of Feet

All men should wash their feet at least once a day, preferably in tepid water. After this they should be steeped in cold water for ten minutes. Soaking them in a solution of salt and alum, 100 g of each to 10 litres of water, is useful to harden very soft feet.

(b) Prevention of Sore Feet

It is useful to wear a pair of thin nylon or cotton socks under the regulation socks if the boots are large enough to allow this. If any particular part of the foot feels sore, a search should be made inside the boot for any roughness and projection of a nail; corns are due to nails pricking the sole of the foot. Changing into chappals at the end of the day's work is of great value. Those with a tendency to sore feet should dust their feet liberally each day with 'foot powder'(zinc oxide 10 per cent). It is an advantage to have the medical assistants trained in the elements of chiropody. At all halts on the march, and at the end of the march, he should attend to all those who are known to have tender feet. The feet must be kept scrupulously clean.

(c) Hyperhidrosis

Men who suffer from excessively sweaty feet develop inflamed and blistered feet. The best treatment for these conditions is to bathe the feet in 0.5 per cent solution of formaldehyde and dry them thoroughly, followed by dusting with 'foot powder'.

(d) Blisters

If the sore or irritation in the boot or socks is removed and the foot rested, the blister fluid will be gradually absorbed in four to five days. This can be hastened by draining the blister through a stout, sterilised long hypodermic needle, inserted into the blister through the surrounding sound skin painted with tincture of iodine. When the blister is empty, the skin over it should be carefully flattened down, but not cut away, and painted with iodine. Over this a piece of lint secured in position by adhesive plaster should be placed.

**Considerations for health care of troops during move by marching**

- Training for marching
- Preliminary preparations
- Start time
- Rate of march
- Halts
- Distances to be covered
- Load to be carried
- Physiological considerations
- Sanitary arrangements
- Personal hygiene
- Procedures on arriving at Camp
- Duties of MO during the march
- Care of feet
- Care of footwear

**Care of Footwear**

The aspects which need consideration are as follows :

(a) Boots

These should always be kept pliant and soft. The foot spreads about 1 cm in length and 1.25 cm in breadth under the weight of the full marching load. Therefore they should be fitted over regulation socks while the soldier is carrying his load and standing.

(b) Socks

A clean pair of socks should always be carried on the march for putting on after feet have been washed at the end of the march. Woolen socks shrink after being washed. New socks should therefore, be 2.5 cm long, and worn by the soldier while on duty in barracks. Two washes make them the right size for marching. Darning must be carefully done as holes in socks or badly darned socks cause blisters. Socks should be carefully washed and be kept clean at all times.

Move by Mechanical Transport

Precautions during moves in Mechanical Transport (M.T.) by road to be taken in addition to those mentioned above are as under :

(a) Movement should, as far as possible, be in the cooler hours of the day.

(b) Distance covered daily should not, as a rule exceed 160 km and there should be one day's rest after every 4 days driving.

(c) Every effort should be made to take the maximum benefit of available shade for halts, even if it means going some km further than scheduled.

(d) Canvas water bags (chaguls) filled with water

should be carried, slung on the outside of each vehicle for ensuring cool drinking water.

### Move by Rail

Besides all the usual measures to ensure the health, comfort, well-being and efficiency of the personnel required to be taken during a move, the following precautions to safeguard against health hazards should be taken when moving by rail :

(a) All electric fans in military coaches should be checked for their working.

(b) Overcrowding should be avoided in the coaches. These should be washed and sprayed with insecticides prior to occupation.

(c) A compartment, in addition to that for hospital accommodation, should be reserved and equipped for the treatment of men suffering from effects of heat.

(d) Entertainment should not take place overnight when the train is due to leave in the early morning; a long period cooped up in a stationery train in the hot weather is most uncomfortable and even dangerous.

(e) Ice containers are authorised and should be supplied at the scale of 5 per military coach and 1 per hospital compartment, officers compartment and kitchen cars.

(f) Ice is authorized at the scale of 35 kg per container or per 8 men at the beginning of the journey and a further 35 kg for replenishment later in the day.

(g) Adequate cold drinking water should be supplied to troops.

(h) Taking food, drinks or water from unauthorised sources at halts enroute should be prohibited. Halts for meals should be scheduled prior to starting and meals prepared by own cooks should be given.

### Disembarkation from a Ship

Men freshly disembarked possibly suffering from the after effects of sea sickness, and certainly soft from being on board ship, are susceptible to the effects of heat. They should on no account be subjected to a long march, moving heavy baggage, fatiguing works etc; until they have been fed and rested. Water points, shelters from the sun, and heat stroke centers should be provided at the docks.

## Provision of Maternal and Child Health Care in the Armed Forces

In the Armed Forces, Family Welfare Centers are organized on a station basis in all large, medium and small stations. Initially these centres were funded by the Ministry of Health and Family Welfare. However, at present, these centres are funded by the Ministry of Defence from their own budgetary allocation In large stations the establishment to provide health care for mothers and children is more elaborate than other stations. In addition to these centers some large units also run special health Centers exclusively for the care of family members of the service personnel. In the Navy, "Family Clinics" funded from non-public funds but under control of medical administrative authorities provide for comprehensive health care of families of naval personnel and are located at convenient places close to concentrations of family quarters. Antenatal, postnatal, under five clinics and family planning clinics are held on specific week-days at all these centers. Although a standard plan for staff and equipment is recommended for Family Welfare Centers, its implementation depends mainly on local resources, needs and enthusiasm. The OC SHO provides technical assistance and guidance on behalf of and under the general direction of the SEMO. The lady medical officer-in-charge is, however, the actual working head. In the case of unit run family welfare or health centers the RMO is responsible for the supervision of work in such centers. To enable the Medical Officers at various levels to carry out their duties in respect of provision of comprehensive medical care for the families of armed forces personnel, a brief resume of maternal and child health care is provided as follows :

### General

Mother and child has been recommended by WHO to be considered as one unit for provision of health care. In India, Women in the reproductive age group ( 15-44 years) who constitute about 19% of the population and children upto age of 15 years constitutes about 40% of the population and are considered a vulnerable group with high risk to life and health. Women carry a special risk to life and health during pregnancy, parturition and pueperium; the child bearing age shows higher death rates and morbidity rate in the female population. Infants are highly susceptible to infections, malnutrition, dehydration and environmental changes. The risk of life decreases as children grow up but they are still vulnerable to many adversities and infections. The pre-school and the school going children from one to ten years of age form 20% of the community; if adolescents upto 15 years of age are added to this, the total is about 40% of the community. In the armed forces, service personnel are invariably of younger age group as compared to the general population as they retire at a younger age. The proportion of families in the child bearing age group and children in the younger age groups will be more among service personnel as compared to the general population. However, a large percentage of service personnel are unable to or do not bring their families to the place of their posting due to various personal and accommodation problems. Hence they do not benefit from the comprehensive services provided by the armed forces and remain dependent on health services provided by the states or private practitioners (41).

### Maternal Mortality and Morbidity

Maternal mortality means the death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of pregnancy, from any cause related to or aggravated by pregnancy or its management but not from accidental or incidental causes.

Maternal mortality rate is expressed as maternal deaths per 1000 live births. At present it is 3.4 per 1000 live births. However, as compared with rates under 0.5 per 1000 live births in developed western countries this is still very high. Maternal morbidity is about 20 times the mortality. The commonest cause of maternal mortality in India are anaemia, haemorrhage, sepsis, obstructed labour, abortion, and toxaemia. Maternal morbidities are the anaemias, chronic malnutrition, pelvic inflammations, liver and kidney diseases. In addition, the pathological processes of some preexisting diseases, such as chronic heart diseases, hypertension, kidney diseases and pulmonary tuberculosis are aggravated by pregnancy and childbirth. A majority, of all the conditions causing maternal mortality and morbidity are preventable; by ensuring efficient antenatal, intranatal and postnatal care. (42,43)

### Child Mortality and Morbidity

Pre-school age child mortality means the deaths of children aged 1-4 years; 'infant mortality' means death of children upto 1 year of age; 'neonatal mortality' means death upto 28 days after birth; early neonatal deaths are the ones that occur upto 7 days after birth. Deaths from the 28th week of pregnancy upto 7 days after the birth, including stillbirths, are included in 'perinatal deaths'. Although perinatal period occupies less than 0.5% of the average life span, there are more deaths within this period than during the next 30-40 years. (44,45 )

The infant mortality rate in India which was 40 to 45 per 1000 of population at the beginning of last century has now fallen to 8.7 per 1000 on account of general improvement in environmental conditions, specific control of endemic communicable diseases, improved general nutrition and medical care, and health (or rather illness) consciousness of the people. Approximately half of the total mortality occurs among children below 5 years, half of the under five child mortality occurs below one year, and half of these die before they become one-month old.

Infant mortality in India halved from 146 per 1000 live births in 1951 to 40 in 2004. In developed western countries the infant mortality rates are uniformly below 10 per 1000 live births. At least 50 to 60 per cent of the child, mortality & morbidity can be prevented by efficient antenatal intra-natal and postnatal care.(29)

**Health of mother influencing maternal & child health**

The better the health of the mother during pregnancy and after delivery, the lesser will be the risk to her own life and health, and that of the infant; because the care of the mother before, during and after parturition contributes to the health of the foetus and infant as well. Maternal and child care as a combined service is thus an important constituent of the comprehensive health care of the community. Continuity of supervision is essential and the prenatal services can not be separated from the intranatal midwifery services from the infant and child welfare services. The aim of the combined services are;

(a) To further reduce the maternal mortality and morbidity during pregnancy, labour, puerperium.

(b) To ensure normal progress of pregnancy.

(c) To further reduce the perinatal, neonatal and infant mortality and morbidity.

(d) To ensure normal growth of children upto the time their health care is taken over by the school health service. The maternal and child health care programme includes antenatal care, maternity services and postnatal care, mother craft, under five clinics and family planning services. Various clinics may be held on different days of the week at the same premises and also the services may be extended to homes of the families.

### Antenatal Care

The antenatal service in the armed forces may be offered in the clinic by the lady doctor or extended to the home through Lady Health Visitor(LHV). The objectives of an antenatal care are to decrease the maternal morbidity and mortality before, during and after the child birth and to ensure the safe and healthy progress of pregnancy. Most of the causes of maternal morbidity and mortality can be rectified or avoided if detected early during pregnancy, if the nutrition of the mother is kept at its best during pregnancy and if diseases like syphilis, anaemias, hypertension, diabetes and toxaemias are treated early and kept controlled. Normally each expectant mother should be seen at least once a month in the clinic by lady doctor or LHV. To study environmental conditions and give practicable advice and demonstration, a proportion of the visits should be at the home. A minimum of three complete medical examinations are required. The first one should be before the 16th week. The second examination at the 32nd -36th week and the third examination during the 38th-39th week. A general review of the health of the mother and her mode of life accompanies each medical examination

The pregnant woman is usually first brought under antenatal observation about the 3rd month of pregnancy when she is thoroughly examined for any defects or diseases, approximate period of pregnancy is determined and in primipara the pelvic measurements are taken and recorded. The weight is recorded; blood is examined for VDRL, HIV, Hepatitis B,ABO & Rh grouping and for complete haemogram. Urine is examined for sugar, albumin and casts. Blood pressure is taken and recorded. Appropriate treatment for any defects or diseases is started. Immunization against tetanus should be given. Advice on personal hygiene in pregnancy and the instructions to return again after a fortnight /month or earlier if she feels unwell ( danger signs are explained) are given. By $32^{nd}$ to $34^{th}$ week the position, lie and presentation of the foetus should be ascertained and any remedial external measures, if considered necessary, can be carried out for correcting it. After the $36^{th}$ week the visit should be weekly and presentation checked. The head is generally fixed in the pelvic brim by the $38^{th}$ or $39^{th}$ week and prediction as to the absolute normality of labour can be made and case referred to the specialist if considered necessary..

### Maternity Service

The midwifery services can be a domiciliary or institutional service. The latter is particularly needed for prenatal and postnatal complications of abnormal labour, for normal labour in primiparas and for mother whose home surroundings are overcrowded or unhygienic. For the individual as well as an organization, institutional care is expensive where as domiciliary midwifery is less expensive and simpler to arrange. Domiciliary deliveries are safe for the normal confinement even where housing conditions are not ideal, but it is unsafe even for minor obstetric manipulations. For domiciliary work in urban areas one midwifery unit for every 100 birth in a year has been recommended. In rural areas where distances are great and communications poor one trained birth attendant in every village is necessary. The Health Worker Female (HWF) has all resources of the Primary Health Center and its staff behind her. She is supplied with the sterilised outfit and her knowledge is kept upto date by her contacts with hospital methods and practice. An institutional midwifery service in the armed forces scenario with hospital delivery is the preferred mode practised in the Armed Forces. It is run in conjunction with a family welfare centre for antenatal and post natal care.

### Postnatal Care

The postnatal care is also conducted either at the clinic on fixed days of the week or extended through paramedical healthcare workers at the homes. The postnatal rehabilitation of mothers, their mother craft training and inspection of babies for normality can be carried out simultaneously. The mother is educated regarding her own health and the health of the baby, and given advice regarding personal hygiene. Family planning clinic is attended by the mother about a month after the first child birth. IUD is usually inserted 6 weeks after child birth. After the second child, the couple should be advised to adopt permanent methods of family planning. In under five Clinic immunization schedule as given in Chapter IX should be carried out and the child examined for normality of growth nutrition; function of all organs and 'mile stones'. In the armed forces, post natal care is conducted in the family welfare centre with the lady doctor and LHV providing services of examination, advice and treatment if required. Home visits are also conducted by the LHV with family planning advice being rendered.

### Home Visiting

The paramedical health worker should visit each expecting mother and every infant once a month, and each child between 1 to 5 years once every three months. More frequent visits are desirable between the 36th and 40th week of pregnancy and the first month of the infant's life, which are the periods of maximum danger. Apart from 8 to 10 visits to each expectant mother and visits to every pre school child, each infant should be visited 12 times in the first year of life for teaching the mother to observe the normal developments and signs of departures therefrom, to manage feeding successfully, to supplements her own diet and to wean the child; deal with vaccination, clothing, bathing, teething habit training and prevention and treatment of minor ailments; educate against wrong customs and habits, to instill into her the elements of home and environmental hygiene, family budgeting, storage of food, and to help her to ameliorate social maladjustments. She has to demonstrate to the mother the preparation of suitable foods for the baby and to supervise the mother while she gains skill in carrying out treatment of minor ailments of the eye, ear or skin. Early visiting also enables the health visitor to register the pregnancy and directly or indirectly supervise the work of the dai or midwife in rural areas and to influence her methods and practices. In the armed forces, the LHV is entrusted with the task of home visits for all the above mentioned purposes. A schedule of visits is issued well in time to the units whose family accommodation is planned to be visited to gain logistical and administrative support.

## School Health Care

School health care is a link between the maternity and child health care and the general community health care. In 1953, the Secondary Education Committee emphasised the need for medical examination of school children and suggested a school feeding program. At the Central Ministry of health a special committee on school health care, "The National School Health Council ", has been established since Feb 1963 especially to plan and organise school children's health care.(46) Provisions have been made in the municipal, cantonment and state regulations for organization and maintenance of a school health service. Schools for children of Armed forces personnel are organised and maintained under the auspices of and financed from the Defense Ministry, Services HQs, local formation /Station HQs or regimental authorities. The RMOs and /or any MO detailed by the SEMO should regularly inspect the school premises located in the cantonment and the children studying in these schools and submit the report to the administrative authorities to enable them to arrange the remedial action for rectifying the defects and improve the health of children. The objectives of the school health care are as follows :

(a) Help children in this critical period of their physical and mental growth towards normal healthy adulthood.

(b) Maintaining working efficiency at a high level and improving mental assimilating power by :

  (i) Ensuring congenial working conditions.

  (ii) Keeping them physically and mentally fit at all times.

  (iii) Improving the general nutrition of the children.

  (iv) Reducing absenteeism and thus increasing average study hours/days.

  (v) Prevent spread of infections, reduce and detect minor ailments before they develop into major ones or permanent disabilities.

  (vi) Imparting health education and physical training to children.

(vii) Providing special arrangement for the education of handicapped children.

The aspects of school which may affect the health of the children and therefore warranting consideration by medical officers entrusted with the responsibility of coordination of school health services are as follows :

Healthful School Environment (47,48)

The environment at the school has an important influence on the health of the school children. General environs around the school building should be made healthy and sanitary by ensuring the following :

(a) The school should be located in areas free from crowded surroundings, away from bazars, butcheries, factories, disposal grounds for waste matters, public sanitary areas or enclaves, and such other places which may create a public health nuisance.

(b) There should be sufficient open space around the buildings.

(c) Enough playgrounds should be provided. Free muscular activity reduces mental boredom and strain and provides a stimulus for growth.

(d) There should not be any mosquito or fly breeding places around the school area.

(e) Traffic around the area should be restricted to the minimum so as to avoid noise, smoke and dust nuisance and mainly accidents.

(f) Accidents should be prevented not only on roads around school but also on the playgrounds and in class rooms. First aid should be taught to all teachers and senior pupils.

Seating Arrangement

These should be such as to allow adequate space, permitting freedom of movement for children on the bench so as to enable them to work without strain. The vertical and horizontal distance between seat and desk should be such as to permit children to write without raising their shoulders or stooping down on the desk. The distance of the seat from the floor should be such that the child is not required to either hang the legs down or raise the knees too high. Feet should rest on the ground while sitting on the seats without the popliteal space touching the seat i.e. the height of the seat should be an inch shorter than the leg from knee to the sole. An inclined foot-rest under the desk is the best device to achieve this. There should not be any obstructions to knee protruding under the desk. Normally the desk should be at elbow level when the child is seated. Its horizontal distance from the seat should not be more than 5 to 7 cm and vertical elevation such, that he is not required to lean forward while writing. The backrest should be adapted to the normal spinal curvatures. The black board should be at such a distance that the last student should be able to see the letters distinctly. Provision for keeping books and stationery should be made in the desk.

Drinking water

It should be procured from an authorized clean source, centrally stored and chlorinated. Laddles should be provided to take out water if taps are not possible. The ideal method is to provide water fountains which enable children to drink water without the use of cup or a glass. Common cups and glasses have the inherent danger of spreading upper respiratory tract infections.

Toilets and Urinals

Enough sanitary urinals should be provided at a central place but as near the class rooms as possible. Normally privies and urinals should be provided one urinal for 60 students and one latrine for 100 students. These should be kept clean at all times. Habitual use of clean sanitary urinals and latrines serves as a good medium for inculcating healthy habits in children. Toilet facilities should be separate for boys and girls.

Midday meals

These should be provided for supplementing the food available at home. These should provide about one third of the total daily requirements of calories, proteins, vitamins 'A' and 'B' complex and calcium. They should provide about 20-30 g of fat, 20 g of protein of which one-third should be of animal origin. Inclusion of milk in the meals will ensure this requirement. The schools meals not only aim at supplementing the nutritional requirement but also at inculcating healthy food and eating habits. In order to derive the greatest benefit the teacher must be trained in to elements of health and nutrition (49) .

Immunization

Children should be immunised against typhoid group of fevers, diphtheria and tetanus as a routine. If and when facilities exist immunization against poliomyelitis and tuberculosis by BCG should be carried out. Cholera inoculations should be given when the town is threatened by outbreaks.

Medical examination

All children should be thoroughly examined once a year or at least three times during the curriculum in addition to the one carried out at the time of entry. Results should be recorded in the health card and parents should be advised regarding remedial action. There should be a permanent register and health cards with column for remarks against examination of each system. The card is meant to be transferred to the institution the child may go after leaving one institution. A monthly, quarterly and annual report must be sent to the coordinating authority and medical authorities. The special points to look for are given below:

(a) Eyes for trachoma and vision (including tests for acuity of vision )

(b) Ears for perforated drums, otitis and power of hearing.

(c) Teeth for caries, non-alignment, mottling, gingivitis and so on.

(d) Nose and throat for adenoids and enlarged / infected tonsils & enlarged glands.

(e) Chest for lung involvement or congenital or

acquired cardiac defects.

(f) Abdomen for enlarged spleen, liver and any palpable lymph nodes.

(g) Genitalia for phimosis, undescended testicles or patent inguinal canal.

(h) Lower limbs for varicosity or other skeletal and muscular defects /deformities.

(j) Skin for ring worm, scabies and any depigmented patches.

(k) Hair for pediculosis, signs of malnutrition, etc

(l) Weight and height for normality.

(m) Any abnormal curvatures/ postures, delicate health, nutrition etc.

Minor Ailment Clinics

These should be provided and children should be encouraged to visit them whenever they feel unwell. It not only helps to reduce minor ailments from developing into major ailments or disabilities but also helps to detect any other major ailments or disabilities undetected in the incipient or early stages.

Referral Facilities

Facilities for reference of children to a specialist for investigation of ailments and their treatment/ hospitalisation should be ensured.

Physical Training

It is a major item of a school curriculum and should be insisted upon. Teachers should be trained in physical training or special instructors should be appointed.

Health Education

This should be part of the curriculum. It can be imparted either as an integrated part of curriculum or otherwise. Health education is also incidentally acquired by children through the experiences and observation of healthy school life as described above.

School health Committee

It should consist of the Headmaster or Principal as the Chairman and class teacher, health educator, school nurse, physical training instructor and the school medical officer as members. They should meet once a month or a quarter. A few parents should also be invited to attend these health committee meetings.

Parents Committee

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Col A Datta

# Assessment of Health in Armed Forces

## Introduction

The medical officer providing medical cover to the unit is very important in the scheme for provision of health cover in the armed forces. This could be the Regimental Medical Officer (RMO), if posted to the unit or Authorised Medical Attendant (AMA), if posted to some other unit but assigned responsibility to provide medical cover to personnel of a specified unit. In general, personnel specially young personnel posted to a unit are medically fit because they have been selected after a pre-placement medical examination. After being certified medically fit based on a thorough medical exam, young able bodied men are recruited in the services and thereafter undergo strenuous military training. The health of the troops under the care of RMO / AMA requires continuous monitoring right from the time of enrolment to enable maximum availability of combatants during war, operations or for peace time duties. The RMO / AMA is required to bring to the notice of the commanding officer (CO) of the unit any condition considered responsible for deterioration in health or likely to affect adversely the health, morale and welfare of the personnel of the unit. The further responsibility for rectifying such conditions rests with the CO under the advice of RMO / AMA. The Defence Services Regulations provide that the maintenance of health and prevention of disease among troops is a command function and commanders at various levels are responsible in this aspect while Medical Officers are responsible for rendering advise (1). In order to provide this advice, the RMO/AMA has to periodically conduct following activities :

(a) Conduct assessment of the environment - living and working conditions of the personnel by regular periodical inspections of the unit lines.

(b) Conduct assessment of the health of troops by regular periodical health inspections and examinations of the men under his medical care.

## Unit inspection

The RMO / AMA should make frequent inspections of the area under administrative control of the unit. These inspections should not be concerned only with the environmental sanitation. The inspections must include all the factors which combine to make up the soldiers' living and working environment, which in turn, determine his physical and mental efficiency, health and sickness, morale and welfare, and above all his fighting fitness. The unit hygiene inspections by the RMO / AMA are of four kinds :

(a) Periodic sanitary inspections for which detailed description is provided

(b) Inspections to check action initiated for rectifying defects highlighted

(c) Special inspections on occurrence of any disease in epidemic form. For this purpose expert help from a preventive medicine specialist must be sought at the earliest to pinpoint source of infection and institute remedial measures.

(d) Inspection for siting and locating the unit and its sub units upon its move into a new area. All aspects of hygiene and sanitation needs of a body of troops need to be considered and advice provided for adequate planning and meticulous execution through the CO of the unit. Details are available in the relevant chapters, for prevention of common infectious diseases.

## Periodic Sanitary inspection

General Principles. Regulations for the Medical Services of the Armed Forces 1983 in para 114 lays down that the RMO / AMA should visit every part of the barracks and camp at least once a month (2). The descriptions enumerated in the succeeding paragraphs pertain mainly to army units. However, with minor alterations in procedure they also apply to navy and air force ships/ units / installations. The concept of "monthly sanitary round" does not mean that only one day during the course of a month should be set aside for complete unit inspection. Indeed, such an inspection thoroughly carried out would occupy the whole day. It is much better to hold weekly inspections so planned that every part of the unit is covered once a month. In that case, a set day and time each week should be allotted to the inspection. This procedure has been sometimes contended to be faulty on the grounds that it removes the element of surprise, which would have enabled the medical officer to see the conditions as they always are rather than when specially prepared for inspection. The advantages of fixing date and time outweigh this objection. Firstly, this procedure ensures that such officials as the second in command (2IC) and quartermaster (QM) of the unit accompany the RMO/ AMA on his round. Secondly, it guards against the possibility of the medical officer missing the inspection in a particular month and finally, it has an educative value for all personnel on how the environmental conditions should ideally exist.

A definite scheme should be drawn out in detail on paper and closely followed to ensure that nothing is overlooked. The plan will naturally depend upon the topography of the camp. After taking over medical charge of the unit, the RMO / AMA should obtain or make a map of the camp and unit showing the location of all departments, buildings, huts, roads, latrines and so on. Army units are structured to possess a number of sub units called company (infantry or engineers) / battery (artillery) / squadron (armour) or other such sub units which function with some degree of cohesion and independence within the unit. The accommodation is usually distributed to these sub units which function their independent cookhouse and dining hall (approximately for a strength of 100-150 persons). The locations of all these sub units should be studied and

the plan of visit closely followed at the first few weekly inspections until the RMO / AMA becomes fully conversant with the location of every part of the unit and camp, including the layout of the water supply and drainage system. It is also important for him to know the sanitary problems which had arisen in the past and the way they had been dealt with from a study of the previous reports and the "Unit Sanitary Diary".

It will be appreciated that for units which are operationally deployed specially in mountainous terrain or during "training exercises" which simulate operational deployment, the sub units are at some times at considerable distances from the main headquarters of the unit and will need to be visited by RMO / AMA in a deliberate manner to appreciate the living conditions and conduct sanitary inspection.

As per page 51 of AO-27/2004/DGMS, the medical officer should also be accompanied on his inspection round by the unit sanitation and anti-malaria officer (usually QM is so designated by CO) and any other individual specially required (3). In some units a designated officer instead of the 2IC is detailed by CO to accompany the RMO / AMA. It will usually be found that once the RMO / AMA has secured the confidence of his CO, the attendance of the 2IC, at least occasionally, can readily be obtained. Before starting on the inspection the RMO / AMA should always visit the CO. This offers an opportunity for discussing with the CO such important points as the number of cases of sexually transmitted diseases (STD) , malaria, viral hepatitis and other preventable infectious diseases among unit personnel and any other matter having bearing on the health and welfare of personnel.

During the inspection minor defects should be commented upon verbally and not included in the written report. The more serious defects may, however, be noted for subsequent report to the CO in the sanitary diary. A suggested format for the "Unit Sanitary Diary" is enclosed as **Appendix** at the end of the chapter. This format helps the RMO / AMA to focus attention on those aspects which need attention and need to be commented upon. It should be borne in mind that the "Unit Sanitary Diary" is produced for annual administrative inspection of the unit. The endorsements should therefore be appropriate to the importance of the document. The inspection should be carried out systematically. The list of places to be visited during the "Sanitary Round" are enumerated below. All the areas however may not be applicable for every unit.

(a) Living accommodation - barracks, huts, tents
(b) Cook houses
(c) Dining halls
(d) Bath houses / Bathrooms
(e) Latrines
(f) Officers' and JCOs' messes
(g) Barber shop
(h) Dhobi Ghat / Washing places
(j) Water supply point
(k) Recreation room / Information room
(l) CSD canteen
(m) Wet canteen
(n) Regimental school
(o) Offices, QM stores (specially ration stores and store for hygiene chemicals & spray equipment)
(p) Guard rooms / Quarter guard
(q) Gymnasium & swimming pool
(r) Medical Inspection Room (MI Room)
(s) School
(t) Rubbish and waste matter disposal area
(u) Animal lines or private animal farm
(v) Slaughter houses
(w) Aerated water factory
(x) Family accommodation of other than officers

Living Accommodation

The requirements of ventilation, lighting and so on have been described in chapter IV. The permanent location of a unit is as per Key Location Plan (KLP). As an interim measure units may be located for a short duration, which may continue for several years, at a place which is specified in the Interim Location Plan (ILP). Units located in KLP location are authorised permanent accommodation as per specifications in "Scales of accommodation" of Military Engineering Services (MES). Unfortunately it takes years, sometimes decades, for proper accommodation (as per authorization, MES specification and design) to be built. During this period adhoc accommodation as available is allotted under arrangements of the Station Commander. Over a period of time, units use their own funds as well as through MES sanctioned construction works, to make themselves reasonably comfortable. However, the accommodation may be far from ideal design or teaching. The RMO / AMA must bear this in mind while conducting the sanitary inspection and forwarding subsequent comments or suggestions. RMO / AMA must however familiarize himself with the "scales of accommodation" which are available with Garrison Engineer of MES, Station Headquarters or formation headquarters - Quartermaster General Branch and suggest construction of deficient accommodation affecting hygiene and sanitation of the unit.

Whatever accommodation is allotted needs however to be kept in proper state of repair and as clean as possible. Compliance with all such requirements, including the state of general hygiene should be scrutinized by RMO / AMA. The general cleanliness of the place should be meticulously maintained. Floors, walls and ceiling should be in good state of repair to avoid harbouring of pests. Daily sweeping and /or mopping should be encouraged. The unit sanitation and anti-malaria squad should carry out their duties efficiently and regularly; their work in respect of spraying insecticides in all accommodation should be checked from time to time. Every barrack, hut, or tent should display on the wall at a prominent place the record of residual insecticide spraying. Detailed assessment of mosquitogenic conditions and anti -

malaria measures should be made. Guidelines are available on page 54 of Army Order 27 / 2004 / DGMS - Prevention of Malaria & other mosquito borne disease (3)

The RMO / AMA should inspect the arrangements for fixing mosquito nets, stringing of charpoys, cleanliness of beds, bug infestation and so on. The individual "kit", containing all items of personal clothing issued to every individual, is laid out during the inspection to enable assessment of the state of clothing of the personnel. Randomly, a few dining plates should be inspected for cleanliness ; water bottles should be checked for fungus, mould and cleanliness; few mosquito nets should be examined for tears and proper repairs by patching (and not stitching or tying) ; and boots for the state of repair and likely chance of causing corns / callosities. Barrack inspection thus affords an opportunity to go into many details of the living conditions of troops. In areas where impregnation of bed nets is advised, the RMO / AMA has a duty to check that the impregnation with recommended chemical (as specified by the medical authorities like Officer Commanding Station Health Organisation (OC SHO) or Deputy Assistant Director of Health (DADH) is properly done on the mosquito nets.

**Accomodation**
- KLP / ILP
- Adequacy
- Repair state
- Cleanliness
- Lighting
- Ventilation
- Personal kit

Feeding Arrangements

It is an old saying that "an army marches on its stomach". Provision of safe, adequate and tasty meals under all circumstances is the aim of all units. Adequacy and suitability of space, ventilation and lighting for the cooking and serving of the meals must be considered during inspection and all the standards should be taken into account. In general, the inspection can be grouped into that of the cookhouse - where food is prepared, and that of the dining hall - where food is served and partaken by the personnel. Detailed sanitary guidelines are available on page 20&21 of Army Order - 25 / 2004 / DGMS - Prevention of Food and Water Borne Diseases (4). The under mentioned points should be observed and commented upon :

**Cookhouse / Dining hall**
- Adhoc / as per scale
- Cleanliness
- Lighting / Ventilation
- Rat & Fly proofing
- Smoke nuisance
- Chapatti basket / utencils
- Meat box / chopper
- Rations dry & fresh
- Hyg of cooks / immunization
- Clothing of cooks /

(a) State of repair which may affect sanitation, fly and rat proofing, cockroach nuisance, ventilation, lighting, smoke nuisance and so on.

(b) Inspection should be carried out of the raw foodstuff, especially the fresh items, and their cooking from the point of view of any loss of nutritional values, digestibility, palatability and possible contamination or deterioration of cooked food.

(c) Inspection of personnel working in cookhouse and handling food for personal hygiene, especially cleanliness of clothing and hands, personal cleanliness, trimmed finger nails, clipped hair and any skin conditions.

(d) Inspection of food items for taste, palatability and acceptability in general. Food should also be tasted to ascertain these points.

(e) Availability of fresh water supply and its protection.

(f) Inspection of dining hall from the point of view of adequacy of space, comfort, fly and rat proofing, seating and eating arrangements, plate washing arrangement and disposal of left over food, meat bones, etc.

The following documents on public display should be checked:

(a) Cook house rules including authorisation of rations.

(b) Nominal roll of food handlers and their monthly medical examination and immunisation records.

(c) Bill of fare (weekly menu).

(d) Store room for rations (dry & fresh) from point of view of general hygiene, fly and rat proofing and quality of rations.

(e) Samples of food preparation of each of the three meals served in all cookhouses should be preserved in refrigerator wherever the facility exists for at least 24 hours, preferably 48 hours, and the containers should be properly marked. This assists in proper diagnosis in the event of an outbreak of food poisoning.

**Sanitary Annexes**
- Bathing facilities
- Adequacy
- Hot water arrangements
- Latrines
- Adequacy
- Cleanliness
- Repair state
- Dhobi ghat
- Availability
- Waste water disposal

Washing and bathing Arrangements

All permanent accommodation are designed to house the dormitories for men, cookhouse & dining hall as well as sanitary annexes (bathroom & latrines) in the same building. However, in adhoc or older constructed accommodation, dormitories are separate from bathing spaces & toilets. Inspection should be carried out to see the adequacy, cleanliness, surroundings, disposal of wastewater, shelter from wind,

arrangements for drying and arrangements for provision of hot water (specially in winters).

**Bathing Arrangements**

Each unit should have a definite arrangement for providing men a daily bath, and at least two hot baths a week during winter. The unit medical officer should make himself familiar with the system of bathing of the men of his unit and should make it his duty to see that it is adequate.

Dhobi Ghat and Shop

Arrangements should exist for washing of the clothes of the personnel by the individual himself for his clothes, under garments and socks and centrally through the services of washer men (dhobis) for articles of uniform, arrangement for drying of clothes and ironing of clothes by washer man. These should be established as far as possible near the unit lines. Washed and unwashed clothes should not be allowed to be mixed. Water used for washing should be clean and no water-logging of waste water should be permitted. Waste water should be drained well away from the unit area after removal of the soapy scum.

Latrines

Common latrines are the norm for lower ranks of the armed forces which are usually part of sanitary annexes located at the end of the building housing the dormitory / in separate annexes. Water carriage system is provided in permanent accommodation with flushing system. In case of water shortage or malfunctioning of flushes, hand flushing is resorted. A water storage masonry tank or other adhoc arrangement for storage of water for ablution and flushing is provided wherever 24 hours water supply is not possible (which is the usual system). Blockages of the latrines due to inadequate availability of water for flushing is a recurrent occurrence specially in older accommodation. Servicability and cleanliness of the latrines are of prime importance to prevent fly nuisance. RMO/ AMA should also carry out an occasional inspection of the condition of latrine seats and urinals. In case they have lost their glaze, become pitted or are no longer cleanable due to prolonged use, they can be recommended to be replaced by MES as per existing provisions. An "unhygienic certificate" is required by MES to be rendered by medical authorities, Officer Station Health Organisation in a large station or even RMO / AMA in a small station, to facilitate the replacement action.

Officers' and JCO's Mess

It is often experienced that the kitchens of officers' and JCO's messes are far below the standard demanded of the cookhouse serving the lower ranks. They are usually never inspected and are neglected. These messes should neither be overlooked nor any lower standard accepted. The points to be considered are exactly the same as enumerated above

Water supply

Chapter on water supply describes methods of provisioning of safe and wholesome water to troops. Details of the source, system of purification and distribution must be always known to the RMO / AMA. Where water supply is piped to the unit from a water point, water samples at various points of delivery in the unit and sub-units should be examined for the presence of free chlorine at frequent intervals (preferably daily) and records maintained. It must be noted that chlorine rapidly evaporates if exposed to sunlight and air. Therefore tests should be conducted only when "fresh water" is being supplied and not from water drawn from overhead tanks of a building. These tests should be conducted regularly, preferably on a daily basis. If chlorination is not done centrally at the water point or in the unit after getting it, the method of chlorination at sub-unit levels should be checked, not only during monthly inspection but more frequently and records maintained. Absence of "free chlorine" at the consumer end leads to suspicion of leakage / sewage contamination in the distribution water pipelines and needs to be immediately investigated to prevent outbreak of water borne diseases. Any likelihood of pollution at any stage before its consumption should also be ascertained. The tests are conducted and records of daily chlorination maintained by water duty personnel at various sub-units which should be scrutinized during the monthly round.

**Barber shop**

- Space adequacy
- Cleanliness
- Instruments
- Waste disposal
- Hygiene of barbers
- Clothing

Barber shop

Barber Shop Detailed instructions for cleanliness of Barber shop has been laid down in AO-247/73 (5). This can become a focus for dissemination of HIV, Hepatitis B, skin infections like sycosis barbae, Tenia barbae or Tenia capitis through infected instruments and also respiratory infections to the personnel due to close contact, which is unavoidable during shaving or hair cutting. During inspection the following points should be checked :

(a) The shop, furniture and equipment should be kept clean at all times.

(b) No bedding or unauthorized clothing should be kept therein.

(c) A nominal roll of all employees showing the date of monthly medical examination, inoculation and vaccination under the signature of the medical officer should be displayed in the barbershop.

(d) Arrangements for frequent washing of hands of the barbers and adequate water supply should be provided.

(e) All barbers should wear clean overalls and aprons when at work.

(f) Shaving or hair cutting of men suffering from skin disease is prohibited.

(g) Clean towels and sheets are used in the shop.

(h) If a 'barber's chair' is provided, its headrest should be protected by clean paper; a fresh piece being used for each individual.

(j) A bucket or a tin is provided for used cotton wool and clipped hair. The tables are provided with sunmica, zinc sheet or marble top and kept clean.

(k) Combs, razors and clippers are kept immersed in 2.5 per cent cresol, dettol, or chlorosol solution when not in use during working hours. Before use they are washed with clean water. The rest of the time they are cleaned and protected with Vaseline excepting combs which are cleaned and washed with soap and dried. Shaving brushes after each shave are washed in a solution of savlon /dettol and then rinsed in clean water. Razors are wiped on a clean towel kept for the purpose. It is better to encourage use of changeable blade razors. The blade should be used once and then disposed. The used blades should be disposed by deep burial after disinfection in a strong bleach solution (5% strength for half an hour). In general, shaving by barbers should be discouraged where possible and individuals be encouraged to shave themselves.

| Canteen |
|---|
| As for cookhouse |

(l)All cuts are swabbed with tincture of iodine.

Canteen

The wet canteen in army units is run by a civilian contractor appointed by the unit and is an important adjunct for the unit personnel who partake of the tea and snacks prepared. The canteen should be inspected exactly in the same way as a cookhouse, but probably with a more detailed scrutiny. Sanitary control of canteens is extremely important, as laid down in page 22 of Army Order - 25 / 2004 / DGMS - Prevention of Food and Water Borne Diseases (4).

Recreation and Information Rooms

The standards recommended for space, ventilation, lighting and furniture should be ensured. Overcrowding in a recreation room, specially for viewing the very popular entertainments beamed by television channels, is as dangerous as it is in living barracks. Therefore, space and ventilation are important factors. Moreover, the rooms should be adequately warm in severe winter and cool in summer. The function of the recreation room is to provide healthy recreational facilities in order to promote the mental well being, to break the boredom and divert attention from the temptation of visiting civil areas. Attention should be paid to general cleanliness.

Regimental School

Regimental school caters for lower ranks to improve their basic educational qualifications and is different from the school for children. With the change in minimum qualification standards of soldiers to matric level, the utility of such schools has greatly reduced. Nevertheless, if they exist, adequacy of space, ventilation, lighting and general cleanliness should be examined. The seating arrangements and the relative position of black board and teacher must be checked.

Office Rooms and QM Stores

These places also require inspection for ensuring adequacy of accommodation, maintenance, lighting, heating/cooling and ventilation from the point of view of health. Clothing and ration stores must be examined for rat and fly proofing. Working comfort of the staff in office and rat proofing of stores are also important and must be ensured. As the RMO / AMA is concerned with the correct storage and issue of hygiene chemicals and serviceability of spray equipment, these must be checked during the inspection. Preferably all hygiene chemicals (which are obtained from Army Service Corps) must be demanded as per the size of the container provided by the manufacturer. Storage in adhoc containers can be dangerous due to accidental misuse. All items must be stocked as per requirement. Hygiene chemicals are demanded and consumed based on medical advice. Usually OC SHO controls the issue action at station level so all units have to route their hygiene chemical indents through him. RMO / AMA with more intimate advance knowledge of training commitments of the unit can ensure adequate and timely stocking of hygiene chemicals for use when the unit or detachments are deployed in un-controlled areas for operations or training. State of repair of spray equipment is also required to be monitored and repairs / demands for new items placed well in time on Army Ordnance Corps units (Divisional Ordnance unit / Ordnance Depots) to enable appropriate spraying activities. The authorisation of spray equipment is laid down in page 44 of Army Order - 27 / 2004 / DGMS - Prevention of Malaria and other mosquito borne disease (3-4)

| Offices / Stores |
|---|
| Ventilation |
| Lighting |
| Repair state |
| Cleanliness |
| Hygiene chemical store |

| Quarterguard |
|---|
| As for accomodation |

Guard room / Quarter guard

Large units like infantry battalions are authorised a Quarter guard which provides ceremonial guard to the unit and is a showpiece where the regimental flag, “colours” and other valuables including cash of specified amounts are stored temporarily. The quarter guard also has prisoner cells to house offenders who have been awarded “imprisonment” for their offence as per Army Act. The cells are required to be of such construction as to be conducive to healthy living for an offending soldier undergoing a spell of imprisonment. His health should not deteriorate during the imprisonment due to the conditions prevailing. Hence, aspects of environment applicable to living accommodation except provision of fans are catered. The prisoner is under observation at all times and is conducted by the duty sentry for bathing and calls of nature for which sanitary facilities are provided. These aspects are also inspected by the RMO / AMA during his round.

| Family Lines |
|---|
| As for accommodation |
| Also CILQ accn |

Family Lines

In a military station where units are located in peace time, married accommodation is built as per specified design and

scales and are available to all ranks. Usually, units are allocated blocks of such accommodation in single or multi storied construction for better coordinated maintenance. The accommodation allotted to Personnel below officer rank (PBOR) should be included in the inspection as the health and hygiene of families and their living standards influence the health of the soldier also. Their health is as much the responsibility of the CO as the health of personnel he commands. The same uniformly high standard in the ordinary married quarters as in the men's barracks cannot be expected. Everything possible should be done to raise the level of living conditions of the soldier's family by lectures and talks delivered during inspection as well as by using the forum of Family Welfare Centre of the unit. An attitude of helpfulness should be adopted during these inspections. It should be realized that the average soldier's wife with duties of house-keeping and care of the children has her hands full in keeping her home even reasonably clean. The important points on which to lay stress are the condition of the food storage, water supply, waste disposal and drainage, ventilation and general cleanliness of the house and health of the children.

The MES constructed married accommodation available in a station is usually insufficient to meet the requirements of all those who may wish to avail of this facility. To overcome the shortage, a provision of providing allowance as "Compensation in lieu of quarters" (CILQ) , has been authorised by the government. Any PBOR wishing to hire a house on CILQ is required to have the house inspected for both medical and security aspects. Station Headquarters sanction CILQ based on medical inspection reports of OC SHO. However, the continued maintenance of hygiene and sanitation condition of the hired accommodation is the responsibility of CO of the individual. RMO / AMA must therefore focus attention on houses hired on CILQ by PBOR of his unit and advise corrective actions if required. The aspects which need attention are the condition of living rooms, kitchen, bathroom, latrine, water supply, waste disposal and general sanitation of surroundings.

### Family Welfare Centre (FWC)

Traditionally army units have maintained a Family Welfare Centre to impart some skills to the wives of PBOR who are invariably with the unit only for a brief period of the entire career of the husband. The FWC is actively supervised by the wife of CO or in her absence a senior lady to ensure adequate patronage and logistical support. At least once a month there is a unit level organization of "family welfare meet" during which all available ladies including wives of officers of the unit attend, interact and discuss ways and means of improving the status of the wives of all ranks. In the earlier days the skills imparted by the FWCs mainly pertained to housekeeping but over the years this has also evolved to equipping the wife of PBOR with economically viable skills like computer education, handicrafts manufacture, etc.

One of the duties of RMO / AMA is to appropriately use the opportunity provided by this forum to stress on healthy lifestyle and other health related information to enable the ladies to provide a healthy environment, proper nutrition and correct upbringing for the entire family including their children and their husband, besides themselves. Of late with instances of mental stress related problems (marital discord, substance abuse, delinquent children, problems of adolescent child, etc) arising in the increasing nuclear families of PBOR, the opportunity to sensitise the ladies about the various aspects of mental health or illness should also be utilised by RMO / AMA. In this he may seek professional assistance with support of CO. Often a full time or a part time lady doctor is appointed by large units for day to day work pertaining to health care of wives and children of PBOR of the unit. Appropriate support and supervision of the activities of the lady doctor by RMO / AMA will greatly assist in provision of comprehensive maternal and child health services.

| School |
|---|
| As for accomodation |
| Medical examination |

### Children's School

Some large units, as a welfare measure, have started schools for small children - usually for pre-school age children. These should be inspected frequently, preferably, once a month due to the very high chance of infectious diseases among the vulnerable young children. General cleanliness, adequacy and the state of sanitary conveniences, water supply arrangements, programme for health and physical education and the general state of health of the children should be checked. Once a year all children should be subjected to a proper medical examination to enable early detection of disabilities which can be corrected and facilitate the learning process. Necessary records must be maintained in a systematic manner.

### Aerated Water Factory

Many units run their own aerated water factories. Sometimes, the natural desire to bring down the production cost tends to a lowering of the hygienic standards of production. As a principle, the hygienic standards of the aerated water should be the first criterion in its manufacture; and low cost, although desirable, should be of secondary consideration. The premises in which the factory is located should have concrete floors and impervious walls. The personnel employed in the factory should be directly under the unit medical control and supervision. Special clothing for use during working hours should be supplied to all workers. Chlorinated water from a piped supply from a central water works can be used. When such is not obtainable, clarified water should be chlorinated and used half an hour after chlorination. Strict attention should be paid to the cleanliness of the bottles and the method of washing them. The satisfactory method of washing bottles is first to scrub them inside and outside with a brush,

| Aerated water factory |
|---|
| As for cookhouse |
| Cleaning of bottles |
| Raw material |
| Hygiene of staff |
| Testing samples |
| Documents |

then steep them for 30 min in a bleaching powder solution (30 grams to 5 liter) and then in running chlorinated water, and finally allow them to dry on a draining board without wiping with cloth. The method of preparing and storing the syrups and flavouring agents for lemonade, colas, and other sweetened aerated water should be hygienic. These products are attractive to flies and the possibility of contamination by this means should be guarded against. From time to time (preferably once a month) , samples of all types of aerated water made in the factory should be sent to the laboratory located at nearest military hospital for bacteriological examination. The health standards expected of personnel employed in the factory are the same as those for cooks of unit kitchen. All concentrates used should be certified by ISI / FPO / AGMARK and the labels be appropriately endorsed to indicate appropriate processing and use of safe preservatives, colouring or flavour agents. Guidelines given in pages 22 & 23 of Army Order - 25 / 2004 / DGMS - Prevention of Food and Water Borne Diseases should also be referred (4).

| Abattoir |
|---|
| As per cookhouse |
| Scaffolding |
| Waste disposal |
| Hygiene of butchers |
| Instruments |

Abattoir

When slaughtering of animal is carried out under unit arrangements, the RMO / AMA should inspect abattoir thoroughly for hygienic standards, as it becomes a source of health hazard to personnel. Fly breeding and contamination of meat are the two hazards. Special notice should be taken of the floor and general cleanliness of places where the carcasses are dressed. Floor should be of impervious concrete and interior wall of smooth concrete which should be lime washed frequently. Concrete channels should drain all liquid manure from the lairs and the slaughter room to a place of disposal outside; semisolid manure should be dealt with in the same way as manure from a dairy. The slaughter room should be fitted with scaffolding having chrome plated hooks for dressing of animals, be fly proof, have an adequate water supply and be provided with a suitable means of dealing with blood, offal and waste animal products. Where it can be arranged, all liquid waste should be run into a water carriage sewer, and all solid refuse should be burnt in an incinerator. Above measures, however, are rarely possible because slaughtering under unit arrangements is usually necessary in the operational service when live animals designated meat-on-hoof (MOH) is supplied. The best method of disposal then is daily burning of all refuse and offal in the beehive incinerator. On rare occasions when burial method is adopted, the pits should be well limited and the offal covered by a layer of mud. Once the pit has reached its maximum capacity, a layer of oiled earth should be arranged on top and firmly rammed in. Special covered receptacles for holding blood and offal pending incineration or burial should be provided. The carcass hanging room should be well ventilated and fly and rodent proof.

There is a chance of contamination of slaughtered meat from the dirty hands and clothes of meat handlers. In order to reduce contamination of meat, all personnel handling meat must wear clean clothing, must have their nails clipped short, be free of any communicable diseases and be protected against enteric group of fevers. All implements used in cutting meat like choppers, knives, etc must always be boiled for 20 mins after use and wooden blocks cleaned with salt powder. Meat is kept in meat safes and stores which are fly and dust proof, are well ventilated and are cool. Detailed guidelines on meat hygiene are laid down in pages 17 & 18 of Army Order - 25 / 2004 / DGMS - Prevention of Food and Water Borne Diseases (4)

| Animal Lines |
|---|
| State of repair |
| Hyg / sanitation |
| Rat / fly |

Animal Lines

Animals - mules, horses, dogs, etc are authorised to animal holding units like Animal transport battalions of Army Service Corps and Dog units and veterinary hospitals of Corps of Remount and Veterinary Corps. In addition, some units may also maintain Dairy animals for the welfare of the troops located in some inaccessible or hilly areas where fresh milk may not be easily available. The chief sanitary problem of the animal lines is the collection and disposal of animal litter in such a way as to prevent fly breeding. RMO / AMA must visit the animal lines frequently to maintain vigilance on the method of removal and storage of animal litter pending final disposal as it is a potential fly-breeding place in a unit. The floors of animal standing and for their litter should be made of sound concrete; otherwise it is difficult to deal with fly menace. The RMO / AMA should satisfy himself that at no place in the system of removal and disposal of animal litter there is any possibility of fly breeding. The grain stores for feeding the animals should be examined specially with a view to ensure that they are rat-proof.

| Waste disposal |
|---|
| **Sewage / sullage** |
| Type & serviceability |
| Blockage / overflow |
| Potential water contamination |
| **Refuse** |
| Disposal type |

Disposal of Waste

This should be inspected at the end of the tour. The methods of disposal are described in Chapter V. Military sewage disposal plants in large stations are under central control of Military Engineering Service (MES) ; the RMO / AMA during sanitary round has little role to play in this aspect. However, in small stations a sewage disposal plant may come under the unit's sanitary control and should be inspected by the RMO/ AMA for its efficiency. The RMO / AMA should proceed as follows to ensure the efficiency of methods adopted :

Excreta Disposal

Temporary systems of excreta disposal (shallow / deep trench latrines) are constructed for use for short durations upto a year These latrines require strict monitoring to ensure maintenance in hygienic condition. RMO/ AMA

may need to make a daily inspection of these latrines. The points to be noted are cleanliness of latrine seats, oiling of the rammed down earth surrounding the latrine seats and daily spray of insecticides to prevent fly breeding (Dichlorovos (Nuvan) 100ml in 10 litres of water can be sprayed over 500sqm surface).

**Water carriage system**

If a water carriage system connected to main municipal drainage is in use, very little attention is needed except to ensure that the latrines and urinals are clean, the flushing system is working efficiently and that there are no leakages, breakages and blockages in the whole system. In cantonments, garrison stations and permanent camps this is the method of choice. At the time of construction, the sewage pipelines are laid below the level of water distribution pipelines. However, it is likely that due to blockages, raw sewage may overflow and lead to sewage accumulating in areas through which water pipes are passing. In case of leakages in the pipelines providing intermittent water supply, there is a strong chance of contamination of water supplies due to negative pressure in the pipes when there is no water in the pipes and an outbreak of water borne diseases like gastro-enteritis, viral hepatitis, enteric fever, etc can occur. It is necessary to be aware of the layout of water and sewage pipelines in the unit area. Monitoring of any sewage overflow from manholes and prompt corrective action through MES are necessary. RMO / AMA plays an important role in early detection of such overflows during his periodic visits to different parts of the unit and educating the personnel on necessity to report such overflows immediately to QM and himself.

**Septic tanks**

Wherever septic tanks are used their efficacy and maintenance should be checked. Effluents from septic tanks are usually connected through perforated pipes to the soil after a period of treatment. This enables aerobic digestion and ultimate disposal as water and carbon dioxide. The septic tanks need periodic maintenance by MES. Bailing out the sludge at the bottom of the tank as well as the scum on top and disposal by burying in pits ensures that the septic tank is in appropriate state of functioning. In case the septic tank fills up in spite of periodic maintenance, the fluids can be pumped out after digging appropriate pits and burial. It is a sign however, that new septic tank is required to be constructed.

Refuse Disposal

Control should be kept over refuse collection and disposal in a hygienic manner. Unit hygiene and sanitary squads must be properly trained to construct and maintain the sanitary appliances. The beehive incinerator is ideal for any camp except the purely temporary camp in which proper drum incinerators should be used. All cook house refuse should be appropriately disposed as it is a source of fly nuisance. In military stations refuse disposal is usually entrusted through a conservancy agreement to Cantonment Board. Refuse is to be conveyed to designated garbage points / bins under unit or station responsibility. Cantonment Board conservancy staff remove the refuse from these points for final disposal periodically - usually on alternate days. Burial as a method of refuse disposal is superior to burning if properly conducted with a layer of mud covering the day's refuse. Dumping as a method should not be adopted except as a last and temporary resort. It attracts rats and flies, breeds cockroaches and creates general unhygienic conditions around kitchen. Bio-degradable refuse may be disposed by vermi-composting or other such methods of in situ disposal.

Sullage Disposal

In permanent camps, garrison stations and cantonments, underground drainage connected with the main sewage system is ideal; otherwise disposal in large streams or soakage pits should be resorted to. In every case grease traps and gully traps should be properly constructed and maintained.

Animal Litter

It should be disposed off by trenching, composting, tight packing or incineration according to the facilities available, amount of litter, and duration of the camp.

Medical Inspection Room (MI Room) or Regimental Aid Post (RAP)

Promotion and maintenance of health of troops being the concern of the CO of the unit, it is incumbent upon the unit administration to make provision for a suitable, centrally located, Medical Inspection Room (MI Room) /Regimental Aid Post (RAP) where detection of illness and adequate treatment for needy soldiers can be provided by the RMO / AMA conveniently and comfortably. The MI Room is a peace time designation while in operational areas or during War the term RAP is used. The authorisation of medical and ordnance stores are however the same for both. It should be kept meticulously clean, neat and tidy. It should be well equipped with all the medical and ordnance equipment as authorized. The work should be well organized and all equipment should always be in working order. The staff, nursing assistants and unit personnel trained for such duties (Battle field nursing assistants (BFNA) ) should be courteous and caring towards the sick and infirm seeking their assistance and be professionally competent to discharge the designated health care activities. Disposal of bio-medical waste generated from the MI Room / RAP has assumed an added importance in recent times with the greater awareness among all of the dangers posed by improper waste disposal on the lay population as well as health care workers.

**Action after the unit Inspection**

After the inspection, the CO of the unit inspected should be given a verbal report mentioning all defects and measures advised for their rectification. A severely critical written report should, except in very exceptional circumstances, be avoided as this usually leads to misunderstanding and defeats its objective which is to rectify the potential hazards identified. The written report, which also indicates the state of immunization of the troops and average daily sick attendance, is endorsed in

the sanitary diary which should be submitted to the CO as soon as possible after the inspection. The sanitary diary should be a large substantial book, which is not likely to be lost, and which allows a record of the sanitary state of the unit to be maintained over a long period. Its upto date maintenance is the unit's responsibility. A sample is enclosed as Appendix with pages ruled into three vertical columns as per page 25 of Defence Services Regulations headed 'Points to be commented', 'Remarks of RMO', CO's remarks and 'Action taken' (usually by QM) (2). The report should conclude with a summarization of the general sanitary condition of the camp as, for example, 'excellent'. 'good', fair' or 'poor'. Comments should always be constructive and the observation of a defect should invariably have a concrete recommendation for its rectification. It must be remembered that all actions connected with the inspection are for an official purpose and lack of appropriate action / response from any official should not be construed as a personal affront by RMO / AMA. The motive of unit inspection is to achieve a progressive improvement in environmental conditions for maintenance of high standards of health and battle-worthiness of the unit at all times and should be accordingly appreciated by all concerned. The inspection note should provide a valid guide to the CO for assessment of the health of troops, their morale, and living conditions. After the CO has scrutinized it and rectification recommended are carried out by the regimental officers concerned or the reasons for not carrying them out are given, the sanitary diary should be forwarded by the unit to the SEMO through OC SHO by the 10th of every month as per page 12 of Army Order - 25 / 2004 / DGMS - Prevention of Food and Water Borne Diseases (4). The report serves as a guide for the SEMO to further advise the CO of the unit and keep the formation commander / station commander informed. Therefore, difficulties experienced by the unit also should be mentioned. The RMO should, whenever necessary, obtain advice and help from the DADH, and OC Station health Organisation. The RMO should also advise the CO and Regimental Officers to go through the simple procedures on elementary hygiene as given in DGAFMS publication on "Elementary Hygiene" (6).

**SEMO / SMO Visit**

Senior Executive Medical Officer (SEMO) is usually the CO Military Hospital. However any other officer may be designated SEMO by ADMS / DDMS for whole or part of a station. He visits the units under his jurisdiction in the unit once in a quarter and informs the Station Commander of any shortcomings. He is responsible to ensure that RMOs and OC SHO carry out their duties and responsibilities. He must keep the ADMS / DDMS also informed about all matters affecting the health of troops in station. In stations where no military hospital is located the ADMS / DDMS of the field formation whose troops are located in station may detail a medical officer to carry out the duties of SEMO. Such an officer is designated as Senior Medical Officer (SMO) for the units entrusted to his care (7, 2).

**Assessment of Health**

General considerationsThe armed forces select persons who are medically FIT besides physically strong to subject them to grooming and conditioning in training centres for transforming them to "trained" soldiers / sailors / airmen. A group of physically and medically fit individuals are thus available to the Commanding officer (& to his RMO / AMA). The armed forces attempt to provide good nutrition and a reasonably safe environment for their peace time duties and conditions them (acclimatization) for adverse conditions on need basis to ensure availability of fit combatants for war. The RMO / AMA gets some idea of the state of health (or extent of ill health) and morale of personnel in the unit under his medical care from the "daily sick report". However, this only reveals the state of illness. It does not automatically follow that those who are NOT reporting ill are healthy. The thoroughly carried out, regular, periodical medical inspections are more revealing. This is a reliable method of keeping himself informed of the state of health of unit personnel. The RMO / AMA is required to carry out the medical inspection of the following :

(a) All food handlers once a month. (4)
(b) All ranks newly posted to the unit. (2)
(c) All ranks before proceeding on courses of instruction/ leave/ temporary duty
(d) PBOR returning from courses of instruction/ leave/ temporary duty (2)
(e) Recruits posted to the unit from regimental centres (2)
(f) All ranks joining their units after serving abroad / proceeding abroad (2)
(g) All unit personnel yearly (8, 9)

Such medical inspection enables the RMO / AMA to detect a disease early in an individual and the rising incidence of any disease / condition in the unit, early enough to enable him to take prompt action and to advise the CO on the control measures to be adopted.

Food handlers

The detailed instructions for food handlers have been enumerated in page 9 of AO 25/2004/DGMS. All food handlers are medically examined with a view to detect harbouring of infections by food handlers which can be communicated through food or drinks. "Food handlers" will include any person concerned with the collection, storage, purification, cooking, serving or distribution of food or water and maintenance of cook house / kitchen equipment. This term therefore refers to NCO i/c cook house, cooks, masalchis, mess waiters, bar tenders, all personnel working in wet canteen and aerated water factory and any civilian staff or PBOR employed in cook house / mess. Special care should be exercised to also ensure that such staff are not returned to food handling duties after an episode of diarrhoea, jaundice, furunculosis or boils or unexplained fever (which could be enteric fever). Similarly, working parties detailed for episodic requirements like for parties / barakhana or as cookhouse working detail should not be suffering from the above mentioned diseases (4).

Newly posted personnel or personnel reporting to unit after course of instruction / leave/ temporary duty

These personnel may be harbouring an infectious disease in mild manner, in its incubation period or in convalescent stage. Early detection and segregation / isolation are needed to prevent an outbreak of the disease among personnel of the new unit. Common examples are conjunctivitis or a respiratory viral infection. Such personnel may also be harbouring vector borne diseases like malaria (on suppressive therapy). A proper history taking and examination followed by appropriate action by RMO / AMA will prevent introduction of the disease among the unit personnel.

Personnel proceeding on courses

All personnel proceeding to attend courses of instruction are required to be in acceptable medical category compatible with the requirement of the course. A medical certificate is required to be issued accordingly by the RMO / AMA after conducting a general examination and verifying that the individual is protected from diseases by immunization and is not due for recategorisation of medical category (if in low but acceptable medical category). In case found to be not fit for the course, the individual must be referred to the concerned specialist at the nearest MH for opinion regarding fitness to attend the course. Institutions conducting the course lay down specific instructions which are available in the joining instructions issued to the individual.

Recruits joining the unit

All recruits joining the unit are screened for presence of a communicable disease as well as any visible disability which may have been acquired during the training period or during transit period.

Personnel proceeding abroad/returning from abroad

Personnel proceeding abroad are required to be medically fit. They are therefore medically examined as per stipulations laid down periodically which include ECG, Chest - X-Ray, blood examinations (including HIV). Administration of appropriate immunizations at an appropriate date and initiation of chemo suppressive therapy for malaria or other diseases if recommended also form part of the medical examination at such an occasion.

Personnel may be harbouring exotic diseases acquired abroad including sexually transmitted diseases like HIV. It is mandatory that all such personnel are therefore screened immediately after return.

Annual medical exam

Yearly medical inspection of all personnel implies a thorough inspection of a person for fitness. A detailed record is to be maintained of such inspections and the health record card filled up. Detailed instructions on methodology of annual medical examination for officers (Army order 1 / 2004 / DGMS) and for PBOR (Army order 3 / 2001 / DGMS) has been laid down. In view of the increasing incidence of chronic diseases like Diabetes mellitus and IHD affecting PBOR in the Army, a system of Periodic Medical Examination (involving a more detailed medical examination) has been started for JCOs during 41st year of age or within one year of becoming Naib Subedar (8, 9).

Civilians

In order to protect the health of service personnel, as few civilians as possible should be employed or allowed into the unit lines. Certain civilians are employed as regular civilian government employees / temporarily for leave relief, etc as per laid down policies. These civilians provide logistic assistance where combatants may not be authorized. Vendors and hawkers of food articles should not be allowed in the unit area. All civilians employed or permitted to work in unit lines should be under strict medical supervision. The following precaution must be taken by RMO / AMA to ensure that no civilian entering unit lines conveys an infection to personnel :

(a) Before any civilian is engaged he should be medically examined by the unit medical officer. If passed as fit, he should be inoculated against the enteric group of fevers.

(b) All civilians employed in the unit for duties involving food handling should be regularly inspected once a month in same manner as for cookhouse staff. They should all be re-inoculated when due.

(c) Before a civilian returns to duty after an absence for any cause, he should be medically examined; and if the absence has been due to illness, this should be kept in mind before passing him fit to return to his work.

(d) Civilians in dairy farms, canteens, cookhouses, messes, butcheries and barber's shop should be employed on a permanent or long term tenure and always more thoroughly examined.

(e) Short term hiring for few days of persons of unknown past medical history should be discouraged, specially for tasks like cooks or food handlers.

Inspection of school children

Medical examination should be carried out preferably once a year for all children studying in schools run by armed forces or for armed forces. School children are specially vulnerable to develop diseases or conditions which adversely affect their scholastic performance. However most of the disorders if detected early are curable / correctable and hence the importance of medical examination of school children. OC SHO is responsible to organize the medical examination of school children in a station. Resources required for conduct of the medical examination can be provided by SEMO. Some schools organize the medical examination from their own funds, however, coordination of activities, record keeping and follow up actions are required to be ensured by OC SHO in conjunction with school authorities.

A complete examination should be made of the children with the assistance of school teachers. The points to note are the general appearance and demeanour of each child, height, weight, eye sight (near & distance vision) teeth, tonsils & adenoids, & the intelligence and systemic examination. The teacher in charge of each class should

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## Appendix

**Format of Unit Sanitary Diary**

MONTH_____

**SANITARY ROUND REGISTER**

| Points to be commented | Remarks of RMO | Remarks of CO | Action taken |
|---|---|---|---|
| 1. **Accommodation** | | | |
| (a) Cleanliness | | | |
| (b) Lighting & Ventilation | | | |
| (c) Floor | | | |
| (d) Overcrowding | | | |
| (e) State of Charpoys & bedding | | | |
| (f) Mosquito nets | | | |
| (g) Personal eqpt | | | |
| (h) General area | | | |
| (j) Other observations | | | |
| 2. **Cookhouse** | | | |
| (a) Cleanliness | | | |
| (b) Space | | | |
| (c) Floor | | | |
| (d) Lighting & Ventilation | | | |
| (e) Rat & Fly proofing | | | |
| (f) Smoke nuisance | | | |
| (g) Chapatti basket | | | |
| (h) State of utencils | | | |
| (j) Meat box | | | |
| (k) Meat Chopper | | | |
| (l) Ration Store | | | |
| (m) Personal hyg of cooks & state of immunisation | | | |
| (n) Clothing of cooks | | | |
| (p) Disposal of garbage & sullage | | | |
| (q) State of hand pumps | | | |
| (r) Wash basin | | | |
| (s) Other observations | | | |
| 3. **Dining Hall** | | | |
| (a) Cleanliness | | | |
| (b) Floor | | | |
| (c) Lighting & Ventilation | | | |
| (d) Seating arrangements | | | |
| (e) Fly proofing | | | |
| (f) Dining Hall | | | |
| (g) Bone receptacles | | | |

| Points to be commented | Remarks of RMO | Remarks of CO | Action taken |
|---|---|---|---|
| (h) Drinking water arrangements | | | |
| (j) Menu of food | | | |
| (k) Food tasting book | | | |
| (l) Arrangement for washing plates & glasses | | | |
| (m) Standing orders | | | |
| (n) Any other observations | | | |
| 4. **Barber Shop** | | | |
| (a) Space | | | |
| (b) Cleanliness | | | |
| (c) Furniture | | | |
| (d) Hair cutting appliances | | | |
| (e) Towels & aprons | | | |
| (f) Pers hygiene | | | |
| (g) State of Immunisation & nominal roll | | | |
| (h) Water supply | | | |
| (j ) Any other observations | | | |
| 5. **Latrines** | | | |
| (a) Cleanliness | | | |
| (b) Lighting | | | |
| (c) Water supply & drainage | | | |
| 6. **Bathrooms** | | | |
| (a) Cleanliness | | | |
| (b) Floor | | | |
| (c) Water supply & storage | | | |
| (d) Water drainage | | | |
| 7. **Office Room / Guard Room / QM Store** | | | |
| (a) Lighting | | | |
| (b) Ventilation | | | |
| (c) Rat proofing | | | |
| (d) Fly proofing | | | |
| (e) Working comforts | | | |
| 8. **Recreation, Information Room** | | | |
| (a) Space | | | |
| (b) Lighting | | | |
| (c) Ventilation | | | |

| Points to be commented | Remarks of RMO | Remarks of CO | Action taken |
|---|---|---|---|
| (d) Charts , Periodicals & Magazines | | | |
| (e) Indoor Games facilities | | | |
| 9. **Dhobi ghat** | | | |
| (a) Water supply / drainage | | | |
| (b) Washing platforms | | | |
| (c) Drying arrangement | | | |
| (d) Ironing arrangement | | | |
| 10. Family Lines | | | |
| (a) General Cleanliness | | | |
| (b) Lighting & ventilation | | | |
| (c) Mosquito nets | | | |
| 11. **Water supply** | | | |
| (a) Source | | | |
| (b) Chlorination | | | |
| (c) Leaking taps & pipes | | | |
| (d) Any unauth sources | | | |
| 12. **General observations** | | | |
| (a) Any mosquito nuisance | | | |
| (b) Any mosquito breeding areas | | | |
| (c) Residual spray | | | |
| (d) Drains | | | |
| (e) Provision of adequate litter bins | | | |
| (f) Any nuisance of stray cattle / dogs | | | |
| 13. **Medical Documents** | | | |
| 14. **General hyg / Sanitation** | | | |

Date : Signature of RMO / MO

Remarks of CO Remarks of OC SHO / Remarks of SEMO

Col UB Misra, Col S Basu & Col S Kant, VSM

# Hospital Administration in Armed Forces Hospitals : An Overview

## Introduction

Hospitals are complex matrix organizations. In provisioning of effective patient care it is essential that both clinical and administrative issues are considered. A holistic understanding of these is essential for efficiency of the hospitals. It is important that Medical Officers (MOs) and specialist officers, in addition to their clinical skills, are also well versed with the important administrative issues in the hospitals. Important managerial and administrative issues likely to be encountered by MOs / specialists in the hospitals are discussed in this chapter.

## Ward Management

### Functions and Responsibilities

MO Incharge (I/C) ward is the overall in-charge of the ward. He is responsible for efficient performance of the staff placed under his charge. His duties / responsibilities include the following :

(a) Ensure that the prescribed medication is given to the patient.

(b) Ensure dangerous drugs are kept under safe custody.

(c) Ensure medicines are properly indented, checked, stored and accounted. He should check the expense book of drugs at least once a month.

(d) Ensure correct distribution of diet/extras to patients.

(e) Ensure functionality of equipment in the ward at all times.

(f) Supervise and take measures for maintenance of furniture and fittings.

(g) Ensure general cleanliness and upkeep of ward.

(h) Ensure visitors visit during authorised hours only.

(j) Ensure availability and updation of following documents and records in the ward:

(i) Day and night report book.

(ii) TPR recording book.

(iii) Treatment / Injection book.

(iv) SIL/DIL register.

(v) Instructions / Round book.

(vi) Controlled and local purchase drugs accounting book.

(vii) Dangerous drugs book.

(viii) Inventory Register.

(ix) Breakage / loss book.

(x) Lab report (Advance report book).

(xi) DMO call book.

(xii) Input and Output chart record.

(xiii) Demand book for various stores.

(xiv) Out pass book for inpatients.

(xv) Complaint book.

(xvi) Suggestion book.

(xvii) Admission and discharge book.

(xviii) Register for diets and extras.

(xix) Fire orders.

(xx) Expense book.

(k) Ensure timely diagnostic investigations of patient as advised.

(l) Ensure timely specialists opinion for patient management.

### Management of SIL/DIL patients

The salient features to be considered are:

(a) Patients admitted to service hospitals are placed on Dangerous ill list (DIL) or Seriously ill list (SIL), if they are brought to the hospital / MI Room in grave or serious condition or their condition worsens while being treated in the hospital to an extent that intense monitoring becomes necessary. Placing a patient on DIL/SIL is purely based on clinical judgment of a medical officer or specialist.

(b) The progress of SIL/DIL cases on the case sheets must be written once a day for SIL cases and twice a day for DIL cases.

(c) Reporting of the DIL/SIL patients to higher formation must be done as per policy guidelines (1).

(d) Relatives of personnel placed on DIL are authorised free conveyance (2). The various provisons available on the subject are :

(i) Two persons are entitled free conveyance by Rail / Road in the same class as entitled to patient.

(ii) If traveling by air only one person is entitled free conveyance. The second person may travel by rail / road. The second individual may be allowed to accompany the relative by air subject to the following conditions:

- Where the relative is a lady.
- Where the relative is a male but is over 60 yrs of age or is infirm/physically handicapped.

(iii) The return journey is to be performed by rail/road and will be limited to the same persons who are provided free conveyance for the onward journey.

(iv) Airlift by service aircraft for hospitals in areas inapproachable by any civil means of conveyance (3).

(e) Free of cost ration may be issued at the scale laid down in Table-1, SRS/AI dt. 10/3/76 to the relatives of patients of the rank of JCO/OR and equivalent ranks in Navy/Air Force placed on

SIL/DIL in Service Hospitals not exceeding 02 in number for each patient. This concession is admissible only to the relatives of patients who are admitted is Service Hospitals which are located beyond a distance of 02 kms from the market (4).

Medical Ethics and Medico Legal Issues

The important points to be considered are as follows. Further details are given in the next chapter.

**(a) Misconduct**

MO I/C ward should ensure that there is no abuse of professional position by committing improper conduct with patients or by maintaining an improper association with patients. A male medical officer should examine a female patient only in the presence of husband/female attendant.

**(b) Consent**

The rights of the patient must be respected. Patients must be informed about their treatment and illness details. Written consent must be taken especially for the following :

(i) Surgical procedures.
(ii) Anaesthesia.
(iii) Disposal of tissues/organs removed during operation.
(iv) From NOK for autopsy examination in cases other than the medico-legal.

**(c) Refusal of treatment**

When the patient refuses treatment or insists on discharge from the hospital against medical advice after he has been explained the consequences, a certificate must be taken from him that he is seeking discharge/refusing treatment. The unit of the individual and CO/Registrar of the hospital should be immediately informed.

**(d) Discharge in Absentia**

If the patient leaves the hospital without having been discharged, the patient should be discharged in absentia and following to be informed immediately (5).

(i) CO/Registrar
(ii) CMP
(iii) Civil Police
(iv) NOK
(v) Unit concerned
(vi) Higher authorities

However all efforts to find the patient should be made before discharging a patient in absentia.

Medical Officers / Specialists should be conversant with the provisions of the following

**(a) Consumer Protection Act, 1986**

The Government of India enacted the Consumer Protection Act in the year 1986 with a view to provide simple, speedy & inexpensive redressal for consumer grievances related to defective goods, deficient services 7 unfair trade practices. A doctor can be held liable under the Consumer Protection Act, 1986 for deficiency of service. The National Consumer Disputes Redressal Commission and later the Supreme Court of India in the case of Indian Medical Association V/s V.P. Shantha, (AIR 1996 SC 550) has held that the services rendered by the medical practitioner is included and covered under the definition of services as per Section 2 (l)(o) of the Consumer Protection Act, 1986.

**(b) Right to Information Act 2005**

The Right to Information Act enacted in the year 2005, provides for setting out the practical regime of right to information for citizens to secure access to information under the control of public authorities, in order to promote transparency and accountability in the working of every public authority. The Public Information Officers (PIOs) are to provide timely information to person seeking information. Information such as that available to a person in his fiduciary relationship or which relates to personal info the discharge of which has no relationship to any public activity is exempt from disclosure. The Armed Forces are also under the purview of this act. The guidelines for providing information in the Armed Forces have been elucidated vide Human Right Cell, Addl Dte Gen Discipline and Vigilance, AG's Br, AHQ vide letter No 17732/6/Info Act/AG/DV-1(c) dt 18 Nov 2005. The PIO in the Armed Forces at various levels are as shown in Table 1. In the O/o DGAFMS, Director, AFMC (Coord) is the PIO for various sections and the DGHS (Armed Forces) is the Appellate Authority (Auth : DGAFMS, DG 1 (c), Army HQ, New Delhi letter No 43244/RTI/2006-07/Gen/DG-Ic dt 07 Dec 2006.

**(c) Medical Termination of Pregnancy Act, 1971**

Table - 1 : Public Information Officers in Armed Forces

| Formation | PIO | SOs of 'A' Br |
|---|---|---|
| Integrated HQ of MoD (Army) Command | Additional Director General of Public Info Brig | **Appellate Authority** DGD.C & W/AG's Branch |
| Corps/Area/Sub Area | 'A' (D & V) Col A | Chief of Staff |
| Stn HQ/Units/Est | | |

The MTP Act of 1971 lays down the condition under which a pregnancy can be terminated, the person(s) who can perform such termination and the place where such termination can be performed. Written consent of the guardian is necessary before performing abortion in women under 18 years of age.

**(d) Prenatal Diagnostic Technique (Regulation and Prevention of Misuse) Act and Rules. 1994 (amended 2002)**

Diagnostic Techniques (Regulation and Prevention of Misuse) Act, 1994, was enacted and brought into operation from 1st January, 1996, in order to check female foeticide. The Act prohibits determination and disclosure of the sex of foetus. It also prohibits any advertisements relating to pre-natal determination of sex

and prescribes punishment for its contravention. All hospitals/medical establishment in AFMC having Ultra sonography medicines are to be registered (Auth : O/o DGAFMS letter No 20028/PNDT/DGAFMS/DG-3A dated 28 Jul 2002). The various action, reports and returns that are to be furnished are detailed in the letters.

### Issue of Medical Certificates

All medical and medico-legal certificates and reports issued from a hospital are to be issued by the Administrative Authority of the hospital i. e. CO/Registrar/Administrative Officer. MO I/C ward should not issue certificates of such nature. A record of issue of such certificates to be maintained in the hospital.

### Bio Medical Waste Management

In wards should be done as per guidelines issued by O/o DG'sMS (6). Ward SOPs should be prepared for the management of biomedical waste. These should be in consonance with the hospital SOPs and guidelines issued by O/o DG'sMS . Accident reporting should be as per Appx `B' of DGMS (Army) letter and maintenance of records as per Appx 'C' of the ibid letter. Periodic bio waste audit should be done for improvement in processes and procedures. Details of Bio Medical Waste Management is discussed in a separate chapter.

### Fire Safety

One fire point is authorized for a ward having 24 beds (7). All patients must be briefed on actions to be taken in case of a fire in the ward / hospital. Appropriate structural and functional actions to be undertaken by the hospital. Regular fire fighting practice make the staff alert and prepares them to take appropriate action during fire hazards.

### Inpatient Death

All cases of hospital in-patient deaths will be attended by the Medical Officer-in-charge (MO I/C) of the ward during working hours or by the Duty Medical Officer (DMO) once the working hours are over. When death is declared by the Medical Officer, following actions are required to be undertaken by him :

(a) Death certificate AFMSF-93 (Part-I) is to be issued, mentioning diseases/ conditions directly leading to death, along with the antecedent causes, giving rise to such conditions. If the MO has examined the person before death and is sure of the cause of death and has no doubt about the death he should issue the death certificate (AFMSF-93, Part I) immediately. Cases of unnatural deaths (suicidal, accidental and homicidal) or when there is suspicion about death being natural, are to be reported to police for investigations as a medico legal case (MLC). Commandant / CO of the hospital must be kept informed.

(b) Arrangements should be made for speedy disposal of dead bodies from the wards to the mortuary. The Chief Ward Master and the mortuary duty staff should be immediately informed for this purpose.

(c) The Stats Section of the Hospital / Duty Clerk is instructed to pass a telegraphic message / signal to the NOK of the deceased and to others concerned, as per laid down policy.

(d) In medico-legal cases, the civil police is to be informed in writing.

(e) Detailed case notes should be written in the medical case sheets. Details of incidence leading to death of the individual, the clinical findings and the course of management, undertaken before death of the individual, are required to be mentioned.

(f) In case of `Sudden Death' in the hospital, Medico Legal Case (MLC) should be initiated in all cases and civil police to be informed.

### Accounting of Drugs and Stores (8)

The do's and don'ts for accounting of drugs and stores in wards is given in Box - 1.

**Box 1 : Do's and don'ts for accounting of drugs**

**Do's**

Following must be strictly accounted for in expense books.

- All NIV items.
- Expensive and easily pillferable items.
- Schedule E (Narcotics and Dangerous Drugs) of Drugs Act1940.
- Prepare indents in triplicate.
- Tally quantity issued by Medical Stores and quantity received by wards.
- For routine indents frequency of indenting should be:
  - ICU - weekly
  - Acute wards - fortnightly
  - Chronic wards - monthly
- Intimate Medical Stores of drugs/expendable items likely to expire at least 3 months before date of expiry.
- Maintain inventory for non-expendable items.

**Don'ts**

- Overstock drugs in wards.
- Place urgent indents too frequently.
- Countersign handing-taking certificate for

### Indices of Measurement of Hospital Utilisation

Hospitals generate various types of information from its various wards and departments. Hospital utilisation indices are one of the important data generated within a hospital. Some of the important indices related to hospitals are as follows:

**(a) Bed Complement**

The bed complement of a hospital is the total number of hospital beds available for use by in patients. In the Armed Forces it is called authorised beds.

**(b) Hospital bed**

A hospital bed is the one which is regularly maintained and staffed for the accommodation and full time care of a succession of in-patient and is situated in wards or areas of the hospital in which continuous medical care for inpatients is normally provided. This does not include healthy babies in maternity wards but includes incubators and bassinets for premature babies.

**(c) Admission**

Admission refers to the number per year of acceptances by a hospital of a patient who is to receive medical care while in residence therein and who is expected to remain in hospital for one or more nights. Healthy, newborn babies should not be counted as inpatient admissions, but babies requiring special care should be included among the admissions.

**(d) Discharge and Deaths**

The annual number of discharges includes the number of patients who have left the hospital (cured, improved, etc.) , the number who have transferred to another health or social institution and the number who have died.

**(e) Bed days or patient days**

"Bed day" or Patient day" is the unit of measure denoting the service rendered to one in patient in the hospital census between one day and the succeeding one. Sometimes the day of admission and the day of discharge are counted as one day. In other cases, a full day is counted only when admission is before mid day or discharge after mid-day. Thus, the data given should be the annual total of the daily census of occupied inpatient beds throughout the reporting year.

**(f) Average Length of Stay (ALS)**

This index indicates the average period in hospital (in days) per patient admitted. This figure may be calculated by adding cumulative number of bed-days of all discharged patient (including those dying in hospital) during one year divided by the number of discharges and dead patients. The hospitals holding patients of general nature as well as chronic cases should calculate the ALS separately. e.g. Patient "A" is discharged from hospital after staying in a hospital for 10 days, patient "B" died after 4 days of admission and patient "C" left hospital on transfer after 4 days of stay. The average length of stay of these patients would be ( (10+4+4)/(2+1))=6days

**(g) Bed Occupancy Rate (BOR)**

This figure expresses the average percentage occupancy of hospital beds. It is calculated by dividing the daily average number of beds occupied (obtained from the daily census of occupied beds) by the bed complement (nominal number of beds in the establishment) and multiplying by 100. e.g. If 130 beds are occupied of the total 200 beds, the bed occupancy rate for the said hospital would be 130/200 x 100 = 65%.

**(h) Hospital Care Evaluation Statistics**

There are certain other statistical values in addition to patient mortality and morbidity indices given above which reflect on the quality of care rendered by the hospitals. These are used in comparing the standard of work performed in different hospitals or in the same hospital at different periods. These are enumerated below :

(i) Post operative infection rate.
(ii) Post operative complication rate.
(iii) Caesarian section rate.
(iv) Autopsy rate.
(v) Rate of normal tissue removed.
(vi) Percentage of disagreement between final and pathological diagnosis.
(vii) Gross result of treatment i. e. patients discharged, recovered, improved and not relieved.

The do's & don'ts for ward management are given in

Box - 2 : The do's and don'ts for ward management

**Do's**

- Ensure correct and timely medication to patients.
- Ensure timely diagnostic investigations of patients.
- Ensure correct availability / accounting of drugs.
- Keep dangerous drugs under lock and key.
- Ensure functionality of equipment.
- Update documents timely.
- Measure hospital indices.
- Take appropriate consent from patients especially prior to surgical procedures. Keep the Registrar/ Commandant informed of any untoward incident in wards.
- Dispose biomedical waste as per guidelines. Ensure fire safety for patients and staff.

**Don'ts**

Box-2

**Out patient department (OPD)**

Out patient department is a section of the hospital where a person is given general or emergency diagnostic, therapeutic or preventive health service on an ambulatory basis, at regular hours by qualified personnel. OPD is rightly called the "Shop window" of the hospital. It makes the first impression on the visitor, as it is the first contact point. It is most important that adequate facilities are provided in this area. Some of the suggested measures for judging the performance of OPD are listed in following paragraphs :

(a) Workload

A record of the workload of OPD attendance, admission etc. provides the backdrop against which performance should be judged. Emergencies should be reflected separately, since they consume more time, effort and resources.

(b) Waiting Time

This is the most important factor in patient satisfaction. The shorter the waiting time in an OPD, the better is the state of satisfaction. Some waiting is unavoidable in a busy OPD. However, no patient should be expected to wait for more than 30 min for consultation.

(c) Comfort and Conveniences

Provision of appropriate facilities in OPD go a long way in improving image of the hospital, e. g. toilets, drinking water, cafeteria, music, TV, spacious lobby, waiting area, telephone, etc.

(d) Transport

Ambulance must be on standby 24 hours under control of MO I/C. At least one ambulance should be equipped with life support equipment.

(e) Behaviour of Staff

Most complaints against hospitals are due to rude behaviour of the staff. It is the responsibility of the MO I/C to inculcate the correct behaviour pattern in his/her staff and also to remain vigilant towards any breach of etiquette.

(f) Turnaround Time

This is the time taken for reports of Laboratory tests / other investigation reports / X-Rays to become available to patient. Efforts should be made to give patients their reports on the same day.

(g) Availability of Staff

Absence of doctors or paramedical staff from their place of duty is a significant factor in patient dissatisfaction. It should be ensured that doctors reach the OPDs in time and do not leave their duty station for trivial reasons.

(h) Availability of Equipment

Absence of needed equipment, or non-functioning equipment, is not only bad for the image of a hospital but can cost a patient his/her life. Hence all equipment must be functional at all times.

(j) Grievance Redressal System

Patient should know whom to approach in case he/she has a problem. The presence of a"May I Help You" counter may serve this need. Suggestion books or suggestion boxes must be provided to enable patients to express their views, complementary or otherwise, about the department.

(k) Patient Satisfaction Survey

To know the patients perception of services being provided, surveys to know their views/suggestion must be conducted. The results of these must be analysed and improvement in process / procedures / infrastructure incorporated.

Intimation of Medico Legal Cases to Civil Police

MO I/C MI Room / DMO is responsible to inform all cases of accident, suicide & homicide to the police, as required under Sec 39 of Cr PC. MO I/C MI Room / DMO / Specialist who order the stomach wash in suspected cases of poisoning is responsible for safe custody of the fluid obtained till it is handed over to the police. Same is the case with other substances like vomitus, stools, container of poison etc. (Sec 201 IPC). A careful labeling of these specimen hold legal importance.

Found Dead (BID) Cases

The following actions are to be taken in case of found Dead / Sudden Death Cases:

(a) The deceased to be examined in detail by the MO I/C MI Room / DMO and death confirmed.

(b) The identification marks to be recorded accurately,

(c) The circumstances leading to death to be ascertained from the person (s) bringing and identifying the body.

(d) All particulars of the person (s) bringing the deceased to be noted in the case sheet and statement given by them will be endorsed in the case sheet.

(e) Civil police to be informed in writing

(f) MO I/C MI Room / DMO to inform Comdt, Sr Registrar, Stats Sec/Duty Clk and CMP immediately.

(g) Body to be sent to mortuary for preservation.

(h) If no clearance is given by the police, the body to be handed over to them for further disposal, after taking proper receipt.

(j) In case the body is sent for postmortem to civil hospital, a brief summary of the case to be given to civil police. Under no circumstances the fatal case documents are to be handed over to civil police.

(k) The body will not be handed over to NOK without clearance of civil police in writing.

(l) The following documents will be initiated by MOIC MI Room/DMO:

(i) Flimsy (AFMSF 8A)

(ii) Case sheet (AFMSF 7)

(iii) Death Certificate (AFMSF 93 Part I) in red ink

(iv) Record of summary in Medico Legal Register

Case of Alleged Rape

Rape being a serious criminal offence, the nearest police station should be informed immediately and necessary examinations of accused and the victim to be carried out by authorised Medical Officer.

Do's and Dont's for OPD are given in Box - 3.

**Medical Stores**

Armed Forces Medical Services has a well-organized system of provisioning and procurement of Medical stores and it is undertaken by DG-2 group at the officer of DGAFMS.

Classification of Medical Stores

The Medical Stores are divided into the following categories

(a) **Expendable Medical Stores** : Depending on the life of pharmaceutical product these are further

**Box - 3 : Do's and don'ts for OPD management**

**Do's**

- Examination of female patients should be done only in the presence of husband/female attendant.
- Plan for accessibility to various facilities for patients/visitors with disability.
- Plan to ensure design follows function.
- Design to cater for future expansion.
- Plan effective signage system.
- Design for unilateral flow of patients and visitors.
- Plan to cater effectively for peak hours.
- Specify the role of MI Room / OPD in Disaster Management.
- Do maintain a separate medico legal register and ensure its safe custody.
- If patient is in a dying state and is giving a statement, record the dying declaration. Two witnesses should also be incorporated. Treatment should precede all legal formalities.

**Don'ts**

- Do not refuse emergency treatment to non-entitled cases.
- Do not throw away bullets/pellets/clothing of patients in medico legal cases.

categorized into:

(i) Short life, having shelf life of 2 years

(ii) Long life having shelf life more than 2 years

(b) **Non-expendable medical stores** : These consist of electro medical and non electro-medical equipment.

Important Terminologies

The following are some important terminologies regarding Medical Stores:

(a) **Medical Equipment Scale (ME Scales)** : This is the list of Medical Store items authorised to units and forms the basis for indenting.

(b) **Priced Vocabulary of Medical** : Stores (PVMS). This is a catalogue of government-approved list of Medical Stores in common use. Introduction / deletion of items is done by Drug Review Committee, which generally meets once a year under the chairmanship of DGAFMS.

(c) **Not in Vocabulary (NIV) Items** : These are items not included in the PVMS list. These are usually recently marketed drugs/equipment which have yet not been introduced in the PVMS.

(d) **Monthly Maintenance Figure (MMF) :** It is the average consumption of pharmaceutical products and forms the basis for calculation of requirement in indents. Availability of the product needs to be considered while calculating the requirement.

Disposal of surplus stores

The stores held in units may become surplus either due to change in authorisation or change in the requirement. Hospitals should intimate Command HQs, dependent depots and O/o DGAFMS to give disposal of surplus drugs/drugs nearing expiry date. As per the policy in vogue, DDOs may ask firms to replace unconsumed stocks 03 months before date of expiry free of cost. (9)

Disposal of Stores suspected of Toxicity

Drugs and other Medical Stores found to be defective should be disposed off in accordance with DGAFMS policy on the subject (10). The use of suspected product should be suspended immediately. Office of DGAFMS/DG-2E and the concerned Medical Stores Depot should be informed immediately and specimen of the suspected product should be sent to Controller of Quality (CQA), Kanpur for testing. The suspected product should be segregated and stored till clearance is received from O/o DGAFMS/CQA. Records of such cases should be maintained.

Table - 2 : Financial Powers of Competent Financial Authorities

| CFA | Without Consultation | With consultation with IFA |
|---|---|---|
| Maj Gen | Rs. 1, 00, 000/- | Rs. 2, 00, 000/- |
| Brig | Rs. 50, 000/- | Rs. 1, 00, 000/- |
| Col | Rs. 30, 000/- | Rs. 60, 000/- |
| Lt Col | Rs. 20, 000/- | Rs. 40, 000/- |

Financial Power of the CO/ Commandant

Financial Power of the CO/ Commandant of Hospitals for Local Purchase. The financial powers of the various CFAs is given in Table 2: (11)

Direct Demanding Officers (DDOs)

The salient features of the policy guidelines on the subject are as follows (9):

(a) Rate Contract (RC) powers for both PVMS and NIV drugs and consumables upto a value of Rs. 5 crore have been delegated to DGAFMS.

(b) Hospitals commanded by Brigs and above and four hospitals of Navy and Air Force commanded by Col and equivalent have been made Direct Demanding Officers (DDOs) to empower them to obtain their supplies of drugs and consumables directly from the vendor with whom RCs have been concluded by DGAFMS.

(c) Procurement against Rate Contract (RCs). Important points are as follows:

(i) Drugs and consumables with an annual turnover of more than 20 lakhs are to be progressed for Rate Contract.

(ii) DDOs must submit correct MMF every year to DGAFMS based on which DGAFMS will decide

on the quantum of drug/consumables for RC.

(iii) In case of non supply/delay in supply against central supply order and whenever deemed essential, DDOs may place supply order on Rate Contract holder directly under intimation to DGAFMS.

Local Purchase of Medical Stores by DDO

The following are the salient points for the local purchase:

(a) **Registration of suppliers :** Firms from where the purchases are to occur should be registered by a Board of Officers, duly approved by DDO. Item wise database should be maintained which should be reviewed ever year.

(b) **Tendering** : Two-bid system should be followed for all procurements. Bids should be asked, evaluated and selected first on fulfilling technical specifications and then being the lowest in financial terms. Details of tendering including preparation of Tender Enquiry, quantity to be procured, tender opening, preparation of Comparative Statement, Price Negotiation, placement of Supply Order, Acceptance of Contract, repeat orders, delivery and inspection of stores and payment of bills should be done meticulously. The essential requirements are:

(i) Tender Enquiry must include full details of the item required, delivery date, terms and conditions including payment terms.

(ii) The quantity to be procured should be calculated so as to ensure optimal availability.

(iii) The supply order should contain the name and address of contractor, contractor's quotation number and date, inspection authority, place of delivery, date of delivery, specifications of the pharmaceutical product/equipment, labeling particulars and packing details. Supply order should incorporate a cause that products supplied should have a minimum of 5/6th of balance shelf life at the time of supply.

(iv) Repeat orders should ensure:

- Items ordered in the original order have been delivered successfully.
- Repeat orders quantity is to be restricted to a maximum of 50% of original quantity.
- Placed within one year from date of supply against previous order and only once.
- Items are obtained at the same price as before and there has been no reduction in the price.

The important do's and don'ts of indents of medical stores are given in Box-4.

**Box - 4 : Do's and don'ts for indents of medical stores**

**Do's**

- Do indent item s of the same group and same PVMS section in the same indent sheet. Do quote the authority for indenting (ME Scale / GOI letter etc.)
- Do write the correct six /seven digit PVMS number in the indent.
- Do mention the correct NRS (Nearest Railway Station) in the indent sheet. Do forward requisite copies of indent sheet.
- Do reflect the correct MMF.
- Do submit the schedule of indent along with the indent.
- Do forward the sample signature of the indenting officer to the Depot.

**Don'ts**

- Do not mix up items of different group (special/short life/long life) in the same indent sheet. Do not place an indent at a wrong period.
- Do not exceed the number of items in a single indent

## Equipment Management

Effective management and efficient maintenance of hospital equipment have an impact on all aspects of patient care. Equipment management includes need assessment, procurement, inventorying, utilization, maintenance repairs, condemnation and disposal. An effective equipment maintenance plan saves lives, contains costs and ensures patient and staff satisfaction.

AO 5/99 and AO 12/2004 (12) gives details for procurement, stocking, issue, repair and maintenance of medical equipment. As per this AO medical equipment is categorized into the following:

(a) **Electro-Medical equipment :** Equipment listed in PVMS sections 25 and 28. Some equipment from other sections including NIV equipment are also categorised in this group.

(b) **Non-electro Medical equipment :** All mechanical, electrical and optical equipment not listed as electro-medical equipment or imported equipment are categorised as non-electro medical equipment.

(c) **Imported equipment :** These equipment are highly sophisticated in technology and procured either through foreign firms directly or through their Indian agents.

(d) **Gift equipment :** These are equipment received from non-public funds or as gift stores.

On receipt of the equipment from the AFMSDs it must be ensured that :

(a) Spares and accessories are received as per the equipment schedule of the manufacturer.

(b) Technical documents like the service/repair and maintenance manuals are available.

Maintenance of Equipment

The following are the salient aspects for effective maintenance of equipment:

**Box - 5 : Equipment maintenance objectives**

- Maximum availability, reliability of equipment.
- Useful life of equipment is extended.
- Safety of operations.
- Prevention of wastage of consumables.
- Maximum return on investment

(a) Equipment Maintenance Objectives (13) are listed in Box 5.

(b) Levels of maintenance are as follows

(i) First level. Maintenance carried in unit/ by operator of equipment.

(ii) Second level. By EME personnel in Station Workshop.

(iii) Third Level. By EME personnel in workshop (CRC) / AFMSD Pune / Equipment manufacturer)

(c) Classification of Types of Maintenance of equipment :

(i) Preventive Maintenance. This is the maintenance carried out at predetermined intervals or according to prescribed criteria and intended to reduce the probability of failure of functioning of an item.

(ii) Breakdown Maintenance. This is the maintenance carried out after fault recognition and is intended to put equipment into a state in which it can perform a required function.

Repair of Equipment

The following are the salient features regarding repair of equipment.

(a) For sophisticated / costly equipment. These will be maintained and repaired by the firm by undertaking the Annual Maintenance Contract.

(b) Non-electro equipment not under AMC is sent for repairs to the dependent EME workshop. If the repairs cannot be done equipment is labeled "Beyond Economical Repair (BER)".

(c) Electro-medical equipment not under AMC is sent to workshops designated as nodal repair workshops. If the repairs cannot be done the equipment is labeled "Beyond Local Repair (BLR)" and sent to nominated Command Repair Cell (CRC) or AFMSD, Pune

(d) If the equipment cannot be repaired at CRC or AFMSD it is declared BER. If the repairs cannot be under taken through workshops it may be carried out through a civilian firm. The financial powers for repairs are given at Table 3 : (12, 14)

Table - 3 : Financial Powers for Repair of Equipment

| Designation | Financial Powers |
|---|---|
| Commandant / COs Upto Col | Rs. 5, 000/- per repair |
| Brig & above | Rs. 25, 000/- per repair |
| Commandants: AFMSDs / AFT | CRs. 25, 000/- per repair |
| DGAFMS | Rs. 1, 00, 000/- per |

(e) The following maintenance performance indices may be utilised to determine the maintenance state of equipment:

$$\text{Downtime Index} = \frac{\text{Downtime hours}}{\text{Service hours}} \times 100$$

(i) $$\text{Maintenance Cost Index} = \frac{\text{Maintenance Cost}}{\text{Capital Cost}} \times 100$$

(ii)

(f) Log Book : This should be maintained for all important / costly equipment to facilitate maintenance state. This should include the following details :

(i) Name of equipment

(ii) Date of purchase

(iii) Cost of equipment

(iv) Name, address, fax, e-mail and phone Nos of supplier

(v) Date of installation

(vi) Spare parts of Inventory

(vii) Technical / users manual / circuit diagrams

(viii) AMC details

(ix) Warranty period

(x) Breakdown details

(xi) Repair details

(xii) Preventive maintenance details

**Box - 6 : Do's and Don'ts for Equipment Management**

**Do's**

- Do follow the guidelines and instructions for equipment management as given in AO 5/99 and policy letters of O/o DGAFMS.
- On receipt of equipment from AFMSD ensure that spares and accessories are received as per the equipment schedule of the manufacture along with service, repair and maintenance manuals.
- Do follow preventive maintenance.
- Do utilise the equipment performance indices.
- Do maintain log book for critical/costly equipment.
- Do utilise Armed Forces as well as authorized civil, repair facilities for early repair of equipment.

**Don'ts**

- Do not follow only breakdown maintenance for equipment (preventive maintenance is must).
- Do not get equipment repaired through unauthorised sources.
- Do not let a equipment be non functional for want of repair. Take prompt actions and follow up for early

The important do's and don'ts for equipment management are given in Box - 6

**Fund Management**

Funds constitute the finances available with an institute, formation or an unit which are either allocated by the Government or raised through the contributions from the serving personnel, canteen profit or rebates from regimental contractor / institute (15).

These are of two types :

(a) Government Funds. These are further sub divided into:
  (i) Public funds
  (ii) Imprest Account
(b) Regimental fund & Private funds

Public Funds

These include all funds, which are financed entirely from public money. Unspent amount is refunded to Government (in the event of it not been utilised within the same financial year). Following funds are included in this group :

(a) Annual Training Grant (ATG)
(b) Educational Training Grant (ETG)
(c) Library Grant
(d) Amenity Grant
(e) Incidental & Miscellaneous Grant (I & M) / Annual Contingency Grant (ACG)
(f) Civ Pay & allowance
(g) Hospital Stoppage Rolls (HSR)

**Annual Training Grant (ATG)**

This is a grant meant for Trg Aids and Eqpt. It is allotted by DGMT (GS Br) to Command and Formation HQs. It is then sub-allotted by the Formation HQs to units under their administrative jurisdiction. The management of this fund is governed by AIs 26/79 as amended vide AI 29/80 (16). Items which may be purchased from ATG include trg items, which are not in WET e. g. hiring tpt for training purpose, weapon-trg stores, training aid-audio visual, map reading stores and stationery can be purchased through these funds.

**Education Training Grant**

The grant is meant for periodicals, newspaper and magazines for troops. The claim is submitted to the CDA on contingent bill quarterly, based on actual posted strength present in the unit on the last day of every quarter. Items that can be purchased from this grant are – Educational items for unit school e. g. books, periodicals and stationery and other items for info rooms. The management of ETG is governed by provisions of AIs 9/84 and 24/91.

**Amenity Grant**

This grant facilitates expenditure on welfare of troops and patients. Its allotment is made out of Defence Service Estimates based on strength of troops. It is claimed in two equal installments, in Apr & Oct of year from the Regional Controller of Defence Accounts.

**Annual Contingency Grant (ACG) & Annual Stationery Grant (ASG)**

Earlier known as Incidental and Miscellaneous (I&M) grant. Contingent expenditure comprises of all those charges which are incidental to the management of a unit / establishment / office and include the cost of postage, telegrams etc. telephone charges, advertisements, office rent, books and periodicals, charges on hot weather appliances, liveries to office peons, repair of furniture, local transport charges on duty connected with the unit, garden impliments and other similar petty charges.

**Hospital Stoppage Roll (HSR)**

Money charged from dependent & family members of Offr, Para Military personnel, non entitled cases, Officers PSO and retd officer and their family members for hospitalisation period, is deposited in Government treasury.

**Imprest Account**

Imprest is advances of public money issued in bulk to certain nominated officers termed as 'Imprest Holders'. Imprest is maintained on IAFA-125 (Cash account book). All transactions, i. e. receipt / payments will be supported by vouchers i. e. acquittance rolls / MROs / Contingent bills. Expenditure from the imprest account can be undertaken for the following :

(a) JCOs/OR Pay & allowance.
(b) TA/DA advances to officers in exceptional cases when move is on short notice and money cannot be drawn from CDA (O)
(c) Condiment allowance of personnel.
(d) Rum & Cigarette allowance.
(e) Payment of funeral allowance.
(f) LTC adv JCO/OR.
(g) Urgent special investigation/treatment of patients in civil.

**Regimental Funds**

Regt funds are welfare funds of army which are raised through contribution by serving army personnel, canteen profits & rebates collected from regimental contractor. CO is trustee for regimental funds and is responsible for proper utilisation of funds. These funds are used for welfare activities and benefit of personnel and unit. It comprises of :

(a) All funds other than public funds mainly by unit, which are, financed either wholly or partly by public money.
(b) Private funds are those, which are not solely financed by public money. They are part of Regt funds.
  (i) Partly or wholly financed by public funds - Condiments allowance, Civ Labour welfare fund, Ex-Servicemen Fund.
  (ii) Privately financed funds – Unit funds, Sports

funds, Canteen profits, Religious institutes fund, Barrack damage fund, Officer Mess fund, JCO Club fund, Patient Comfort fund.

**Cash Books**

There are two types of cash books IAFA-125 & IAFA-811. History of the funds or source of income with scope of expenditure of all sub heads should be typed out and pasted on the first page of each book. Rate of Regt subscription and details of monthly remuneration as approved by CO will also be recorded on the first page. Cash books of Public and Regt funds are to be maint separately but on similar pattern. The following points must be remembered while writing cashbooks :

(a) There must be a separate book for every fund e. g. columnar cash book (IAFA-811) & cash acct book (IAFA-125) for Regt and Public funds.

(b) All entries must be in 'ink' with initials of accts officer.

(c) There should be no overwriting or erasing. Incorrect entries must be struck off with 'red ink' in a a straight line and correct entry inserted above it, duly attested by the officer (Auth: FR-II rule 46).

(d) At end of the month, the cashbook must be closed and balanced.

(e) Balance statement and balance sheet must be written in ink and bank reconciliation statement must be recorded monthly on the cashbook.

(f) Separate cashbook (IAFA-811) must be maintained by the cashier.

Box – 7 : Do's and don'ts for fund management

**Do's**

- Maintain separate cash accounts for Public and Regimental funds in RTC.
- Exercise supervision on all financial transactions. Sign only after studying and understanding the contents of financial documents. Keep cash in bank / RTC. Make entries for all transactions in cash books promptly. Surprise check of cash in RTC. Check details of sundry debitors and creditors.
- Prepare balance sheets monthly. Prepare conciliation statement between bank and unit account books.
- Expend the funds within stipulated time.

**Don'ts**

- Keep excessive cash balance in RTC.
- Exceed payment of pay and allowance beyond entitlements. Do unauthorised transactions between different funds.

The important do's and don'ts for fund management are given in Box - 7

Conclusion

In a hospital there are multiple and diverse administrative and managerial issues which emerge in provision of patient care activities. It is essential that MOs and specialists are acquainted with the likely issues/problems that may arise and the various options for dealing/solving them. Understanding and application of these is a major step in achieving patient satisfaction and continuous

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# Legal Aspects of Health Care

## Medico-legal case

### Definition

A Medico-legal Case (MLC) is a case of injury or illness where the attending doctor, after eliciting history and examining the patient, thinks that investigation by law enforcement agencies is essential to establish and fix responsibility for the occurrence of injury or illness in accordance with the law of the land.

Section 39 of Cr PC gives the list of incidents, which must be reported to the police by every citizen, including the medical officer, irrespective of the outcome of the incident.

The following cases are to be registered as medico-legal cases:

(a) Vehicular accidents, factory accidents or any other unnatural mishaps.

(b) Suspected or evident homicides, suicides including attempted ones.

(c) Suspected or evident poisonings.

(d) Burn injuries due to any cause.

(e) Injury cases where foul play is suspected, if the doctor thinks that the patient is an accused or a victim in a crime

(f) Injury cases where there is likely hood of death in near future

(g) Suspected or evident sexual offences

(h) Unconsciousness when the cause of unconsciousness is not clear.

(j) Medico-legal Deaths – as elaborated in the subsequent chapters.

However the list is not exhaustive. Hence the above-mentioned general principle is the best guide.

If the MO fails to report ML Case to the police authorities he can be punished under Section 202 & 176 of Indian Penal Code (IPC) with imprisonment of either description for a tem which may extend to six months, or with fine, or with both.

### Registration of a medico-legal case - procedure

(a) In all medico-legal cases that are not brought by the Police, written intimation must be sent to the Police Station in whose area of jurisdiction the hospital or heath care center reporting a case is located.

(b) It is the legal duty of the first doctor who attends the case – Sec 39 of Cr PC.

(c) In case where a casualty medical officer has not labeled a case as medico legal but a treating physician in the ward feels that a case needs to be registered as a MLC, he should inform the hospital administrative authorities for such action.

(d) There is no stipulated time period beyond which a MLC cannot be registered. A case can be reported as MLC not only at any time of its stay in the hospital but also after death.

(f) Referred / Transfer cases – Although legally not mandatory to re-register in the new station, it is advisable to report the case to the local police authorities in the new station to avoid problems if the patient dies in the new hospital.

(g) At the time of discharge/transfer of the case the police station with which the case is registered as MLC should be informed, preferably well in advance.

### Medico-legal cases brought by the police

Whenever the police bring a person for medical examination, a requisition to that effect by the Investigating Officer (IO) or the Station House Officer (SHO) giving a brief description of facts pertaining to the case is submitted to the medical officer specifying the purpose of the examination. This requisition constitutes authority for the examination and issue of a medico-legal report/certificate.

A police constable must accompany the person to be examined to identify the examinee to the medical officer as well as to prevent impersonation.

The report/certificate is to be submitted to the concerned IO in a sealed envelope.

The MO must retain a copy of the certificate/report submitted.

These medico-legal certificates/reports are legal documents and hence need to be prepared with great care after thorough examination of the person. They are to withstand legal scrutiny subsequently during the court proceedings.

### Consent for medico-legal examination

Informed Consent of the examinee is a must for all medico-legal examinations.

The legal provision that the examinee is at liberty not to consent and submit himself to examination, even if he is the accused, should be brought to his notice. This provision is based on the general legal principle that no individual, including the accused, can be compelled to give evidence against himself. He should also be informed that the findings of the medico-legal examination will be presented in the court and they may turn-out to be against his interest.

If the individual refuses to consent, the refusal should be obtained in writing, witnessed and the individual is sent back to the IO. Forcible medical examination should never be carried out.

However, where a person has been arrested for committing an offence and produced for medical examination under Sec 53 of the Cr PC, he can be

examined under force even if he refuses to give consent. The police is asked to make him ready for examination after his refusal is recorded.

Consent for medico-legal examination should always be a written expressed consent irrespective of the nature of examination.

As far as possible, the examination of a female should be conducted by a female registered medical practitioner. A male registered medical practitioner should examine the female, only in the presence of a female attendant.

#### Hospital death of medico-legal case

Should a case admitted and reported to the police as medico-legal case die in the hospital, the dead body should be sent to the mortuary and intimation regarding death is sent by the hospital administration to the police. Medical Certificate of Cause of Death will NOT be filled up by the ward MO/DMO. Under no circumstances the dead body should be handed over to the relatives directly. The concerned police officer (IO) will take over such body for inquest and will hand over the body to the relatives only after he decides that the same is no more required for any investigation/examination.

The same procedure is to be followed by the RMO for non-institutional medico-legal deaths.

#### Medico-legal report

A Medico-legal examination report must be prepared in the appropriate format by the attending doctor or Casualty Medical Officer (CMO). The report should be written by a doctor in his own handwriting. Particular care must be taken to ensure that the writing is legible and neat. Specific formats for different ML Case Reports should be available in the MI Room.

The general format of a medico-legal examination report is similar to that of a medical case sheet, with necessary minor modifications. It has three parts:

(a) Part I – Particulars of the Case

(b) Part II - Findings/Observations.

(c) Part III - Opinion

The following points are to be kept in mind while expressing opinion:

(a) Opinion expressed should be based on observations recorded.

(b) Opinion need not be expressed immediately following examination. The MO, at his discretion, should reserve his opinion till additional information becomes available to him like reports of investigations ordered by him.

(c) Despite all efforts if the MO is unable give definitive opinion about the issues under question, he should not hesitate/feel ashamed to say so, eg. Negative Autopsy.

The MO must retain a carbon copy of the report in his file for future reference.

Any samples (exhibits) collected by the MO for further forensic investigations should be mentioned in the report and handed over to the IO/his representative in sealed containers, ensuring Chain of Custody of Evidence.

#### Medico-legal certificate

A medical certificate issued and used for legal purposes is called Medico-legal Certificate. Like all other certificates, it is a brief, precise document in which the medical officer expresses opinion about a fact, eg Age Certificate, Medical Certificate of Cause of Death etc. The accompanying words- "I hereby certify"- require the issuing MO to be absolutely certain about the opinion expressed. Thus the evidential value of a medico-legal certificate is more than that of a medico-legal report.

It is mandatory for the issuing MO to mention his registration number below his signature in a medico-legal certificate.

Approved formats of the commonly issued medico-legal certificates should be readily available in the MI Room.

#### Dying declaration

Although not a medico-legal document, the MO should have some knowledge of it as he may be involved in recording it.

Dying declaration is the statement, written or oral, made by a dying person, with the knowledge that he is going to die shortly, about the circumstances that have been responsible for his imminent death under criminal circumstances.

Ideally a magistrate is to be called to record it, but if the death is too imminent the medical officer should himself record it. Dying declaration recorded only with the dying person in compos mentis (normal mind) will be held valid. A certificate to that effect by the doctor is essential. The doctor should record dying declaration in the same words as narrated by the dying person and in the presence of two witnesses. Police officer in-charge of the case should not be present during the recording.

After recording the declaration, the MO should send it to the magistrate in a sealed envelope.

#### Conclusion

Carrying out medico-legal examination and issuing a medico-legal report/certificate when requisitioned by the authorities concerned, is one of the mandatory legal duties of a MO. Avoiding or performing this duty casually/inefficiently may land the MO on the wrong side of the law.

## Medico - legal aspects of poisoning

#### Introduction

Medical officers might have to deal with cases of poisoning in the course of their professional duties. Poisoning might be accidental, suicidal or homicidal. It results in death on many occasions. All cases of poisoning need to be investigated by the police. Hence it is an essential legal duty of all medical officers as registered medical practitioners to report all cases of poisoning to the police.

#### Definition

Poison is a substance which if introduced in the living body or brought into contact with any part thereof, will

produce ill health or death, by its systemic or local effects or both. Very often it is the intended use rather that the inherent nature of a substance that meets the legally accepted concept of a poison. For instance a pharmaceutical agent which is beneficial in therapeutic doses might act as a poison if administered in higher doses with intention of causing harm.

**Role of medical officers in a Case of Poisoning**

(a) The patient should be immediately hospitalized and resuscitated.

(b) Case should be registered as medico legal case.

(c) Under Sec 39 Cr PC, all cases of poisoning are to be informed to the police by the medical officer. Non-compliance is punishable under Sec 202 IPC.

(d) Material for chemical analysis, like vomits, stools, urine, suspected article of food / drink, stomach-wash fluid etc. to confirm the diagnosis, should be collected by medical officer. These should be handed over to investigating officer in a sealed labeled container.

(e) Failure to preserve any suspected article, with intention to protect accused from legal punishment is punishable under Sec 201 IPC.

(f) Arrangement should be made to record dying declaration, if condition of the patient is serious.

(g) The medical records should be kept meticulously.

(h) In case of death of the patient, the medical officer, should not issue medical certificate of cause of death. The dead body should be handed over to the police for further investigations.

**Collection and Dispatch of Biological Materials for Chemical Analysis to the State Forensic Lab**

Body fluids and tissues collected either ante-mortem or post-mortem is handed over to the investigating officer for chemical analysis in Forensic Science Lab, ensuring chain of custody.

Since the biological material is likely to undergo decomposition, suitable preservative is to be added to the containers.

(a) Equal volume of rectified spirit is the ideal preservative for vomits, stools and viscera in all cases, except in cases of poisoning by alcohol. However, saturated solution of common salt, in equal volume, can be used for all cases except for cases of mineral acid poisoning.

(b) Blood is preserved by adding Sodium Fluoride and Potassium Oxalate to it. Usually 5-10ml blood is collected in ante-mortem situations and about 50ml in post-mortem cases. The preservative for 10ml blood is a mixture of 30mg potassium oxalate and 10mg of Sodium Fluoride.

(c) Urine is preserved by adding a few crystals of thymol or drops of dilute HCl to it.

(d) The containers used should be of adequate size and should not be filled more than 3/4 capacity to avoid spillage. They should be made of glass only.

(e) The container should be sealed and labeled.

(f) The specimen should be accompanied by a duly filled requisition form bearing the ink impression of the seal used, in addition to the clinical details.

## Medico-legal deaths

**When are deaths to be treated as Medico - legal ?**

As a rule the following deaths are reported as ML deaths:

(a) Un-natural Deaths

(b) Un-identified Deaths

(c) Un-diagnosed Deaths

(d) Un-attended Deaths (including Found Dead & Sudden Death Cases.)

(e) Deaths due to industrial occupational diseases, food poisoning etc too are reported as ML deaths as these are not naturally occurring diseases.

(f) All operation room, labour room and post invasive procedure deaths, where death is directly linked to the procedure.

The list is not exhaustive. It is the discretion and responsibility of the medical officer diagnosing (declaring) death to decide whether the death needs to be reported as medico-legal.

Battle Casualties and Battle Accidents are not ML deaths, hence are not reported to the police. However all Physical Casualties are ML deaths - A.O. 1/2003/MP refers.

Death of a military person in an accident involving military aircraft is exempted from the purview of Cr PC 174 and hence need not be reported to civil police. (Auth- Govt of India, Ministry of Home Affairs letter No. 8/179/71-GP A.1 dated 25 Nov 1972).

**Action by the Medical Officer**

(a) Examine the person and declare death after resuscitation is unsuccessful.

(b) Inform the (Civil) police by telephone followed by letter.

(c) Take custody of the dead body and preserve it in the mortuary till the police arrive and take over the body.

(d) DO NOT issue Medical Certificate of Cause of Death.

A case can be declared medico-legal by any medical officer at any stage of hospitalization. Though in routine practice, the MO IC MI Room handles the bulk of these cases, at times the circumstances of a case may become apparent only during hospitalization. In these cases the treating specialist or MO IC ward can declare a case to be medico legal.

**Investigation of ML Death: Cr PC Sec 174**

Inquest

An Inquest may be defined as a legal inquiry by an authorized agency to establish the cause and circumstances surrounding the death of a person, where death has occurred under illegal or suspicious

circumstances .

Investigating agency

Cr PC sec 174 vests the power of investigating ML deaths with Police. An officer of the minimum rank of Sub Inspector is empowered to carry out the official inquiry called "Inquest".

In special circumstances like death in custody, death due to police firing, dowry deaths the magistrate carries out the inquest as per Cr PC Sec 176.

Military Court of Inquest (AO 20/2001/DV)

(a) The formation commander can also order a military inquest under the authority of AO 20/2001/DV.

(b) Findings and opinion of military inquest will have the same legal authority as the police/magistrate inquest when it has been held in lieu of police/magistrate inquest provided prior approval of the civil authorities has been obtained for holding the military inquest. This step is usually undertaken in areas where civil administrative set-up to carryout the inquest is not available.

(c) The disposal of dead body will take place only after concurrence of the presiding officer of the court of inquest has been obtained.

(d) A copy of the court's proceedings is forwarded to the magistrate of the area.

**Conclusion**

It is again emphasized that the MO or the hospital administrative authorities should not hesitate to declare deaths as medico-legal and report the same to the civil police. This is not only a legal requirement but also help in establishing all the facts about that death.

## Medical Certification of Cause of Death

Mortality Statistics forms an integral part of the vital statistic system. They are one of the basic components of population growth. Cause specific mortality rates are key indicators of the health trends in the population and are provided by the system of medical certification of cause of death.

The law requires all births and deaths occurring within India, to be registered with the Registrar of births, and deaths in accordance with the provisions of the Registration of Births and Deaths Act, 1969. Registrar General of India is the highest official.

In India as per the provisions of Sec 10 (3), Registration of Births and Deaths Act, 1969 every medical practitioner is duty bound to issue, without charging any fee, a Medical Certificate of Cause of Death (MCCD) in cases where he has attended to a person during his last illness and where he is satisfied that the death was due to natural causes.

(a) Medical officer should not delay, issuing death certificate, once he is sure of the cause of death.

(b) He can not charge any fee for issuing death certificate.

(c) He should not withhold issuance of death certificate even if his dues are not cleared by the relatives.

(d) No medical officer should sign death certificate in advance or without viewing and examining the dead body personally.

**MCCD should NOT be issued in any of the following situations**

(a) Where a practitioner is called to see a person who has died suddenly and whom he had never examined before.

(b) When he has some suspicion as regards the cause of death

(c) Where there is the slightest suspicion of violence, even in the presence of serious natural disease.

For battle casualties and battle accidents, the decision of commanding officer and RMO, as regard the cause of death is final. As per Army order 1/2003/MP, death certificate in case of battle casualties is issued by AHQ AG's branch.

**Instructions for filling Medical Certificate of Cause of Death**

The first part consists of particulars (identity) of the deceased including age and date and time of death.

The second part is the medical part. Its format has been standardized and approved by WHO. It consists of two parts:

(a) First - Immediate, Antecedent and Underlying Causes (Primary / Direct cause).

(b) Second - Other significant (secondary) conditions that contributed to the death.

Abbreviations should not be used while filling up the certificate and the diseases have to be mentioned as per ICD-10 along with their code numbers.

Part - I

Only one cause is to be entered on each line of Part I. The underlying cause of death should be entered as the lowest line in this part. The underlying cause of death is the condition that started the sequence of events between normal health and the immediate cause of death.

**(a) Immediate cause**

The direct or immediate cause of death is reported on line (a). This is the disease, injury or complication that directly preceded death. It can be the sole entry in the statement. There must always be an entry on line (a)

Mode of dying such as cardio respiratory failures, heart failure should not be entered at all. In the case of violent death enter the result of the external cause (e.g. fracture of skull, crushed chest).

**(b) Antecedent Cause**

If the condition on line (a) was the consequence of another condition, record that in line (b) as antecedent cause. This condition must be antecedent to the immediate cause of death, both with respect to time and etiologically or pathologically. Violence or circumstances of accident antecedent to an injury entered on line (a), should be entered on line (b). (e.g. Road Traffic Accident, fall from height).

**(c) Underlying Cause**

The condition which gave rise to the antecedent condition on line (b) is to be reported here. If the condition on line (b) is the underlying cause, nothing to be entered on this line.

(d) The original format, approved by WHO, had only (a), (b) and (c) under I, but as per recommendations of 43rd World Health Assembly, 1990, an additional line (d) has been added below (c).

Part- II

Diseases or conditions believed to have influenced the course of the morbid process and thus contributed to the total outcome but which were not related to the disease or condition causing death.

After completing the form the certifier signs the certificate giving his name, qualification, designation and registration number. The date and time of signature will be the same as in the beginning of the certificate, except in cases where the cause of death has been certified after an autopsy.

**Conclusion**

Medical Certificate of Cause of Death is the back bone of mortality and morbidity statistics of a community, based on which National Health Policy is formulated. Hence it is essential that every medical officer should be careful in providing the information through MCCD.

## Consent in medical practice

**Introduction**

A successful relationship between a doctor and his patient is based on mutual trust. To establish trust a doctor must respect patient's autonomy - the right to decide whether or not to undergo any medical intervention. A patient must be given sufficient information, in a manner that he / she can understand, to enable him / her to exercise the right to take an informed decision about the care they are to receive.

**Definition**

Consent means voluntary agreement, compliance or permission. As per the Indian Contracts Act, Section 13, two or more persons are said to consent when they agree upon the same thing in the same sense.

To be legally valid, the consent that is given must be intelligent, informed and with free will. Consent is not free when it is produced by coercion, under influence, fraud or misrepresentation and intoxication. (I.P.C. Sec 90)

**Types of Consent**

(a) Implied
(b) Express
  (i) Verbal
  (ii) Written

Implied Consent

An implied consent is indicated by the patient's co - operation and conduct. It is the most common variety of consent in medical practice. The patient implies consent to medical examination by registering with the doctor, narrating his symptoms and providing other information asked by the doctor in connection with his disease etc. It is sufficient for only external clinical examination involving not more than inspection, palpation, percussion and auscultation.

Verbal Express Consent

The patient expresses his consent verbally to a specific oral question by the doctor. This grade of consent is a pre-requisite for internal clinical examinations, giving intra-muscular injections and other non-invasive procedures. Ideally it is to be obtained in the presence of a disinterested witness.

Written Express Consent

For all procedures involving threat to life or limb, invasive diagnostic and treatment procedures, blood transfusion etc a written express consent is to be obtained. In these circumstances the consent has to be a fully Informed Consent. Consent for medico-legal examinations as far as possible has to be a written express consent, except where the person is in police custody.

**Informed Consent**

The consent obtained after providing complete information to the patient about the modality of treatment being adopted or investigative procedure being carried out is called Informed Consent.

A fully informed consent is a good defense available to the doctor against blame of medical negligence on the ground of failure to inform a patient of the risks associated with a procedure.

**Who Should Obtain Consent?**

Ideally it is the duty of the doctor providing treatment or undertaking an investigation, to discuss it with the patient and obtain consent.

Consent Under Special Circumstances

**(a) Consent of Persons subject to Army / Navy / Air Force Act**

When a person in uniform refuses to give consent for any investigation or treatment, the medical administrative instructions provide for placing the person under Medical Category 'C'(Permanent) for that ailment. Under no circumstances treatment/investigation should be carried out without consent.

**(b) Consent in cases of emergency where the patient is conscious and competent**

Consent is implied in all cases of emergency.

**(c) Consent in medico-legal case (MLC)**

Consent is required to examine a person even for medico-legal purposes. However, when the person is in police custody as an accused and examination is being carried out under Sec 53 Cr PC (on the orders of the police official/magistrate), necessary force may be applied to carry out the examination if he refuses to give consent for the same.

**(d) Consent for examination of children**

In India the legally accepted minimum age for giving valid informed consent for medical examination and routine

treatment is twelve years. Age of consent for treatment involving danger to limb or life is eighteen years.

**(e) Consent for examination of insane persons**

In case of insane persons, the guardian is the person, legally competent to give consent.

**(f) Illegal actions and consent**

Consent is invalid in illegal procedures like criminal abortion, euthanasia etc.

**(g) Spousal consent for procedure likely to cause sterility/impotence:**

Sterility and impotence do not constitute grounds for divorce when acquired after marriage. However these conditions have a material importance in the nature of conjugal relations. Therefore it is essential that spousal consent should be taken, where treatment induced sterility, impotence or other factors affecting the marital rights of either spouse are involved.

### Conclusion

All MO should be aware of the various aspects of consent. Practice of medicine without due application of various aspects of consent is not only un-ethical but also illegal. A well informed consent is a very good defence should the doctor be blamed for negligence, in these days of 'patient autonomy.

## Injury report

### Introduction

Any medical officer may be called upon to examine an injured person.The doctor who examines an injured person has the responsibility of not only treating but also to prepare and issue the Injury Report, if asked by the police. This may be followed by giving expert evidence in the court of law. All details of examination of injured person should be entered in medico legal/Accident register maintained in the casualty of all hospitals.

Definition: As per Sec 44 IPC, injury is "Any harm whatever illegally caused to any person in body, mind, reputation or property."

### Medical Classification of Injuries

(a) Mechanical Injuries
  (i) Blunt Injuries:
    - Abrasions
    - Contusions
    - Lacerations
  (ii) Incised Wounds
  (iii) Stab Wounds
  (iv) Firearm Injuries

(b) Thermal Injuries:
  (i) Due to Cold
    - Frostbite
    - Trench foot
    - Immersion foot
  ii) Due to Heat
    - Burns
    - Scalds

(c) Injury due to Energies
  (i) Due to Electricity
  (ii) Due to Lightening
  (iii) Due to X-rays
  (iv) Due to Radioactivity
  (v) Due to Explosions

### Legal Classification of Injuries

(a) Simple Injury
(b) Grievous Injury

Sec 320 IPC defines Grievous Hurt.

The following kinds of injuries are designated as "grievous";

(a) Firstly- emasculation.
(b) Secondly- permanent privation of the sight of either eye.
(c) Thirdly- permanent privation of the hearing of either ear.
(d) Fourthly- privation of any member or joint.
(e) Fifthly- destruction or permanent impairing of the powers of any member or joint.
(f) Sixthly- permanent disfiguration of the head or face.
(g) Seventhly- fracture or dislocation of a bone or tooth.
(h) Eighthly- any hurt which endangers life or which causes the sufferer to be during the space of twenty days in severe bodily pain, or unable to follow his ordinary pursuits.

### Recording & Interpretation of Injuries

Any medical officer may be called upon to examine injured person. Injuries should be examined without delay at any time of day or night, as any lapse of time will modify the features of the injury. All details of examination of injured person, whether admitted into hospital or treated as outpatient, have to be entered in an Accident Register, to be maintained by all hospitals and clinics. A detailed and accurate record should be made by the doctor at the time of examination. The doctor will be required to issue injury report when asked by the police. The format of Injury Report and the method of filling it up is given in **Appendix** at the end of this chapter.

(a) The first four columns of the table are for recording of the findings of examination of the injured person. The next three columns are for recording the opinion on various aspects of the injury. The remarks column is for providing other relevant medico-legal information.
(b) Every injury is to be given a serial number and described separately. However, when injuries are minor, of same type (nature) and are located as a group they can be described as a group – e.g. multiple abrasions over the back.
(c) In the column for Nature of Injury the name of the

wound as per the medical classification of injuries- i.e. abrasion, contusion, incised wound, etc., should be noted.

(d) Meticulous recording of the shape and size of the wound is essential to compare with those of the suspected weapon and opine about the possibility of infliction of the wound by a weapon of those dimensions.

(e) For imprints, shape of the imprint (preferably in the form of a diagram) and various dimensions of the imprint are recorded.

(f) Column for "Situation over the body", should mention the exact situation of the wound with reference to anatomical landmarks e.g. the mid-line, a joint, the navel or the nipple etc. Orientation of the wound i.e. horizontal, vertical, oblique, etc. should also be noted.

(g) While describing all the features of the wound technical (medical) terms should be avoided. As far as possible, common English terms understandable by the police and judicial officers should be used.

(h) The medical officer will opine on the following medico-legal aspects of the wound, based upon the above mentioned (observed and recorded) features of the wound:

(j) Legal Type of Injury (simple, grievous or grievous – dangerous)

(k) If the nature of injury and extent of injury cannot be made out at the time of first examination e.g. when a fracture is suspected and expert opinion of the x-ray of the part is awaited; abdominal injuries with vague symptoms awaiting investigation/operation results, etc. the injury report should not be given hastily.

(l) However, if considerable delay is anticipated in obtaining the required information – e.g. awaiting reports of certain investigations or clinical course, prognosis and outcome of the injury - it is advisable to issue the injury report keeping the particular opinion pending. The final opinion can be given at a later date when the necessary information becomes available.

(m) Kind of Weapon: The kind of weapon/instrument possibly responsible for infliction of the injury should be mentioned.

(n) Weapons causing injury are grouped into:

(i) Hard and blunt weapons e.g. stick, stone, fist, etc.

(ii) Light sharp weapons e.g. knife, scalpel, razor blade, sword.

(iii) Heavy 'sharp' weapons e.g. axe, hatchet, saber, etc.

(iv) Firearm

(o) Opinion about the kind of weapon is expressed as per the following guidelines:

(i) Blunt Injuries (Abrasions, Contusions, and Lacerations) are caused by Hard Blunt Weapons.

(ii) Incised Wounds are caused by Light Sharp Weapons

(iii) Heavy Sharp Weapons invariably cause Chop wounds as they are invariably used as clubbing weapons.

(iv) Stab injuries are caused by thrusting of Weapons with Long Blade.

It is to be noted that the nature of injury depends not only upon the kind of weapon but also upon its manner of use.

(p) In some situations the particular injury can be linked to suspected weapon of assault more closely. If the dimensions of the wound exactly tally those of the alleged weapon, e.g. Signature Fracture produced by a Hammer, the opinion can be "The possibility of wound having been caused by the weapon of similar nature can not be ruled out."

(q) In the column for opinion about Age of Injury, the possible time lapsed since occurrence of the injury should be given. This is assessed by noting the stage of blood clotting process, chronological changes of inflammatory reaction, changes due to healing process etc.

(r) The remarks column is for recording observations about the condition of clothing, the clinical condition of patient, the investigations carried out to confirm/diagnose the nature of injury and their results, any trace evidence collected from the wound like broken glass piece, broken tip of knife, grease, pieces of cloth, bullet, wad, etc. Similarly information whether the injured person is hospitalized should be provided.

(s) Having prepared the injury report in duplicate according to above guidelines, the medical officer affixes his signature and other details at the bottom of the report. Original copy is handed over to the authorized representative (constable) of the investigating officer after obtaining his signature for receipt of the same on the report. The second copy is maintained by the medical officer for future requirement when summoned as expert witness in the case. Any trace evidences collected during the examination are handed over to the police constable, maintaining "Chain of custody of Evidence", for forensic examination.

(t) If an injured person comes directly to the medical officer, it is his legal duty –under Sec 39 of Cr PC - to send a written intimation to the police station in whose area of jurisdiction the hospital or health care center is located.

### Introduction

Medico – legal aspects of patient care is receiving considerable attention in all health care delivery systems. In the Armed Forces Medical Services, health care establishments are located in all parts of the country. Law and order being a state subject, subtle differences in legal procedures do exist from one state to another.

Every MO should bear in mind that the legal procedures followed in a particular state have to be followed in handling cases that fall within the medico legal domain. Guidelines given hereafter are generally applicable all over the country. Nevertheless in specific cases, it would be advisable to familiarize oneself with current rules and regulations that apply to a particular place.

### Medical Certification and Competence

Every MO is a registered medical practitioner. Therefore in law, he / she is treated as being technically qualified to carry out all medico – legal work, including medico – legal autopsies. Medico – legal work is carried out in only those centers that have been authorized for the purpose by the State Govt. Within the Armed Forces, only AFMC, Pune is authorized to carry out medico – legal work. However all health care establishments have to handle cases that have medico – legal implications. Therefore a correct approach to a case is essential for all MOs.

Nowadays there is reciprocity between MCI and State medical councils. Therefore MOs in the AFMS can carry out their professional work all over the country, irrespective of their State of registration. Nevertheless in cases of professional misconduct they would be subject to the jurisdiction of the State Medical Council that has originally granted them recognition.

### Medico – Legal Duties of MO

This Section aims at making all the MOs of AFMS aware of their medico-legal duties and responsibilities. Unlike the clinical management of a case, the medico – legal duties involve interaction with non – medical agencies such as the Police and Courts of Law. Therefore fulfilling legal requirements related to the investigation and trial of a case places an additional responsibility upon the MO attending to a case.

### Approach

The different chapters of this section will focus on common medico-legal scenarios that a MO is likely to face in his professional work. This is a very basic guideline. A more detailed ML Manual for AFMS is being published shortly by the Dept of Forensic Medicine & Toxicology, AFMC, which will address all issues of pertinence in greater detail.

Presently the following topics will be briefly discussed :

(a) MLC – Medico – legal Case – Report
(b) Medico – legal Aspects of Injuries
(c) Medico – legal aspects of Poisoning
(d) Medico – legal Deaths
(e) Death Certification
(f) Consent in Medical Care
(g) Medical Negligence
(h) Consumer Protection Act

### Conclusion

It is again emphasized that MOs of AFMS are NOT IMMUNE from any of the laws applicable to medical practice in the country. Since they are employees of AFMS, any legally wrong practice of medicine by them will bring disrepute, including legal action, not only to the particular MO but also to AFMS. Commanding Officers of Military Hospitals have a great legal and administrative responsibility in ensuring that medicine is practiced legally and ethically.

## Medical negligence

### Introduction

Medical officers may be sued by patients for Medical Negligence claiming hefty compensation. This has become more likely due to awareness of patients about their rights and applicability of acts like Consumer Protection Act to the medical profession. Since doctors of AFMS are employees of Ministry of Defence, the blame will partly be on the employer, leading to adverse administrative action too against the MO. Such incidences will tarnish the image of the AFMS. Hence it is essential that all MOs of AFMS must be aware of the issue.

### Definition

Want of reasonable care and skill or willful negligence on the part of a medical officer while treating a patient with whom patient doctor relationship has been established so as to cause bodily harm or mental agony.

### Civil & Criminal Negligence

Difference between the two lies mainly in the degree of harm caused. If the negligent act has resulted in death of the patient then the loss can not be compensated monetarily alone and the act amounts to "causing death due to rash and negligent act". Such gross negligence is termed as Criminal Negligence. All other cases of negligence where the damage can be compensated monetarily are labeled as cases of Civil Negligence.

Negligence is to be proven by the patient by establishing the following points-

(a) That the defendant (doctor) owed a duty of care to the plaintiff (patient)
(b) That the defendant was in breach of duty.
(c) That the plaintiff suffered damage as a result.

Duty of Care

The contract between the patient and the doctor gets established the moment the doctor accepts the individual as his patient and lasts till the cure of the particular illness or till it is terminated by either party, whichever is earlier.

Breach of Duty

A doctor is not liable for error of judgement either in diagnosis or treatment, so long as he applies a minimum reasonable standard of skill and care. A doctor can misdiagnose and mistreat a patient without being

negligent, even if another practitioner of greater skill would have had more success. A doctor does not guarantee to provide the best possible care, but only care consistent with his professional qualification.

A doctor is not liable for error of judgement either in diagnosis or treatment, so long as he applies a minimum reasonable standard of skill and care. A doctor can misdiagnose and mistreat a patient without being negligent, even if another practitioner of greater skill would have had more success. A doctor does not guarantee to provide the best possible care, but only care consistent with his professional qualification.

Damage suffered by the patient - Examples,

(a) Loss of earnings.
(b) Expenses.
(c) Reduction in expectancy of life.
(d) Reduced enjoyment
(e) Pain & suffering
(f) Death

**Precautions Against Medical Negligence**

(a) Good rapport with patient and his relatives
(b) Informed Consent
(c) No guarantee of accurate diagnosis & cure
(d) Follow Approved Modalities of Management.
(e) Duty to be Well Informed.
(f) Duty to communicate with other doctors-consultants
(g) Duty to obey summons for attendance.
(h) Do not omit to institute routine and basic measures like immunisation, sensitivity testing, proper use of antibiotics etc.
(j) Don't operate when unwell / unfit.
(k) Accurate and Legible Medical Records.
(l) The following are certain guidelines for the medical officers to avoid subsequent problems for self as well as for fellow practitioners-
    (i) Do not criticize fellow practitioner in the presence of patients or relatives.
    (ii) Do not make a statement constituting or admitting fault on your part.
    (iii) Refrain from over optimistic prognosis.
    (iv) Check instruments and equipment and keep them in a state of readiness, especially emergency equipment.
    (v) No experimentation without patient's informed consent, even if it is for therapeutic purposes.
    (vi) No procedure to be performed beyond ones skill.
    (vii) To avoid administration of wrong drug, the medical officer should personally read the label on the drug container. Treatment instructions to the subordinate staff should be issued in writing and never telephonically.
    (viii) All male medical officers must ensure presence of a female attendant while examining female patients.

**Common Causes of Negligence**

(a) Failure to Attend

The doctor is blamed on this count due to the ambiguity about the termination of the patient doctor relation. Some authorities feel that the contract lasts till the present illness is cured but others feel that it exists till either party terminates it. The doctor is supposed to attend the call from the particular patient till the existence of the contract.

(b) Casualty Dept

Any lapse on the part of any staff of the casualty dept is likely to invite litigation due to the nature of circumstances and out come of the cases in question.

(c) OT Deaths

Operation theater/labour room deaths and deaths following invasive procedures are bound to give rise to doubts of negligence. Hence these cases should be ideally reported as medico-legal deaths, so that an inquiry by a third party (police) is carried out to clarify all aspects of the incidence.

(d) Therapeutic Hazards

The doctor is likely to be blamed for such mishaps if the consent obtained is not an informed one.

(e) Failure of Communication

A consultant is likely to be implicated if the patient suffers damage due to communication gap between him and the family physician.

**Conclusion**

Medical Negligence is a legal entity. All blames of negligence are considered by the judiciary keeping all aspects of the situation and intricacies and uncertainties involved in the practice of medicine. However all MOs should take due precautions to avoid blame of Medical Negligence.

## Consumer protection act as applicable to medical profession

**Introduction**

Consumer Protection Act was enacted by the Parliament of India in 1986 to protect the rights of consumers. Difference of opinion existed even among the legal luminaries till 1995 as to its applicability to the medical practice. However in 1995, the Supreme Court of India ruled that the act is applicable to medical profession in the land mark case, Indian Medical Association Vs V P Shantha .

**Summary of Supreme Court Judgement - 1995**

(a) Service rendered to a patient by a medical practitioner (except where the doctor renders service free of charge to every patient or under a contract of

personal service) would fall within the ambit of 'Service' as defined in the Act.

(b) The fact that medical practitioners belong to the medical profession and are subject to the disciplinary control of the Medical Council of India and/or State Medical Councils would not exclude the services rendered by them from the ambit of the Act.

(c) A “contract of personal service” has to be distinguished from a "contract for personal services". The service rendered by a medical practitioner to the patient cannot be regarded as service rendered under a "contract of personal services" and is not covered by exclusionary clause of the definition of 'service contained in the Act.

(d) The expression "contract of personal service", can not be confined to contracts for employment of domestic servants only and the said expression would include the employment of a medical officer for the purpose of rendering medical service to the employer. The service rendered by a medical officer to his employer under the contract of employment would be outside the purview of ' service' as defined in the Act.

(e) Service rendered free of charge by a medical practitioner attached to a hospital/nursing home or a medical officer employed in a hospital/nursing home where such services are rendered free of charge to everybody, would not be 'service '. The payment of a token amount for registration purpose only at the hospital/nursing home would not alter the position.

(f) Service rendered at a non-government hospital/nursing home where no charge whatsoever is made from any person availing of the service and all patients (rich and poor) are given free service is outside the purview of the expression 'service'. The payment of a token amount for registration purpose only at the hospital/nursing home would not alter the position.

(g) Service rendered at a non-government hospital / nursing home where charges are required to be paid by the persons availing of such services falls within the purview of the expression 'service '.

(h) Service rendered at a non-government hospital / nursing home where charges are required to be paid by persons who are in a position to pay and persons who cannot afford to pay are rendered service free of charge would fall within the ambit of the expression ‘service’, irrespective of the fact that the service is rendered free of charge to persons who are not in a position to pay for such services. Free service, would also be 'service' and the recipient a 'consumer' under the Act.

(j) Service rendered at a government hospital/health centre / dispensary where no charge whatsoever is made from any person availing of the services and all patients (rich and poor) are given free service-is outside the purview of the expression 'service '. The payment of a token amount for registration purpose only at the hospital/nursing home would not alter the position.

(k) Service rendered at a government hospital/health centre / dispensary where services are rendered on payment of charges and also rendered free of charge to other persons availing of such services would fall within the ambit of the expression 'service ', irrespective of the fact that the service is rendered free of charge to persons who do not pay for such service. Free service would also be 'service' and the recipient a 'consumer ' under the Act.

(l) Service rendered by a medical practitioner or hospital/nursing home can not be regarded as service rendered free of charge, if the person availing of the service has taken a insurance policy for medical care where the charges are borne by the insurance company and such service would fall within the ambit of 'service'.

(m) Similarly, where, as a part of the conditions of service, the employer bears the expenses of medical treatment of an employee and his family members dependent on him, the service rendered to such an employee and his family members by a medical practitioner or a hospital/nursing home would not be free of charge and would constitute 'service' under the Act.

**Note :** As on date Consumer Protection Act is not applicable to hospitals of AFMS. However the ambit of the act is being expanded regularly. ESI hospitals have been brought under its ambit following a recent (May 2007) Supreme Court of India judgment.

**Conclusion**

The medical professionals have become apprehensive of frivolous allegations and loss of reputation following the applicability of the act to medical practice. However there is no cause for worry as the same legal principles as applied in civil courts are applied while deciding the issue of medical negligence in Consumer Fora also. However all MOs need to be more vigilant to avoid blame of negligence.

**Appendix**

Injury report

To,

The Investigating Officer,

Police Station----------

Ref your letter No ---------- dated ----------

Sir,

I am forwarding herewith the report of examination of:

Name of the Injured ----------

son/wife/daughter/of----------

Resident of ----------

Brought by PC---------- No ---------- PS----------

Consent for examination----------

Identification marks

1. ----------

2. ----------

History in Brief:

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Height: ---------- Weight: ----------

| Sr. No. | Nature of injury, whether abrasion, contusion, laceration, incised wound, burn etc | Shape and Size of injury | Situation on the body | Simple or Grievous | Kind of weapon | Age of injury | Remark- Admitted or Not Investigations Carried out, any trace evidences collected. |
|---|---|---|---|---|---|---|---|
| | | | | | | | |

Place ---------- Signature of Medical Officer ----------

Date & Time ---------- Name with Qualifications ----------

Seal Designation ----------

Col Sunil Kant, VSM & Col AK Jindal, YSM

# Health Management during Disasters

## Introduction

Disasters have existed ever since the existence of mankind and no community is immune to the emergencies caused by natural and manmade disasters. Worldwide, natural disasters have been known to be one of the major problems in terms of mortality, number of people adversely affected and economic losses. There is no evidence to suggest that frequency of natural disasters will alter significantly in immediate future. Natural disasters have tended to be more destructive in last few decades as they affect larger concentration of population due to increased urbanization, and settlements in disaster prone areas.

The spectrum of occurrence of disasters indicates that the Asian region is one of the most disaster prone regions as 60% of the major natural disasters reported in the world occur in this region. India is amongst the most disaster prone countries in the world due to high vulnerability to natural disasters like floods, earthquakes, cyclones and droughts. In India, flood affects over 9 million hectares area annually, 56 % of landmass is vulnerable to seismic activity of varying degree and 5700 kms long coastline is prone to severe cyclones with very severe loss of life and economic damage. Besides the natural disasters, India is also vulnerable to manmade disasters like transportation accidents, chemical and technological disasters and other such events.

It is evident from the spectrum of occurrence that adequate procedures to deal with disaster situations are necessary. Disaster management requires well-coordinated public policy for disaster prevention, mitigation, preparedness, emergency response and reconstruction. Health care in disaster is one of the critical elements (1). The issue becomes even more relevant since proper foresight and planning is of considerable importance for disaster management. Often, in disaster situations, a lot of resources have been wasted due to improper planning and impulsive actions (2).

## Definition

The concept and definition of disasters have altered over times in accordance with changing concepts concerning their cause and effect. The definition of disasters have reflected this change, with increasing attention being given to the social aspects of disaster situations and collective ability to meet the requirements of these situations. Disasters have been defined in various ways on the basis of degree of physical impact of the event, magnitude, disruption of public safety, disproportion of resources and in terms of special efforts required and controllability of events.

(a) Pan American Health Organization (PAHO) has described disaster as "an overwhelming ecological disruption occurring on a scale sufficient to require outside assistance."

(b) Sociologically "A disaster is an event in time and space which produces the condition whereby the continuity of the structure processes of social units become problematic."

(c) Commonly disasters are defined as an 'overwhelming ecological disruption which exceeds the capacity of a community to adjust and consequently requires assistance from outside. W Nick Carter defined it as 'an event, natural or manmade, sudden or progressive, which impacts with such severity that the affected community has to respond by taking exceptional measures' (3)

(d) As per the Disaster Management Act 2005, 'Disaster' means a catastrophe, mishap, calamity or grave occurrence in any area, arising from natural or manmade causes, or by accident or negligence which in substantial loss of life or human suffering or damage to, and destruction of property, or damage to, or degradation of environment, and is such a nature or magnitude as to be beyond the coping capacity of the community of the affected area (4).

## Classification of Disasters

Disasters have been classified in various ways, but the most convenient method used is division of disasters in two distinct categories according to their causes i.e. natural and manmade. The understanding of classification helps in short-listing the hazards existing in the area for planning and preparing the facilities for optimum response

### Natural Disasters

These include the following

(a) **Meteorological Disasters**: Storms, cyclones, hailstorms, hurricanes, tornados, typhoons, snow storms, cold spells, heat waves and droughts.

(b) **Topological Disasters**: Earthquakes, avalanches, landslides and floods

(c) **Biological Disasters** : Epidemics of communicable diseases and insect swarms (e.g. locust swarms)

### Manmade Disasters

(a) **Accidents**: Transportation accidents (land, air, and sea), collapse of buildings, dams and other structures, mine disasters, and technological failures such as mishap at a nuclear power station or leak at a chemical plant causing pollution of atmosphere (5).

(b) **Civil disturbances**: Riots and demonstrations.

(c) **Warfare**: Conventional warfare (Bombardment, blockage or siege): Non-conventional warfare: (Nuclear, Biological and Chemical warfare, Guerrilla warfare including terrorism).

(d) **Refugees**: Forced movements of large number of people usually across the frontiers.

## Spectrum of Disaster Management

The spectrum of disaster management involves disaster prevention, mitigation, preparedness, response and recovery.

### (a) Disaster Prevention

It covers those measures, which are aimed at impeding the occurrence of a disaster event and / or preventing such an occurrence having harmful effects on communities. It is concerned with the formulations and implementation of long-range policies and programs.

### (b) Disaster Mitigation

Measures aimed at reducing the impact of a natural or manmade disaster on a nation or community.

### (c) Disaster Preparedness

Measures, which enable governments, organizations, communities and individuals to respond rapidly and effectively to disaster situations. Preparedness measures include the formulation of viable disaster plans, the maintenance of resources and the training of personnel. Organizing, planning coordinating, resource planning and training are its major concerns.

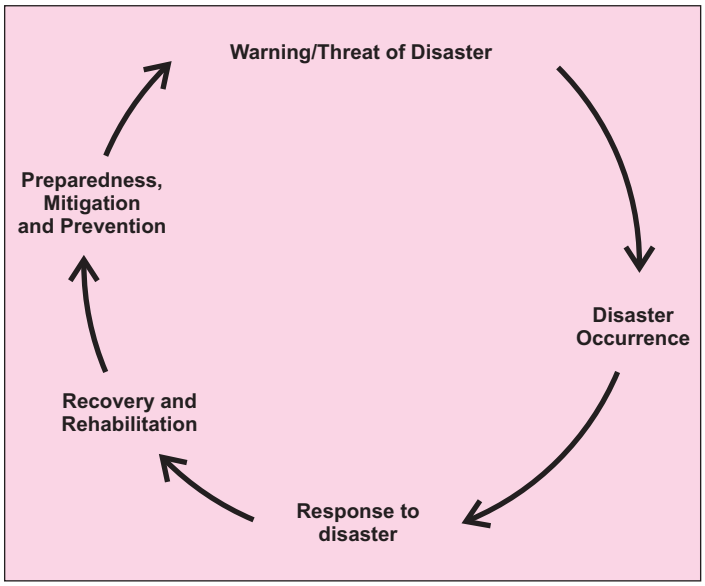
### (d) Disaster Response

Response measures are those, which are taken immediately, prior to and following disasters. Such measures are directed towards saving life and protecting property and dealing with the immediate damage caused by the disaster. Its success depends vitally on good preparedness.

### (e) Disaster Recovery

Recovery is the process by which communities and the nations are assisted in returning to their proper level of functioning following a disaster.

Fig - 1 : Process of Disaster




Disaster situation has been conceptualized as a process with differing phases. In each different phase, the information needed, the action required, the problem encountered and people involved may be quite different. A better understanding of disaster process and inter relationship of these different phases is important for emergency response. The different phases in disaster process are preparedness, warning, threat, impact, assessments, rescue, immediate action, initial recovery, long-term rehabilitation and prevention (Fig 1). Each phase will vary according to the type of disaster event with different time element. Some researchers divide the disasters into three phases, pre-disaster, disaster emergency and post disaster phases.

## Special Characteristics

Disasters are considered phenomena in themselves and have profiles with some special characteristics. Understanding these basic characteristics is essential for its management.

The geographic divisions of area concerned with disaster were conceived in order to classify the arising problems and to help manage them. Three major divisions are in vogue, Impact Area, Filter Area and Community Aid Area. Impact Area is where disaster has struck causing damage; Filter Area is undamaged zone surrounding the impact area from where immediate aid by community starts; The Community Aid area is immediately outside the filter area from where the organized rescue and relief flows.

Analysis of various disaster situations of differing magnitude and its consequences confirm that there are many common pattern of human and organizational behavior in emergency situation. The psychology of disaster involves some distinct facets like victim before, during and after disaster, of the volunteer helper, trained professionals and onlookers. Behavior pattern and disaster psychology must be understood in order to cope with the problem.

Convergence is observed to be a common problem in most disaster events and it has an important bearing on disaster management. Convergence characterized by the spontaneous movement of large number of people, large amounts of material towards the zone of impact and communication convergence are the common problems. Convergence cannot be completely blocked but it can be channeled.

Disaster management implicates different sectors at different times, therefore need for cooperation and coordination amongst various agencies is never more apparent than in the case of disasters, hence there is a need for multidisciplinary approach in disaster planning and preparedness.

## Principles of Disaster Planning

Disaster Management means a planned and systematic approach towards understanding and solving problems in the wake of disasters. Disaster planning cannot prevent disasters but its effects could be minimized by

appropriate plans and preparedness. Some of the general principles of disaster planning are universal and can be applied in all the situations. The foremost requirement is that it should be a continuous process, it should reduce the unknown in a problematic situation, and it should be based on valid knowledge. Other important facts are that it should evoke appropriate action, focus on general principles, and it must be tested.

Disaster plans and preparedness to deal with disaster situation are necessary for every community and particularly the health care system with its critical component, the hospitals which are to be prepared consistently to mobilize all their facilities for maximum use. Realistic, well-rehearsed and properly coordinated disaster plan executed by well-trained system is essential to meet the challenge of disasters. The key issues in disaster management are communication, coordination and control. Important issues in pre-disaster management are prediction, prevention, planning and preparedness. The critical issue when disaster event occurs is the immediate response, rescue, relief and rehabilitation.

## Disaster Management in India

In India the Central Government and State Government share the responsibility for disaster management. The primary responsibility for disaster planning, preparedness, rescue and relief is of the State Government. The States are supported by Central Government by providing informational, financial, technical, material and training support. In the State Government plans, the district, which represents the basic administrative unit, is the focal point of disaster management.

The Disaster Management Act, 2005 was enacted on 23rd Dec 2005 (4). The Act defines disaster management as a continuous and integrated process of planning, organizing, coordinating and implementing measures which are necessary for

(a) Prevention of threat of disaster.
(b) Mitigation of risk of any disaster.
(c) Capacity building.
(d) Preparedness to deal with any disaster.
(e) Assessing the severity.
(f) Evacuation / rescue / relief.
(g) Rehabilitation & reconstruction.

Prime Minister is the Chairperson of the National Disaster Management Authority which has been constituted under the Act. Apart from the Chairperson, the National Disaster Management Authority has Members, Advisory and Executive Committees. Parallel organization structure and authorities also exists at State & District level (4, 5).

The Armed Forces are the key resource and response organization for relief and rescue. The Armed Forces Medical Services are a critical element in the emergency response. In order to be effective and efficient during disaster, event pre-planning and co-ordination with various government organizations and health care institutions in the region would be necessary. Therefore, during preparedness phase, the role, responsibilities, and coordination of health care become very essential at all levels from Formation HQs to the Medical Establishments and upto the RMO level.

## Critical Elements of Preparedness and Response

The preparedness and response depends upon various critical elements. The information of the disaster plans from State Level to District Level, role and responsibilities of various resource organizations, mechanism for coordination, control and practice are some of the critical issues. The preparedness will depend upon appropriate disaster plans for regional / local area based on risk, hazards and vulnerability analysis, and the resources available.

The coordination at various levels of government by the appropriate Formation HQ and at local level by the Medical Establishment based on the anticipated role and responsibility is a critical issue for rational response during disasters.

The disaster plans preparedness and response is dependent on the State Government policies, legislation, organization, disaster plans, resource organization, role and responsibilities of various agencies, logistic plans, coordination, evacuation and shelter plans, training, public awareness and drills. The State Government plans become the baseline for the matching Formation HQ Plans, to provide the support expected in disasters. The Formation HQ plans at various levels will include all the elements of resource organization to meet the demand of anticipated disaster event. The role and responsibilities allotted for health care becomes the total point for preparedness and developing health care plans. Each Medical Establishment then prepares its plans based on the overall objectives, roles and responsibilities and resources available.

## Health Problems Related to Disasters

Though all disasters are unique in that, they affect areas with different social, medical and economic backgrounds, there are still similarities between disasters, which, if recognized, can optimize the management of health relief and use of resources. The following points in this context need to be noted:

(a) There is a relationship between the type of disaster and its effects on health.
(b) Some effects are a potential rather than an inevitable threat e.g. Population movements and other environmental changes may lead to increased risk of disease transmission.
(c) The actual and potential health risks after disaster do not all occur at the same time. Instead, they tend to arise at different times and vary in importance e.g. casualties are greatest when there is crowding and standards of sanitation have declined.

(d) People generally recover quickly from their immediate shock and spontaneously engage in search and rescue, transport of the injured, and other relief activities.

Table - 1 : Short Term Effects of Disasters

| Effects | Type Of Disaster | | | |
|---|---|---|---|---|
| | Earthquakes | High Winds (without Flooding) | Tidal Waves (flash Floods) | Floods |
| Death | Many | Few | Many | Few |
| Severe injuries requiring extensive care | Overwhelming | Moderate | Few | Few |
| Increased communicable diseases load | Potential risk following all major disasters (Probably rising with overcrowding and declining sanitary conditions) | | | |
| Food scarcity | Rare | Rare | Common | Common |
| Population displacements and movements | Rare | Rare | Common | Common |

## Short Term Effects of Disasters

The various short term effects of disaster is shown in table - 1

### Health problems common to all disasters

(a) Social reactions

These could be grouped as follows:

(i) Spontaneous behavioral reaction e.g. generalized panic or stunned waiting.

(ii) Widespread looting.

(iii) Rumors regarding spread of epidemic.

(iv) Population displacements leading to excessive burden on relatives and friends, parks, city squares, vacant lots and government buildings and urban areas where public services can't cope resulting in increased morbidity and mortality.

(b) Climatic exposure

The need to provide emergency shelter varies greatly with local conditions.

(c) Food and Nutrition

Food shortages in the immediate aftermath may arise in two ways. Food stock destruction within the disaster area may reduce the absolute amount of food available, or disruption of distribution systems may curtail access to food even if there is no absolute shortage.

(d) Communicable Diseases

The transmission of communicable diseases after natural disasters may be influenced by following factors:

**(i) Pre existing Disease in the Population**

The risk of epidemic after a disaster is related to the endemic levels of disease in the population. Where a disease agent did not exist in a population before a disaster, there is generally no risk of an outbreak occurring. These include diarrhea and dysentery, cholera, measles, whooping cough, meningococcal meningitis, tuberculosis, malaria, intestinal parasites, scabies and other skin diseases, louse borne typhus and relapsing fever.

**(ii) Ecological Changes Resulting from Natural Disasters**

Natural disasters may alter the potential for disease transmission by altering the ecological conditions. In this context, the most important diseases are those transmitted by mosquito vectors and by water. The breakdown in living conditions following disasters may increase the hazard of transmission of plague, louse borne typhus and relapsing fever. The incidence of dog bite and risk of rabies may increase as neglected strays come in close contact with persons living in temporary shelters.

**(iii) Population Movements**

Population movements may influence the transmission of diseases by increasing population density causing burden on the water supply and other services in the receiving areas and / or introducing susceptible population to a new disease or disease vector. The important diseases to occur in temporary settlements are diarrheal diseases and dysentery, viral hepatitis, measles, whooping cough, malaria, tuberculosis, scabies and other skin infections.

**(iv) Damage to Public Utilities**

Damage to water supplies and sewage disposal systems may increase water borne and excremental diseases.

**(v) Interruption in Public Health Services**

The important services interrupted in this context are vector control programs, which might lead to resurgence of malaria and other vector borne diseases; routine immunization programs against measles, whooping cough, poliomyelitis, tuberculosis and diphtheria.

**(vi) Altered Individual Resistance to Diseases**

Protein Energy Malnutrition, which affects children in poorer population of most of the developing countries, increases susceptibility to many communicable diseases including malaria and tuberculosis.

**Prevention & control of communicable diseases**

The prevention and control measures of communicable diseases should be on the following broad principles (6, 7):

(a) Setting up a Surveillance System

It is established to collect, collate and interpret the data. It will need the services of an epidemiologist / public health specialist, paramedical and health personal and clerical staff.

(b) Disease Surveillance

The objective of disease surveillance after disaster is to identify disease outbreaks, in order to investigate them and to instigate appropriate disease control measures. The diseases considered for surveillance include those known to be endemic to the area, those, which represent a serious health hazard, and those, which are amenable to control. A more focused, system based surveillance system should be instituted. These symptom complexes, which might be important, include fever, fever and diarrhea, fever and cough, trauma, burns, measles etc. These data should be analyzed, interpreted, and presented to the higher authorities (6, 7).

(c) Laboratory Services

Lab for basic diagnostic tests of stool and blood may be established by field reporting units but for specific bacteriological and virological tests, the referral labs in nearby cities or areas will have to be marked (7, 8, 9).

(d) Vaccination and Vaccination Programs

Mass vaccination campaigns against the following diseases will be helpful, as well as some other vaccines for specific diseases, depending on the threat perception ( 7 – 9) :

(i) Tetanus
(ii) Measles

However mass vaccination campaign against typhoid and cholera should be avoided because of the following reasons:

(i) Offer low and little individual protection.
(ii) Complete coverage of population is probably impossible.
(iii) Require large number of workers who could be better employed elsewhere.
(iv) Could lead to reuse of inadequately sterilized needles that may transmit Hepatitis B / HIV.
(v) May lead to false sense of security about the risk of disease and to neglect of effective control measures.

**Environmental Management**

The measures will entail actions in the following areas:

(a) Water Supply

A survey of all water points will have to be made, giving priority to drinking water distribution system. It will have to be determined, if the water supply has been contaminated by sewage or chemical contaminants. If bacterial contaminants are found, the water supply should be disinfected before distribution by increasing residual chlorine. It is recommended that all repaired mains, reservoirs, treatment tanks or other units should be properly cleaned and disinfected (10, 11). The mass distribution of water sterilizing tablet, bleaching powder or liquid disinfectants should be carried out. Individuals in limited and controlled groups may be given such disinfectants to purify small amounts of drinking water for one or two weeks.

(b) Basic Sanitation (10 – 13).

These include the following

(i) Making of emergency latrines.
(ii) Development of solid waste collection and disposal facilities. Burying or burning solid wastes is recommended.
(iii) Health education

(c) Vector Control (7, 14).

Essential vector control measures in disaster are as follows:

(i) Elimination of breeding places by water management and not allowing stagnant pools i.e. by draining, filling and overturning receptacles.
(ii) Enforcement of personal protective measures by people.
(iii) Indoors spraying with 0.1% pyrethrum.
(iv) Outdoors spraying with malathion / fogging.
(v) Control of houseflies by regular spray of Nuvan on dumping sites and around cooking places.
(vi) Prevention against rodents by improving environmental sanitation, storing food in closed areas, early and safe disposal of solid wastes and use of rodenticides like zinc phosphide.

(d) Personal Hygiene (7)

These include:

(i) Provision of washing, cleaning and bathing facilities.
(ii) Avoidance of overcrowding in sleeping quarters.
(iii) Health education.
(iv) Personal safety and protective measures must also be observed by all those involved in disaster relief operations (15).
(v) Burial / Disposal of the Dead

Bodies are unlikely to cause outbreaks of diseases such as typhoid fever, cholera or plague, if death resulted from trauma. However, they may transmit gastroenteritis or food poisoning syndrome to survivors if they contaminate water sources. Despite the negligible risk, dead bodies represent

a delicate social problem. The normal local method of burial or cremation should be used although mass cremation requires large amounts of fuel. Before disposal, bodies must be identified and the identifications recorded.

## Organization of Medical Care for Disaster (3, 16, 17).

The medical care in disaster situation has two distinct facets : pre-hospital care and hospital care. The pre-hospital care involves dispatch of the medical team, care at site and evacuation of victims to definitive care facilities. The hospital care involves triage, emergency care and continuation of treatment, intensive care, diagnosis, treatment and rehabilitation.

The principles of mass casualty management are universal and can be applied in any mass casualty situation natural or manmade. The importance of triage, first aid, life saving measures, transport and evacuation for definitive care to hospital has been recognized the world over. The mass casualty management demands standard simple therapeutic procedures and standardized drugs & medical supplies. On site care demands establishment of a command post triage team, first aid team, mobile hospital (if required), evacuation team, transport and communication.

Hospitals play a crucial role in medical care of the disaster victims. All hospitals must be prepared to meet the challenge of disasters by having an appropriate disaster organization, pragmatic disaster plan, clearly defined role and responsibilities of various staff, laid down plan for each department, accident and emergency department, critical services like OT, ICU, Laboratory, diagnostic, blood bank and other supportive services.

### Disaster Preparedness

The preparedness is the next crucial stage where the following aspects are to be given attention by the Formation HQs and Medical units. Contingency plans prepared by Govt of India for various contingency situations may be referred to (5). In addition, plans for stocking and distribution of medical supplies should be given special attention (18).

(a) Development of disaster plans – which is realistic and adaptable and it is harmonized at all levels. It must be clearly written and periodically tested.
(b) Resource plans for health care.
(c) Role and responsibility of resource organization.
(d) Logistics, equipment and supplies required.
(e) Arrangement for communication, transportation, evacuation.
(f) Coordination and control
(g) Disaster drills.

**Preparedness addresses the following important issues:**

a) Arrangements for on site medical help include the following:
   (i) Alerting and dispatch of mobile help team.
   (ii) Staff, equipment, transport and communication.
   (iii) Arrangements for onsite coordination for rescue and relief.
   (iv) Triage, First Aid and Evacuation Team.

**b) Hospital Disaster Plans. The disaster preparedness includes the following aspects:**

(a) Alert, recall, deployment system.
(b) Triage, First aid, Emergency care arrangements.
(c) Critical area response like OT, ICU etc.
(d) Support services like Blood Bank, Radio diagnosis, Pharmacy, CSSD etc.
(e) Expansion and creation of facilities for disaster victims.
(f) Sustaining the plan and matching resource allocation.
(g) Mock Disaster drills.

### Role of Hospital in Disasters

Hospitals play a major role in the management of all kinds of disasters . They must be organized to respond in a timely and efficient manner to the complex needs arising from a mass catastrophe which may occur within or out side the hospital.

Internal or External Disaster

An internal disaster is an emergency situation that occurs within an institution that may interrupt services, threaten the lives of staff, patients and visitors and may necessitate mass evacuation. Internal disasters may be caused by fires, building, collapses, explosions and others. An external disaster occurs outside the hospital, induced by natural causes or by human activities.

### Objectives of a Hospital Disaster Plan

The main objectives of the hospital disaster plan should be as follows :

(a) To prepare the staff for peak performance during a disaster.
(b) To optimize the available resources during disaster.

### Characteristics of a Hospital Disaster Plan

Irrespective of a hospital's characteristics, complexity and resources, every hospital plan should have the following characteristics :

(a) It should be functional and flexible. The nature and extent of disasters can not be predicted hence the hospital plan should have inbuilt flexibility to cope with varying dimensions of disasters.
(b) It should clearly establish roles and functions as well as lines of authority and command.
(c) It should be applicable for managing internal and external disasters.
(d) It should be part of a regional disaster plan.
(e) It should be comprehensive and should

Box - 1 : Principles of a Disaster Plan

| |
|---|
| **Simple:** Should be simple and operationally functional |
| **Flexible:** Should be able to be executed for various forms / discussions of disasters |
| **Concise:** Should specify various roles and responsibilities. |
| **Adaptable:** For internal and external disaster. |
| **Part:** of a regional plan. |

encompass roles & responsibilities during disaster management.

The main principles of a hospital disaster plan are shown in Box-1

**Phases of Hospital Disaster Plan**

Box - 2 : Phases of Hospital Disaster Plan

**Preparation** : Development of plan

**Alert**

- Notify personnel
- Prepare for immediate action
- Expand hospital capacity
- Organize incoming patient area
- Assure safe transportation
- Provide information

**Emergency**

- Activate the plan contingency plan as per.
- Type
- Magnitude

**Reestablishment**

- Return to normal activities
- Critical evaluation of plan
- Steps for improvement

The plan should be comprehensive from its inception to activation. The essential phases of the plan are shown in Box 2.

Preparation phase

This should include formation of a Disaster Management Committee. Each hospital / medical unit should have a standing committee for disaster management which should be responsible for preparing, disseminating, follow up, update, training and coordinating. The following may be included in the Committee :

(a) Commandant/CO of hospital
(b) Senior Registrar/Registrar/ Administrative Officer
(c) Head of Departments
(d) MO I/C MI Room
(e) Quarter Master
(f) Coy Cdr
(g) Principle Matron
(h) OIC Medical Stores
(j) Chief Ward Master
(k) OC SHO
(l) MES Representative
(m) Representatives from other support and utility services as required.

**The main functions of Disaster Management Committee include the following**

(a) Develop hospital disaster plan
(b) Develop departmental plans
(c) Allocate duties to hospital staff
(d) Develop standards of emergency care.
(e) To conduct and supervise training
(f) Supervise drills to test the hospital plan
(g) To improve and revise disaster plan regularly
(h) To prepare a comprehensive Disaster Manual

All MOs / RMOs must be fully trained in life support management, familiar with signal communication requirement / procedures, air evacuation procedures triage and other related protocols processes & procedures. They must be aware of the disaster plan of the MH.

**Communications** : Effective communications are critical in disaster management. Internal system of communication the hospital various wards and departments of the hospital must be established.

**Signage** : The hospital should have effective and appropriate signage particularly for exits to be used in case of an emergency , entry/exit points for vehicles and ambulances. Directional signs for use during day and night should also be available for the interior and exterior areas of the hospital.

**Reserve Medical Stores** : All hospital should have a reserve of expendable and non- expendable medical stores including OT clothing and sterile surgical instruments. These should be periodically check and replaced if required.

**Standing Operating Procedures** : All hospital should have standing operating procedures

**Staff Training** : Ongoing training must be provided to all the staff. Drills must be practiced at least once in 03 months and the plan continuously improved. The main functions of a hospital disaster drill are as follows.

(a) To test the hospital response.
(b) To determine the effectiveness and efficiency.
(c) To train the staff of the hospital.
(d) To detect errors or flaws in the plan.
(e) To minimize the response time required by the hospital to react to disaster situations.

**Disaster Facilities :** These should be specified in the disaster plan of the hospital.

These should include the following area

(a) Reception Triage area. The word 'triage' is of French Origin and means selection or categorization. The concept of triage in a disaster situation means classifying victims in order to assign priorities for medical care and transportation .A triage area is the area where victims are immediately placed after rescue/received in hospital and undergo a physical examination in order to assign priority for treatment and transportation to hospitals.

(b) First aid station

(c) Primary treatment areas for managing immediate, urgent and non urgent cases

(d) Secondary care areas such as wards, ICU, OTs and Radio imaging

(e) Information centre , A pre designated officer only should release any information to the media on the details of casualties and or disaster situation.

(f) Relatives waiting area

(g) Morgue : If the hospital morgue does not have sufficient capacity, the plan should designate in advance a site where dead bodies may be kept temporarily.

Hospital in-patient bed capacity may be increased through selective discharges, transferring patients to other hospitals, suspending normal OPDs and postponing non-emergency scheduled surgeries.

**Hospital Disaster Plan** : The following are the important provisions that must be incorporated into a hospital disaster plan.

(a) An efficient system of alert and staff assignment.

(b) Conversion of a usable space into clearly defined areas for triage, patient observation and immediate care.

(c) Removal of casualties to more appropriate and definitive medical care facilities.

(d) Security arrangements.

(e) Establishment of a public information centre.

(f) Evaluation of hospital services and its sources of electricity gas, water, food, and medical supplies.

(g) Identification method for patients who are immediately dischargeable or transferable.

(h) Disaster medical record keeping and medical training.

(j) Planning use of OT, Radio imaging, blood bank, laboratory and critical care facilities.

(k) Effective communication.

Pre hospital Management

The objective of pre hospital care is to render first aid to victims at the disaster site and their safe transportation to the nearest health care facility Pre hospital trauma care should have the characteristics of effectively and efficiency, It may be represented by the acronym TRAUMA as shown in Box 3.

Box - 3 : Characteristics of Pre Hospital Trauma Care

T - Tailored to the requirement.
R - Response coordinated.
A - Active including medical management of casualties.
U - Urgent reactions.
M - Methodical approach.
A - Authority, roles and responsibilities well defined .

The principles of pre hospital care include.

(a) Competent and safe extrication, if required.

(b) Primary examination and resuscitation if required.

(c) Effective evaluation.

(d) Level of care as per status of first responder.

The officer first receiving communication about the disaster must seek all available information including the type/severity of incident and its location. The essential details which may be sought may be represented by acronym ETHANE and in given in Box 4

Box - 4 : Essential Disaster related details to be sought from Source of Information

E - Exact location (Grid reference).
T - Type of incident.
H - Hazards - present and potential.
A - Access and egress routes at disaster site.
N - Number and severity of casualties.
E - Emergency services present or not.

**Disaster Response**

The rapid disaster response is heavily dependent on appropriate disaster plan and preparedness. The initial response is hinged on the rescue and relief. Rescue in specific disaster requires trained personnel and special equipment like rescue in case of earthquake to find survivors in debris / collapsed buildings. The important feature of the response includes the following:

(a) Mechanism for rapid survey and assessment to determine immediate and medium term needs & measures required for rescue and relief.

(b) Mobilization and deployment of resources.

(i) Extrication and rescue.

(ii) On site medical care.

- Mass casualty care.
- Triage, First Aid, Evacuation.

(c) Transportation for definitive care at designated hospitals.

(d) Hospital care

(i) Immediate life saving.

ii) Definitive care.

(e) Long term rehabilitation

**Suggested Format for a Hospital Disaster Plan**

No plan can be made to fit every emergency but a general schedule of enunciated activities will prove to be extremely useful, if executed in a coordinated and disciplined fashion.

(a) Organization and Operations

The disaster management services of the hospital should have elements of quick medical response, effective pre hospital care and efficient definite hospital care. Plan must be comprehensive and holistic. It should incorporate SOPs for management of internal and external disaster. It should include pre hospital and hospital components. It should incorporate the following

(b) Disaster Management Committee

The composition and functions of the Committee have been enumerated above.

(c) Alert Activation

Intimation regarding the disaster may be received by the MO I/C MI Room/ DMO/Sr Registrar/ Adm Officer/ CO/ Commandant or anyone else. The information should immediately be conveyed to the CO / Commandant. Depending on time availability CO / Commandant may instruct the Sr Registrar/ Adm Officer to activate the Plan or he may hold an emergency meeting with the Disaster Management Committee.

(d) Control Center

A control center must be established to coordinate and monitor the various activities. Sr Registrar/ Adm Officer should be operationally functional from this center.

(e) Reception Center

This center receives casualties. Traffic, vehicular as well as human, to the center must be effectively directed and controlled. The center should be managed by DMO /MO I/C MI Room. Stretcher squads, stretchers and trolleys should be readily available.

(f) Disposal of Dead Bodies

In case any patient is declared dead on arrival his body will be shifted to the Morgue.

(g) Collection of Valuables

All belongings of the patients including valuables should be collected, and deposited with the Assistant Registrar / Chief Ward Master. A proper accounting of the same should be done. Arms and ammunition should be deposited in Kot and proper records maintained.

(h) TRIAGE System

A predetermined TRIAGE should be undertaken to classify the casualties. Manpower permitting and for a large number of casualties the TRIAGE team should incorporate a surgeon, an orthopedic, a physician and an anesthetist. After first aid the casualties should be sent to various wards and departments as per priority allocation. A functional TRIAGE As follows may be utilized

(i) Priority I - Needing immediate resuscitation. These casualties should be sent to ICU / acute wards.

(ii) Priority II - Needing immediate surgery. These casualties should be sent to OT.

(iii) Priority III - Needing first aid and possibly surgery.

(iv) Priority IV – Needing only first aid. These may be discharged after first aid.

(j) Death Cases

Brought in dead and those who die while on medical management should be sent to morgue. Details of dead bodies with correct identification mark, sex, physical characteristics and preferable with photographs should be maintained .Dead bodies should be handed over to the NOK after completion of medico-legal formalities.

(k) Additional Bed Space

Disaster casualties may require additional beds. The crisis expansion beds should be utilized. If required the convalescing patients, elective surgery patients and patients who can have domiciliary care/daycare/OPD management should be discharged.

(l) Emergency Blood Bank

Blood of all groups should be stocked to meet emergency requirements. List of potential blood donors should be available and they should be requested to report to the hospital as and when required.

(m) Staff

In addition to members of clinical staff, para and preclinical disciplines should render assistance in managing the casualties. Duty roster for standby staff should be available in the Duty Medical Officers' room.

(n) Nursing staff

A list of nursing staff who may be made available at short notice to render nursing assistance should be available in the Duty Medical Officers Room

(o) Other Staff

Duty roster including those on standby duty of other hospital services like radiology, laboratory, house keeping/sanitation service should be available with the DMO.

(p) Hospital Security

Security of admitted patients, their belongings, hospital staff and equipment is essential. It should receive attention during planning execution of disaster plan.

(q) Dietary Services

The dietary services should be capable of handing additional loads during disaster situations. Acquisition of raw materials and supply of appropriate meals for staff patients should be planned.

(r) Transport Services

Intramural and extramural transport services should b e predetermined and coordinated for disaster situations.

(s) Information Services

An officer should be designated to issue details of casualties to media etc. He should obtain prior clearance from competent authorities before issuing information.

(t) Engineering and Maintenance Services

These services should ensure uninterrupted supply of water and electricity during the management of disasters. Standby generators should be inspected and maintained in operationally serviceable condition.

## Recommended Duties For Disaster Management In Hospitals

### Senior Registrar / Registrar / Adm Officer of Hospital.

He should be the chief coordinator for all arrangements to ensure effective execution of the Disaster Management Plan. His duties should include the following:

(a) To ensure the entire staff of the hospital is fully aware of the disaster plan and their respective duties in case of a disaster. He should ensure that the job cards for every appointment/individual associated with the plan is available and known to the concerned. He should also ensure that the plan is updated regularly.

(b) He should ensure regular practices drill of the plan.

(c) On getting the information of the Disaster, he should inform the CO/Commandant of the disaster and depending on their instructions should either activate the disaster plan or arrange for a meeting of the Disaster Management Committee.

(d) If required to be should instruct the Quick Reaction Team to leave for the disaster site.

(e) He should ensure that the manpower is detailed / beefed up in areas/department/wards as per the Disaster Plan. All those who are not on duty and in station including officers. JCOs and ORs should be instructed to report to their respective duty places.

(f) To ensure that wards/department are ready to receive casualties as early as possible.

(g) To ensure availability of comfortable shelter / accommodation and food / refreshments for relatives of patients.

(h) If required to augment manpower and material resources from other local hospital/units.

(j) To prepare and forward reports and returns regarding details of casualties to all concerned.

### Principal Matron

The duties of the Principal Matron should include the following:

(a) To ensure optimum availability of Nursing Officers in wards and departments.

(b) To ensure wards are ready to receive casualties.

### Coy Cdr.

The Coy Cdr should mobilize and optimally distribute the available manpower to the various departments and wards.

### Quarter Master

The QM should ensure availability of additional requirement from the stores to the wards/departments. If required, he should issue stores for crisis expansion of beds.

### Officer-in Charge Medical Stores

He should ensure that medical kit for QRTs and Disaster Management are ready at all times. The items in the kits should be periodically turned over to avoid expiry of pharmaceutical products.. During disaster management he should ensure interrupted and speedy replenishment of supplies to the wards and department.

### Officer-in-Charge Laboratory

In managing disaster the Pathologist, in addition to his duties may also be designated as the Officer-in-Charge of Mortuary. His duties include the following:

(a) Collect additional stores, if required, for blood grouping and other investigations.

(b) Intimate the blood donors from the station units to report for blood donation.

(c) Arrange for alternative place for keeping of dead bodies if sufficient place is not available in hospital mortuary.

(d) Ensure security of the dead bodies.

(e) Ensure preservation of dead bodies till final disposal.

(f) Ensure proper identification system of dead bodies.

(g) Ensure proper record of dead bodies.

(h) Ensure proper handing/taking over of dead bodies to NOK/Police.

### Chief Ward Master

Chief Ward Master plays a crucial role in effective management of casualties in disaster situations. His duties include the following:

(a) To provide additional nursing staff to various wards and department in consultation with the Principal Matron.

(b) To ensure proper documentation of casualties.

(c) To maintain record of casualties.

(d) To ensure timely handing over of dead bodies to their NOK / Unit / Police after correct documentation and procedures.

(e) To ensure safe custody of patients belongings and valuables.

### Training for Disasters

Training is the essential aspect of the preparedness and it will determine the outcome of the response as well. Training needs attention at all levels of Formation HQs, Medical units and up to the RMO level. The factors to be considered are:

(a) Creating awareness of the Risk, Vulnerability and Hazards.

(b) Dissemination of Disaster Management Plans.

(c) Awareness of role and responsibilities of various functionaries. Teamwork yields better results (19)

(d) Arrangements for mobilization and its practice.

(e) Training of hospital staff in operational zing the hospital disaster plans (20).

## Disaster management plan for natural disasters : A Blueprint

Though all disasters are unique in that they affect areas with different social, medical and economic backgrounds, however there are certain peculiar problems associated with floods, cyclones and Tsunami. These are essentially due to increased load of communicable diseases, food scarcity and mass population displacements and movements. Therefore disaster management includes good site planning; provision of basic clinical services, shelter, clean water and proper sanitation; mass vaccination against specific diseases (and chemoprophylaxis if required); a regular and sufficient food supply; and control of insect vectors of diseases. Table 2 lists the main diseases and disease groups targeted by such interventions.

### Organisation of medical setup

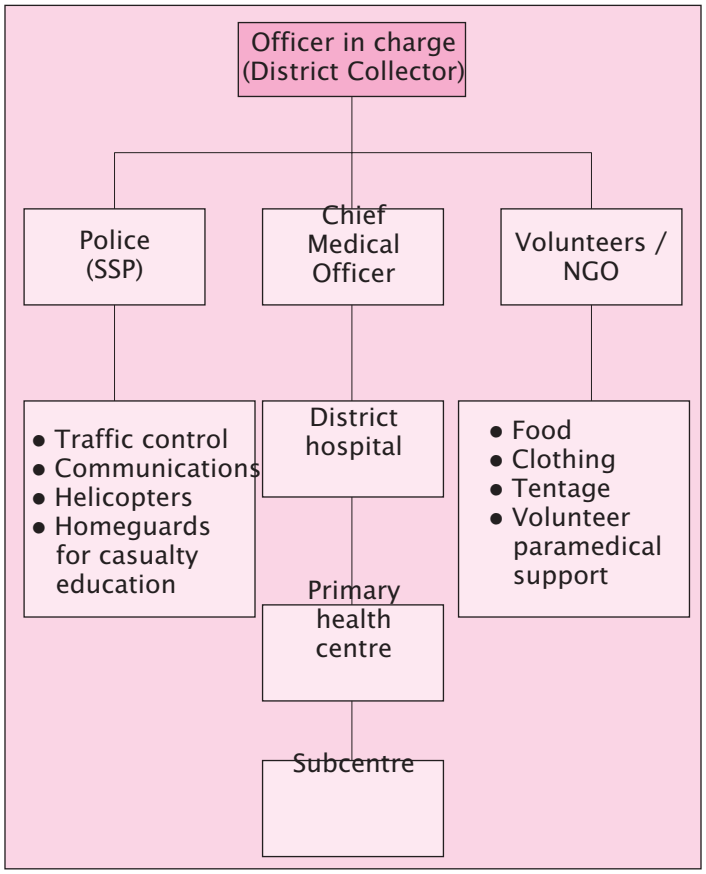
The State Chief Secretary should be overall incharge of Disaster Management in the State. The medical aspects will be coordinated by the State DGHS. He will ensure that adequate manpower reserves are rushed from non affected areas in the State to those which are worst affected so that medical manpower is properly augmented (Fig. 2).

Table - 2 : Main Diseases

| Preventive measures | Impact of spread on |
|---|---|
| Site planning | diarrhoeal diseases, acute respiratory infections |
| Clean water | diarrhoeal diseases, typhoid fever, Hepatitis A and E |
| Good sanitation | diarrhoeal diseases, vector-borne diseases, scabies |
| Adequate nutrition | tuberculosis, measles, acute respiratory infections |
| Vaccination | measles, meningitis, Japanese encephalitis, diphtheria |
| Vector control | malaria, plague, dengue, Japanese encephalitis, other viral haemorrhagic fevers |
| Personal protection (insecticide-treated nets, clothing, shoes) | malaria, leishmaniasis, leptospirosis |
| Personal hygiene | louse-borne diseases: typhus |
| Health education | diarrhoeal diseases |
| Case management | cholera, shigellosis, tuberculosis, acute respiratory infections, |

At the District Level, the District Collector will be the Chief Executive of the Disaster management cell. He will be in a position to coordinate all relief effort with various departments including ensuring NGO participation. The medical team will be headed by the Chief Medical Officer (CMO) of the district. The various programme officers under him like the District Malaria Officer, the District Immunisation Officer, etc will ensure availability of equipment, stores and manpower required for disaster activities. The District hospital will be responsible for providing referral services for curative care as well as outreach teams to be deployed at short notice in affected remote areas. These teams should have medical officers, surgeon, anesthetist, and adequate paramedical staff.

Fig - 2 : Disaster management organisation at district level




The nodal peripheral unit for providing medical relief will be the PHC of the area and the MOi/c PHC will coordinate all effort and seek assistance of the CMO as and when required. The Subcentre staff will support him in all the activities.

### Medical relief

Pre planned medical bricks comprising essential drugs and equipment for management of casualties will be located at the district hospital. This will be issued to the affected relief teams under the directions of the CMO.

Each medical brick should be capable of managing approximately a population of 1000 persons for a period of 30 days. The suggested drugs and equipment are listed at Appx 'A' for one medical brick. However, the same is not exhaustive and can be modified as per local needs and health problems of particular districts.

**Public health aspects**

In the case of natural disasters like floods, tsunami and cyclones it is important to plan the public health activities so that one is prepared for proper management of the disaster. The important aspects include provisioning of appropriate shelter for displaced population, potable water supply, food and nutrition and sanitation. Some suggested norms are shown in Table - 3.

Shelter

In natural disasters, the displaced population must be sheltered in temporary settlements or camps. The selection of sites must be well planned to avoid risk factors for communicable disease transmission, such as overcrowding, poor hygiene, inadequate water supply, insanitary disposal of excreta vector breeding sites and lack of adequate shelter. Such conditions favour the transmission of diseases such as measles, meningitis and cholera. Critical factors to consider when planning a site are: water availability, means of transport, access to fuel and access to fertile soil. The surrounding environment may also pose a threat to health in the form of vectors not encountered in the population's previous place of residence. In order to reduce such risks it is essential that site selection, planning and organization be undertaken as soon as possible. The following criteria should be considered when assessing site suitability; other criteria may also be relevant in specific situations.

Water supply

The availability of an adequate amount of safe water has proved in practice to be the single most important criterion for site location. The water source should be close enough to avoid transporting water by trucks, pumping it over long distances or walking long distances to collect insufficient quantities.

Space

There must be enough space for the present number of emergency-affected population, with provision for future influxes and for amenities such as water and sanitation facilities, food distribution centres, storage sites, hospitals, clinics and reception centres.

Topography and drainage

Gently sloping sites above the flood level is preferred in order to provide natural drainage. Flat areas, depressions, swamp, river banks and lakeshore sites should be avoided. Windy sites are unsuitable, as temporary shelters are usually fragile.

Soil conditions

The soil type affects sanitation, water pipelines, road and building construction, drainage and the living environment (in terms of dust and mud). The most suitable soil type is one that will easily absorb human waste.

Access

The site should be accessible at all times (e.g. for food deliveries, roads during rains).

Vegetation

The site area should have good vegetation cover if possible. Trees and plants provide shade, help to prevent soil erosion, allow recharge of the groundwater supplies and help in reducing dust. It may sometimes be necessary, however, to destroy poisonous trees or plants, for example where populations are accustomed to collecting berries or mushrooms. Table 3 gives the site planning norms.

Water

Water and sanitation are vital elements in the transmission of communicable diseases and in the spread of diseases prone to cause epidemics. Diarrhoeal diseases are a major cause of morbidity and mortality among affected populations, most being caused by a lack of safe water, inadequate excreta disposal facilities and poor hygiene (see Table 4). The goal of proper water and sanitation facilities is to minimize risks to the health of a population, particularly one caught up in the difficult circumstances of an emergency with its attendant displacement and dangers. Such a programme is an integral part of preventive health activities. The main focus of such a programme is on :

(a) The provision of a safe and sufficient water supply,

(b) Provision for excreta disposal and the establishment of other waste control and hygiene measures,

(c) A programme of public education for the affected population on the issues of hygiene and water use.

In a natural disaster, the affected populations need immediate access to a water supply in order to maintain

Table - 3 : Site planning norms

| | |
|---|---|
| Area per person for collective activities | 30 $m^2$ |
| Shelter space per person | 3.5 $m^2$ (4.5–5.5 $m^2$ in cold climates) |
| Distance between shelters | 2 m minimum |
| Area for support services | 7.5 $m^2$/person |
| Number of people per water point | 250 |
| Number of people per latrine | 20 |
| Distance to water point | 150 m maximum |
| Distance to latrine | 30 m |
| Distance between water point and latrine | 100 m |
| Firebreaks | 75 m every 300 m |
| | |

Table - 4 : Diseases caused due to unsafe water

| | |
|---|---|
| Diseases that occur owing to a lack of water and poor personal hygiene | Skin infections: scabies, impetigo<br>Ophthalmic infections: conjunctivitis, trachoma<br>Louse-borne diseases: typhus |
| Diseases that occur owing to poor biological quality of the water | Caused by faecal pollution: cholera, typhoid, other diarrhoeal diseases, hepatitis A, hepatitis E, schistosomiasis<br>Caused by the urine of certain mammals: leptospirosis |
| Conditions that occur owing to poor chemical quality of the water | Poisoning |

health and to reduce the risk of epidemics. If the emergency-affected populations have to be sheltered in temporary settlements or camps, water supply is an essential consideration in choosing the site location. An adequate amount of safe drinking-water must be provided for the entire displaced population. The first objective is to provide sufficient water; quality can be addressed later. Sufficient water of low quality is better than very little water of high quality. During the rapid assessment of a proposed site it is essential to protect existing water sources from possible contamination. If the population has already moved into the area in question, then immediate measures should be taken to isolate and protect the water source, if it is on or near the site. Table 5 gives the recommended doses of Chlorine tablets that can be distributed to the affected populations to prevent diarrhoeal diseases. Location of water distribution points are given in Table - 6 :

Sanitation

The aim of a sanitation programme is to develop physical barriers against the transmission of disease, in order to protect the health of the disaster affected population. These barriers include both engineering measures and personal hygiene measures. The provision of latrines and the development of methods of waste disposal are essential elements of the programme. These measures are only fully effective, however, when complemented by a sanitation education programme. The efficient and safe disposal of human excreta is as important as the provision of water in its positive effect on the health of the emergency-affected population. Human excreta is more likely to transmit disease than animal waste. It contributes to the transmission of numerous diseases (which can be particularly when combined with low levels of nutrition) and can also be a breeding ground for flies and other insects. In the acute phase of an emergency, any form of excreta disposal is better than none. The simplest and quickest methods should be adopted; these can later be improved on and changed. Initially, speedy action is important in averting human catastrophe.

Excretion fields must be prepared on the first day. Indiscriminate defaecation needs to be controlled. Areas where defaecation cannot be permitted are:

(a) Near rivers, streams and lakes and within 30 metres of any water source or water point

(b) Near water storage facilities

Table - 5 : Recommended dilution and use of Aquatabs

| | | Type of water and source | | | |
|---|---|---|---|---|---|
| | | Clear Piped water | Protected tube wells, ring wells, clear rain water | Unprotected wells and cloudy water : filter before purifying | Water known to have faecal contamination : Filter before purfying |
| Tablet size | Chlorine per tablet | Volume of water treated per tablet (Litres) | | | |
| 8.5 mg | 5 | 5 | 2.5 | 1 | 0.5 |
| 17 mg | 10 | 10 | 5 | 2 | 1 |
| 67 mg | 39.41 | 39.41 | 19.7 | 7.88 | 3.94 |
| 340 mg | 200 | 200 | 100 | 40 | 20 |
| 500 mg | 294 | 294 | 147 | 58.8 | 29.4 |
| Free available chlorine content after treatment (Residual) | | 1 mg / Litre | 2 mg / Litre | 5 mg / Litre | 10 mg / Litre |

Table - 6 : Location of water distribution points

| | |
|---|---|
| Location | Water distribution points must be set up in suitable places around the camp. A good location is an elevated spot in the centre of a living area. If the water points are from ground sources, no sanitation facilities should be within 50metres, and definitely not closer than 30 metres. If the water point is too far away, people will not collect enough water or may |
| Design | When designing water points consider the following:<br>✎ Traditional water-carrying methods,<br>✎ The containers used: for example, a raised area is suitable for people who carry the bucket on their heads,<br>✎ Who collects and carries the water (it is usually the women and children),<br>✎ The availability of spare parts.<br>There should be enough space on the concrete slab around the water point for laundry and bathing areas. If sanitation is compromised, it may be felt necessary to locate bathing and washing areas away from collection points. However, traditional practices and habits need to be accommodated as much as possible. Animals must certainly be kept away. If they are mobile herds, watering facilities should be established some distance away and a fence erected around the water point. |
| Number | One tap per 200 - 250 people is the ratio recommended by the United Nations High Commissioner for Refugees (UNHCR). The more people there are per tap, the more wear and tear there is. Nobody should have to wait longer than a few minutes; if collection takes a long time, people will return to old, contaminated but quicker sources. |

(c) Uphill of the camp
(d) Uphill of water sources
(e) Along public roads
(f) Near feeding centres, clinics, food storage depots and distribution centres.

These areas should be fenced off and guarded where necessary. The use of water for anal cleansing may explain defaecation near water sources. Water must be provided in alternative locations to control this practice effectively. These measures must be announced throughout the camp with the assistance of the community leaders, and displayed on signs, using both words and pictures.

As a short term measure Deep trench latrines (DTLs) used by the army would serve as a very effective and simple measure providing one seat (of 5 latrines for 50-75 people) staying in the camp. Adequate seats and digging material should be procured for this purpose.

Food and Nutrition

Food shortages and malnutrition are common features of emergency situations. Ensuring that the food and nutritional needs of an emergency-affected population are met is often the principal component of the humanitarian response to an emergency. When the nutritional needs of a population are not met, this may result in protein–energy malnutrition and micronutrient deficiencies such as iron-deficiency anaemia, pellagra, scurvy and vitamin A deficiency. There is also a marked increase in the incidence of communicable diseases, especially among vulnerable groups such as infants and young children, and these contribute further to the deterioration of their nutritional status. The nutritional requirements of a population must be assessed to:

(a) Identify the nutritional needs of individuals, families, vulnerable groups and populations as a whole,
(b) Monitor the adequacy of nutritional intake in these groups,
(c) Ensure that adequate quantities of safe food and appropriate food commodities are procured for general rations and selective feeding programmes.

Table 7 below summarizes the main daily requirements used to calculate the average content of emergency rations.

Non Governmental Organisations can be effectively utilized for providing nutritional support under a coordinated manner.

Vaccination

The major outbreaks expected during natural disasters would be of feco oral group of diseases namely typhoid and cholera. It is therefore essential that vaccines should be procured in advance so that they could be used in the eventuality of an outbreak. Vaccination for typhoid would also assume priority in non immunized populations. However, if there is a strong routine immunization programme in vogue then there is no need to do the same during epidemics. India unfortunately does not have a free child or adult immunization programme against typhoid. It is important to therefore formulate a national

Table - 7 : Nurtitional requirements

| Food Type | Quantity |
|---|---|
| Energy | The mean energy requirement is 2100 Kcal /person /day |
| Fat/ Oil | 17-20% of the energy should be in the form of edible fats or oils. |
| Proteins | 10-12% of the energy should be in the form of proteins.<br>Recommended daily protein intake : 46g from an avarage mixed diet of cereals, pulses and vegetables. |

strategy for routinely immunizing our population against typhoid as is done in the Armed Forces. The use of cholera vaccine is recommended only in stable post-emergency situations.

The other major vaccines used in such situations are those against measles. Measles vaccination is one of the highest priorities in the acute phase of an emergency if vaccine coverage rates in the affected population are below 80%. The main objective of a measles vaccination programme is to prevent an outbreak of measles with the high mortality rates often associated with this disease in emergency situations. In this way, the measles vaccine provides one of the most cost-effective public health tools. Once the acute phase of the emergency is over, plans should also begin to re-establish the Expanded Programme on Immunization (EPI) to routinely immunize children against tetanus, diphtheria, polio and tuberculosis. This should be integrated with the national EPI programme using national vaccination policies, and it is important to involve the national EPI programme from the start of any plan or activity. The organization of a vaccination campaign requires good management ability and technical knowledge. Responsibilities for each component of the vaccination programme need to be explicitly assigned to agencies and persons by the health coordination agency. The national EPI of the host country should be involved from the outset. National guidelines regarding vaccination should be applied in emergency situations as soon as possible.

**Mass vaccination strategies**

To implement a mass vaccination campaign in emergencies, there are two main strategies.

(a) Vaccination can be carried out at the screening centre on arrival at a camp. This is possible when the screening facility has been set up and the influx of refugees is steady and moderate.

(b) Vaccination sites can be set up in different sections of the target area and mass vaccination carried out by outreach teams. This is necessary when the population has already settled at a site or the influx has been too rapid to organize a screening facility.

The list of essential vaccines and cold chain equipment to be maintained at the District Level for rushing into affected areas is given as Appx 'B'. However, they need to be given to the populace only after taking into considerations all epidemiological aspects.

Vector control

The purpose of vector control is to reduce disease transmission by rendering the environment unfavourable for the development and survival of the vector. Prevention is better than cure, and when the planning and construction of camps is undertaken, preventing the development of vector problems should be taken into account. Complete eradication of a vector is rarely possible but the vector population and its life expectancy should be kept to a minimum. Early diagnostic and treatment are needed to prevent severe forms of the disease (especially for malaria) when transmission control is needed to reduce incidence. Both are complementary and two essential components of any effective vector borne disease control programme. The major biological vectors are mosquitoes, sand flies, ticks, fleas, lice, mites. Important carrier reservoirs or intermediary hosts are rodents. The diseases most commonly spread by vectors are malaria, dengue fever, typhus, leptospirosis and plague. The main methods of vector prevention and control can be classified as personal protection; environmental control; campsite, shelter and food store sanitation; community awareness; and chemical control such as residual or space spraying, insecticide-treated traps, selective larviciding and the use of rodenticides. Vector control is very specific to the ecology of the vector, the epidemiology of the disease, the human and social environment as well as resources locally available (e.g. technical staff, structures, logistics). For mosquito control it is essential to have an adequate stock of antimalarial drugs, repellents, and hygiene chemicals for antilarval spray. Cases of dengue need to be isolated immediately. When camps are there for long duration, fly nuisance is bound to set in and can lead to diarrhoeal diseases like shigellosis and salmonellosis. ORS packets should be available in abundance and sanitary control by community education and proper disposal of garbage is to be ensured. The Surat plague occurred immediately following the floods in the city leading to panic. Advanced planning and proper dissemination of information can prevent panic in such situations. Leptospirosis is another common health problem envisaged after the floods. Prompt diagnosis and wearing of proper clothing by the rescue teams (anklets in the case of soldiers) can prevent this disease.

The hygiene chemicals and equipment for vector control is given as Appx 'C'.

Readiness for chemoprophylaxis

The current epidemiological situation will decide whether to give chemoprophylaxis to the entire population or a select sub population or to health care workers involved in relief operations. The common diseases for which chemoprophylaxis should be readily available are:

| | | |
|---|---|---|
| Leptospirosis | - | Doxycycline |
| Cholera | - | Doxycycline |
| Meningitis | - | Rifampicin |
| Malaria | - | Chloroquine |
| Plague | - | Doxycycline |

Surveillance

Surveillance is the ongoing systematic collection, analysis and interpretation of data in order to plan, implement and evaluate public health interventions. The word surveillance means "watching over". A surveillance system should be simple, flexible, acceptable and situation-specific. It should be established at the beginning of public health activities set up in response to a disaster.

The objectives of a surveillance system in a disaster are to:

(a) Identify public health priorities;

(b) Monitor the severity of an emergency by collecting and analysing mortality and morbidity data;

(c) Detect outbreaks and monitor response;

(d) Monitor trends in incidence and case-fatality from major diseases;

(e) Monitor the impact of specific health interventions (e.g. a reduction in malaria incidence rates after the implementation of vector control programmes);

(f) Provide information to the Ministry of Health, agency headquarters and donors to assist in health programme planning, implementation and adaptation, and resource mobilization.

Experience from many disaster situations has shown that certain diseases / syndromes must always be considered as priorities and monitored systematically. In the acute phase of an emergency, the major diseases/syndromes that should be reported are:

(a) Bloody diarrhoea

(b) Acute watery diarrhoea

(c) Suspected cholera

(d) Lower respiratory tract infection

(e) Measles

(f) Meningitis

After the second / third week the following diseases should be added on:

(g) Malaria

(h) Dengue/ DHF

(j) JE

(k) Leptospirosis

(l) Septic dermatological complications

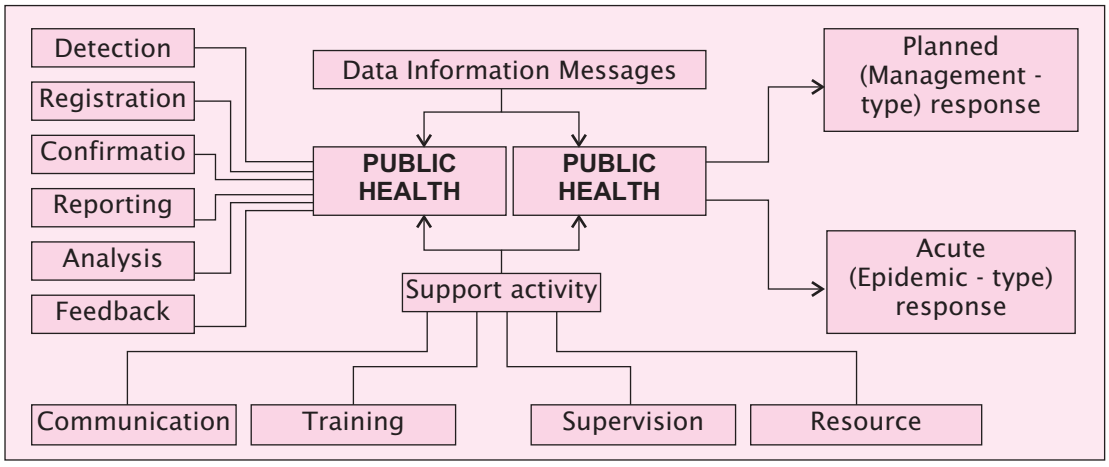
Lab for basic diagnostic tests of stool and blood may be established by field reporting units but for specific bacteriological and virological tests, the referral labs in nearby cities or areas will have to be marked.

### Critical elements of preparedness and response

The preparedness and response depends upon various critical elements. The information of the disaster plans from State Level to District Level, role and responsibilities of various resource organizations, mechanism for coordination, control and practice are some of the critical issues. The preparedness will depend upon appropriate disaster plans for regional / local area based on risk, hazards and vulnerability analysis, and the resources available. The coordination at various levels of government by the appropriate State HQ and at local level by the Medical Establishment based on the anticipated role and responsibility is critical issue for rational response during disasters.

The disaster plans preparedness and response is dependent on the State Government policies, legislation, organisation, disaster plans, resource organisation, role and responsibilities of various agencies, logistic plans, coordination, evacuation and shelter plans, training, public awareness and drills. The State Government plans become the baseline for the matching District HQ Plans to provide the support expected in disasters. The District HQ plans at various levels will include all the elements of resource organisation to meet the demand of anticipated in disaster event. The role and responsibilities allotted for health care becomes the total point for preparedness and developing health care plans. Each Medical Establishment then prepares its plans based on the overall objectives, roles and responsibilities and resources available.

Fig - 3 : Conceptual framework of public health surveillance and action



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## Appendix

### A

**Medical brick for a population of 1000 for 30 days**

| S.No. | Nomenclature | Qty |
|---|---|---|
| 1 | Inj Lignocaine | 02 |
| 2 | Inj Atropine | 02 |
| 3 | Tab Common cold | 2,000 |
| 4 | Inj Morphine | 50 |
| 5 | Inj Ranitidine | 10 |
| 6 | Inj Fortwin | 50 |
| 7 | Inj Adrenalin | 30 |
| 8 | Tab Cetrizine | 800 |
| 9 | Tab Periactin | 100 |
| 10 | Tab Dexamethasone | 200 |
| 11 | Inj Dexamethasone | 10 |
| 12 | Inj Hydro Cortisone | 20 |
| 13 | Inj Avil | 20 |
| 14 | Tab Avil | 400 |
| 15 | Inj Phenargan | 20 |
| 16 | Inj Diazepam | 20 |
| 17 | Anti inflammatory | 1000 |
| 18 | Antibiotics | 5000 |
| 19 | Antipyretics | 1000 |
| 20 | Anti malarials | 2000 |
| 21 | Antitussives | 10L |
| 22 | Antispasmodics | 300 |
| 23 | ORS | 1500 |
| 24 | Hydrogen Peroxide | 5.000L |
| 25 | Liq Antiseptic | 1.000L |
| 26 | Eye Drops cifran | 15 |
| 27 | IV Fluids NS | 576 Bott |
| 28 | IV Fluids DNS | 576 Bott |
| 29 | IV Fluids 5% Glucose | 1,104 Bott |
| 30 | IV Fluids R/L | 2,256 Bott |
| 31 | Haemaccel | 900 Bott |
| 32 | IV Set | 576 Bott |
| 33 | IV Catheter | 576 |
| 34 | Cotton Absorbent | 10 Kg |

### C

**List of hygiene chemicals and entomological equipment**

| S.No | Nomenclature | Qty |
|---|---|---|
| 1 | Thermal fogger | 01 |
| 2 | Knapsack sprayer (16 L) | 02 |
| 3 | Compression sprayer (12 L) | 03 |
| 4 | ULV fogger | 01 |
| 5 | Malathion EC 50% / DDT WP | 300 L/Kg |
| 6 | Temephos/Baytex EC | 10L |
| 7 | Aquatabs (17 mg) | 1,00,000 |
| 8 | DMP oil | 25L |
| 9 | Impregnated bed nets* | 600 |
| 10 | Bleaching powder (33% Available Chlorine) | 30Kg |
| 11 | Cresoli Black | 150L |

* 6L of commercial Deltamethrin containing 2.5% of AI will be required for 600 bed nets.

### B

**List of essential vaccines and cold chain equipment for a population of 1000**

| S.NO | VACCINE | Doses |
|---|---|---|
| 1 | Typhoid oral | 600 |
| 2 | Cholera | 400 |
| 3 | Measles | 250 |
| 4 | Japanese Encephalitis | 250 |
| 5 | Tetanus Toxoid | 300 |
| 6 | Tetanus immunoglobulin | 300 |
| 7 | Meningococcal vaccine | 300 |
| 8 | Vaccine Carrier | 15 |
| 9 | Cold boxes | 10 |

# Socio-Behavioural and Communication Sciences


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# Principles of Health Education

Public Health is the science and art of preventing disease prolonging life, and promoting health and efficiency through organized community efforts. In earlier periods, public health dealt with the sanitation of the environment and the control of communicable diseases enforced by law if found necessary. However stimulating and helping people to assume responsibility for themselves needs understanding people's behaviours and the factors influencing it. Health education attempts to influence the health related knowledge, attitude and behaviour of individuals and communities. In fact, in contemporary public health practice, providing health education, with a view to achieve positive changes in health related attitudes and behaviour from community members is the most important requirement, be it prevention and control of HIV / AIDS or lifestyle (non-communicable) diseases or prevention of infectious diseases and so on.

### Definition

Health education can be defined as a process with intellectual, psychological and social dimensions relating to activities which increase the abilities of people to make informed decisions affecting their personal, family and community well being. This process, based on scientific principles, facilitates learning and behavioral change among both, individuals & communities (1).

### Information Education Communication (IEC)

IEC is a broad term comprising a range of approaches and activities. Visible component of IEC is frequently the material produced and used. Effective IEC makes use of a full range of approaches and activities. IEC activities are grounded in the concepts of primary health care, concerned with individual behaviour change and changes in social or community norms. IEC can be defined as an approach which attempts to change or reinforce a set of behaviour in a target audience regarding a specific problem in a predefined period of time. It is multidisciplinary and client centered in its approach drawing from the field of social marketing behaviour analysis and anthropology.

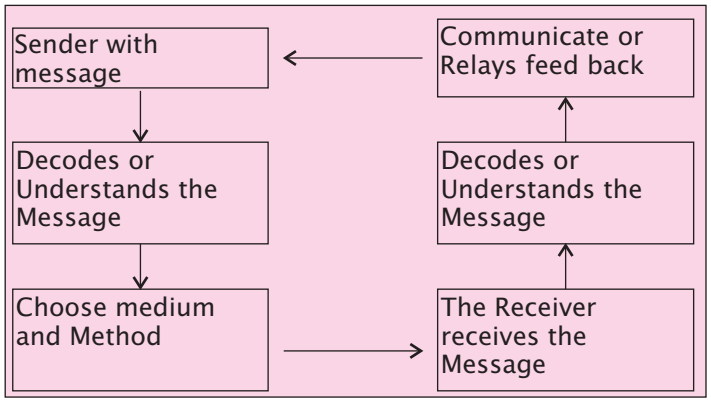
### Communication Process

In health communication we communicate for a special purpose to promote improvements in health behaviour through the modification of the human, social and environmental factors that influence behaviours. It is necessary to understand how communication works. The various components involved in the process of communication are depicted in Fig. - 1.

Components of the Communication process

It is apparent that several elements are involved in the process of communication. It will also be appreciated that communication is two way process. This implies that just as the sender (source) is communicating with the receiver; so also is the receiver communicating with the sender. The components are :

Fig - 1




### The Sender

Sender is the source of Communication. The following aspects need to be particularly considered with regards to the sender :

(a) His own competence and expertise in the subject.

(b) His own convictions about what he speaks.

(c) His own mannerisms, which include non-verbal communication skills.

### The Receiver

Also called the audience who are receiving the message sent by sender.

### The Message

This refers to the information which he/she desires to communicate and must possess the following attributes :

(a) Message should be precise, accurate and to the point.

(b) The ambiguity in the message may create more harm than good.

(c) The information should vary from person to person or from group to group depending upon their background.

(d) The message must necessarily contain clear, concrete suggestions for action in day to day life of the receiver.

### The Medium (Channel)

The communication channel through which the message moves from the sender to receiver is the medium. These include the various methods (as lecture or exhibition) and the "aids" (as slides, slide projector) which are utilized to communicate the message.

**Encoding**

This process includes the language expression, gestures and actions utilized for the purpose of making the information intelligible to the receiver. Obviously the receiver must be familiar with the code.

**Decoding**

The process by which receiver understands or interprets the message is called decoding.

**Feed back**

The part of the receiver's response that the receiver communicates back to the sender.

**Propaganda and Advocacy**

Propaganda is merely a publicity campaign aimed at presenting a particular concept in a favourable light in such a way that public may accept it without thinking. It is a deliberate attempt planned with a view to altering and controlling ideas and values along predetermined lines. The widely employed techniques are an appeal to emotions, feelings and sentiments. It prevents or discourages thinking by readymade slogans. The knowledge is spoon-fed and passively acquired. As a mass-communication activity, propaganda tends to have short-run situationally-defined aims with an appeal to diverse population on the basis of immediate interests, fears or desires. The objective is to not so much influence the individual deeply as it is to win his support for some immediate issue.

The aim of ADVOCACY is to place health problems issues on the political agenda and effectively reach the influential group of policy makers, elected representative, professionals and other interest groups to formulate and implement policies to create pressure groups and supportive systems in order to respond appropriately to the health problems. It helps in identifying potential allies and building alliances and relevant policy and decision making channels. The information concerning position on the issue is collected and provided. A common understanding among stakeholders concerning issue is created through advocacy and negotiating action on the basis of common understanding is taken.

**Barriers in Communication**

Unplanned distortion during the communication, resulting in the receiver obtaining a different message than that sent by the sender, is referred to as or barriers in communication (also called as "Noise" or "distortions" in communication. These can be :

(a) Physiological – Difficulties in hearing, expression.

(b) Psychological – Emotional disturbances.

(c) Environmental – Noise, invisibility, congestion in the classroom, etc.

(d) Cultural – Level of knowledge, understanding and receiver's beliefs, etc.

All barriers should be identified and removed for achieving effective communication. One of the main challenges in the design of effective health communication programs is to identify the optimal contexts, channels, content, and reasons that will motivate people to pay attention to health information.

**Communication skills**

Communication skills are required to make communication effective. These include greeting skills, speaking skills, listening skills, questioning skills, and summarizing skills. In short communication process would be effective if the communicator has skills in introduction, skills in presenting and skills in conclusion.

**Non-verbal communication**

Non-verbal communication is the way in which human beings influence each other without words. In health communication, non-verbal communication plays an important role. It also affects the communication process. Body language is an important constituent of non-verbal communication and consists of gesture, postures, facial expressions, eye contact, manipulating the eye brows etc.

**Behaviour Change Communication Process (BCC)**

This is depicted in Box – 1 & Fig. 2 :

**Components of Health Education Process**

Health Education has three broad components :

Box - 1 : Process of Behaviour Change

**Informed / Aware -** Initially a person is unaware that a particular behaviour may be harmful. The first step in a behavioural change programme is therefore to make people aware through various channels using mass media, group methods and through interpersonal communication.

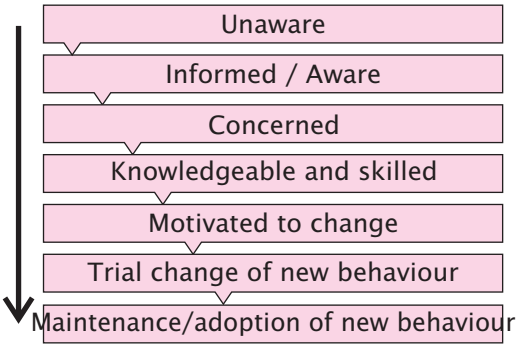
**Concerned -** Information must be given in such a way that the audience feels it applies to them i.e. the audience becomes concerned and people are motivated to evaluate their own behaviour. Targeted communication and interpersonal approaches are more useful.

**Knowledge & skill** - Once concerned, individuals may acquire more knowledge and develop skills by talking to peers, social workers or healthcare providers. More interpersonal communication are needed at this stage, specially training programmes to build and develop skills

**Motivated and Ready to change -** Individuals might now seriously begin to think about the need and importance of new health message and measures. Positive message from peers are particularly effective.

**Trial change of Behaviour -** the individuals decide and try

Fig - 2



(a) Levels of Health Education
(b) Methods of Health Education
(c) Activities undertaken in individual methods

Levels of Health education

Health education is carried out at three main levels, viz., individual and family, group level and general public (mass) level.

**Individual and Family Health Education**

There are plenty of opportunities for individual health education. It may be administered during personal interviews in the consultation room of the doctor or in the health centre or in the homes of the people. The individual comes to the doctor or health centre because of illness. The opportunities are utilized in educating him on matters of interest – diet, causation and nature of illness and its prevention, personal hygiene, environmental hygiene etc. Topics for health counseling may be selected according to the relevance of the situation. By such individual health teaching, we will be equipping the individual and family to deal more effectively with health problems. The patient will listen more readily to the physician. A hint from the doctor may have a more lasting effect than volumes of printed words. The nursing staff has also ample opportunities for undertaking health education. Public health supervisors are visiting hundreds of homes; they have plenty of opportunities for individual teaching while working with individuals. The health educator must create an atmosphere of friendship and allow the individual to talk as much as possible. It is useful to remember, "An effective communicator is not the one who talks too much but one who listens too much."

An effective method of individual education is **Counseling,** which is defined as a confidential dialogue between a client and a health care provider aimed at enabling the client to cope with stress and take personal decisions related to disease. The counseling process includes an evaluation of personal risk of disease transmission and facilitation of preventive behaviour. The aim of counseling must always be based on the needs of the client. The purpose of counseling is three fold : to help clients manage their problems more effectively, to develop unused opportunities to cope more fully, and to help and empower clients to become more effective self helpers in the future. Helping is about constructive change and making a substantive difference to the life of the client. However, ultimately, it is only the client who can make the difference. The counselor is merely an instrument to facilitate that process of change. In the short-term, counselors use basic skills to help clients make personal decisions about their behaviours.

**Group Health Education**

Our society contains groups of many kinds – school children, mothers, industrial workers, patients, etc. Group teaching is an effective way of educating the community. The choice of subject in group health teaching is very important as it must relate direct to the interest of the groups health. The methods in group health education are focus group discussions, health talks, demonstration, panel discussions and workshops. The group health education methods are effective in promoting behavioural change, influence opinion, develop critical thinking and increase motivation. Use of "aids" to education greatly facilitates group education. Examples of commonly used "AIDS" are given in Box – 2.

**Focus group discussions (FGD)**

Box - 2 : "AIDS" in health education

**Auditory :** Audio cassettes, tape records

**Visual :** Text Books, Posters, Charts, diagrams, film strips, comic strips, pamphlets, internet

**Audio-Visual :** Movies, lectures combined with slide presentations, Television.

A Focus group discussion is a group discussion of 6-20 persons guided by a facilitator during which group members talk freely and spontaneously about a certain topic or health problem. The purpose of a focus group discussion is to obtain in-depth information on concept, perceptions and ideas of group on a particular topic.

**Education of the General Public (Mass education)**

For education of the general public we employ "Mass Media" of communication. Mass media are generally less effective in changing human behaviour than individual or group methods because mass communication is one way. Nevertheless they do have quite an important value in reaching large numbers of people with whom there is no contact, in a short period of time. The continuous dissemination of information and views about health through all the mass media contributes in creating awareness and raising of the level of knowledge in the community. Examples of Mass-Media are given in Box – 3.

Box - 3 : Examples of "mass media"

- Television
- Radio
- News Paper
- Films
- Health Magazines
- Posters
- Health Exhibitions
- Health Museums
- Printed Materials

For effective health education mass media should be used in combination with other methods. Television, News Paper, and Radio are the most basic channel of health information communication. The internet and other advance communication technologies such as mobile telephone message and satellite television are important channel for health information communication. They have had more influence in the younger generation and in urban community. These communication channels are emerging and being adapted rapidly in the movement toward modernization.

**Methods of Health Education**

Methods are generic descriptions of how change is to be brought about within the target group; for example, mass media and community development are two terms being

used to describe a host of health education activities. While planning health education programs, it is not that any method can be used (as delivering lectures to all concerned) but rather the method most suited for the topic and the target audience should be selected. The commonly available methods are listed in box - 4. (2)

**Activities in Health Education**

Box - 4 : Commonly Used Health Education Methods

- Individual Instruction(as counseling, patient instruction)
- Lecture – Discussion
- Educational Television / Computer (Use of television, computer and internet for viewing of prepared programs)
- Audio-Visual Methods (see earlier box)
- Mass Media Methods (see earlier box)
- Peer Group Discussion / Focus Group Discussions
- Programmed learning (use of teaching machines, or programmed texts)
- Simulation & games (games, dramatizations, role playing)
- Inquiry Learning (an approach in which students formulate and test their own hypothesis)

The various methods of health education, as enumerated above, are utilized through different activities, depending on the objectives and the type of target audience. For example, a small group / focus group discussion can be undertaken using a LCD projected slide show, or through a flip chart, or may be simply an open multi-way discussion without using any teaching aid. Similarly, mass education process may be through the activities of traveling through the streets with a loud speaker or by inserting TV footages or through a documentary cinema. The appropriateness of the method and how this method is going to be processed (i.e., the activities) should be decided by the health education planner.

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# Planning and Implementation of Health Education Programmes

In contemporary public health practice, health education of the community (whether small groups or large masses) or of individuals (patients or healthy individuals) is one of the most important health care activity. Medical officers, specialists in various medical disciplines and specialists in Community Medicine (Public health and Preventive Medicine) in particular, should therefore be well versed in the various steps to be undertaken while planning, organizing, implementing and evaluating health education programmes. This involves a series of scientific and sequential steps, which are being explained in this chapter, duly illustrated with an example in the settings of Armed forces.

### Step 1 - Situational Analysis

The first, and one of the most crucial steps in health education programme planning is "Situational Analysis", also known as "Community Analysis" or "Needs Assessment". This is the essential step for gaining insight into the health problems, so that programmes can be developed and directed towards conditions which are significant issues for the community members. This step of community analysis consists of following five sequential steps, viz, analyzing the community backdrop, analysis of the health status of the community, analysis of the health care system of the community, analysis of social systems of the community, and SWOT analysis. After these five sub-steps, we move to the next vital step, i.e., community diagnosis". We discuss each of these steps, as follows.

(a) Analyzing the Community Backdrop

The first thing is to get to know the area and the community under your jurisdiction (or the community for which you are planning the health education program), very well. Drive (preferably walk) around the entire area. Find out where are the work places, location of various governmental and non-governmental offices, location of various military units, markets, eating joints, recreation facilities, training areas, schools, hospitals, other health care facilities (as Medical Inspection (M I) Rooms), family residential areas, etc. See for yourself the minute details, as what are the roads and other communication systems, the pattern of residential accommodation, water supply system, night-soil disposal system, solid-waste disposal system, and environmental conditions. Don't forget to find out about sensitive issues like defined red-light areas, clandestine sexual avenues, tobacco kiosks, alcohol shops and so on.

After the initial inspection, define some tentative boundaries that can demarcate the larger area into smaller, more homogenous aggregates. The most obvious choices are the major physical boundaries as major roads, rivers, or government boundaries as those delimiting the village or Taluka or district. In armed forces, a well established method is to divide the area into five "sectors" which all Station Health Organizations (SHOs) undertake for purpose of various preventive health care activities. Having done this detailed exercise, make a detailed "spot map" showing all these various aspects, as described above. In armed forces, developing and regularly updating such spot maps is, in any case, an indispensable duty of the Officers Commanding SHOs. Whenever you take over as the OC, SHO or as DADH of a formation HQ, the first thing you should do is to undertake a detailed, on ground assessment of your area under health cover and update the spot maps. MOs and RMOs should assess the details and update the spot maps for their respective areas. Listen to the local radio and see the local television programmes, which would further assist you in getting an insight into the community backdrop.

Find out the details of the socio-demographic characteristics of the community under your health care. Find out the total population, distribution according to social status (rank structure in armed forces), according to age groups, according to families and children, and further according to the different geographical sectors that you have made to demarcate the community. See the main occupations, industry and business patterns. Now write down the details in a textual form, complemented by the spot maps, tables of various demographic characteristics and other graphics. It is important to develop a written document at this stage since it will come very handy later on while implementing the health education programme. In any case all OC SHOs and DADH should always keep such a written document, duly updated, since it will be an essential and basic document for planning all health care activities including health education; the document can also be placed by the OC SHO / DADH, before the Senior Advisors, as and when they visit them (Box - 1).

(b) Analysis of Community Health Status

In this step, the data related to important epidemiological parameters is collected from various sources as hospital records, official reports, and, if required by a quick sample survey (Details of important epidemiological parameters and sources of epidemiological information have already been covered in the section on "Principles of Epidemiology"). The main parameters, depending upon requirements include Birth rate, death rate, IMR, MMR, Neonatal MR and death rate according to major socio-economic categories (as social class, sex, rank status, etc.). Thereafter, mortality and hospitalization rates per 1000 (or per lac) population are worked out, for the past 3 years, for the leading 10 or 15 causes, separately for males, females and children (preferably for different age groups). These rates give us a clear idea of the leading causes of death and disease for various age and sex groups. These rates are then compared with the rates for

Box - 1

This is a hypothetical example of planning, organizing and implementing a community health education program. Maj 'X' was posted as the OC, SHO of "Juliet" (J) station, immediately after passing M.D. in PSM and being graded as a specialist. Soon after taking over, she went through the existing details regarding the location, physical, socio-demographic & sanitary characteristics. She decided to update these details by making an extensive physical visit to the entire area of 'J' station. Her findings, in brief, were as follows.

'J' is located somewhere in central Indian plains, connected by train and road but not by air. It is a large civilian township and District headquarters, besides being a very old and large cantonment. The civil set up has a population of about 1 million, with a large district hospital having all basic specialties. The civil society is generally a conservative society and lives in harmony. Main source of water supply is a large perennial river. J is also a large educational centre of central India. Climate is subtropical with heavy rainfall during July / Aug, and extremes of ambient temperature during Dec / Jan and May / June. General terrain is undulating, with few hillocks and generally fertile agricultural land. Main occupation of people is retail business in textiles & domestic-ware, governmental jobs and educational industry. No natural disasters or civil strife had been noticed in the city for the past many years.

'J' has a well demarcated cantonment, occupied primarily by the army. It is a peace location, predominated by training centers. There is a formation (Area) headquarters and their troops. There are 3 very large regimental training centers, a brigade group, and two a large ordnance depot. Health facilities include a large (zonal) military hospital commanded by a Brigadier (who was also the designated Senior executive Medical officer(SEMO) of the station, 4 central MI Rooms one in each centre and in the Ordnance depot, a large SHO for public health and preventive medicine cover (of which 'X' is the OC) and a 100 bedded cantonment hospital for civilian population of cantonment. For the sake of preventive health care the area had already been divided into 5 sectors, serially numbered from 'A' to 'E'. Sector 'A' had the Area HQ, their units, the military hospital and family accommodation for all ranks. 'B' had two Regimental training centers; 'C' had the brigade along with their family accommodation; 'D' had the third regimental centre and accommodation for officers, while 'E' had the Ordnance establishment along with separated family accommodation. Water supply was through ten deep borings and supplied as central piped supply. Sewage disposal was by large septic tanks; a new central sewage system was being planned. Road communications within the cantonment area were quite well planned. The Senior most commandant of the 3 regimental centres also officiated as the Station Commander. Sectors 'B' to 'E' had a well established central MI Room each, manned by 1 to 2 Medical officers and Nursing Assistants.

There were a total of 20,000 troops (including recruits in the regimental training centres) and approximately 9000 families (including 2800 ladies and 6200 children). One of the centre was predominantly for recruits drawn from J&K, Himachal and Punjab; the second had recruits mainly from Rajasthan, Haryana and adjoining parts of UP. The third centre catered to recruits from all over the country. All troops and families, irrespective of the place they belonged to, were able to communicate in Hindi language. Though the regimental centres were authorized lesser capacity, at that time, a large number of recruits (total 9000) were present in the 3 regimental centres due to increased recruiting drive as a consequence of operational reasons. There was, thus, definite overcrowding in the training centres, with excessive load on water supply and night-soil disposal facilities. Local markets were available in the cantonment area, catering for eatables and other day to day use items. There was no particularly

various leading causes of death and hospitalization that have occurred, overall, in the state or in the country, to see if there is any particular difference in the leading causes of ill health between the area where we are planning our health education activities and the overall state or country. The data should be arrayed in simple tables, showing the diseases in the first column, the rates per 1000 (or per lac) in the second column and the overall rates in the state / country in the third column.

Sources which need to be explored to obtain this information include census office, Registrar of vital events, civil hospital and private hospital records, and interviews with civil practitioners / government Doctors. In case of Armed Forces, the important sources include military hospital admission and discharge data, monthly health reports initiated by SHOs, Records of outbreak investigations with SHO, Disease notification forms (AFMSF-73) and strength details about troops and families available with Station HQ and individual units.

An additional and extremely important part of this step is to also obtain data on health-behaviour related aspects of the clientele. This is best done by undertaking a cross-sectional and quick survey from a representative sample, obtaining data on leading lifestyle factors (diet, exercise, tobacco and alcohol use, obesity, and sexual practices), personal hygiene and protection (use of road safety and occupational safety devices, protection against insect vectors of diseases, bathing, hand washing and oral hygiene), and on water and food hygiene practices. This quick survey may bring forth some very important issues, (which may not be evident by simple comparison of routine mortality / morbidity data) and which need to be tackled by health education programmes (Box - 2).

(c) Analysis of Community Health Care System

The third step in situational analysis (community analysis) is to collect and analyze data describing the resources for

Box - 2

In our example:- Maj 'X' obtained the basic population data regarding the strength of troops and families according to the five sectors, and sub-distribution according to rank (Officers, JCOs, NCOs, OR and Recruits) and as per age groups for ladies and children, from the Station HQ and respective units. She obtained the data on leading ten causes of deaths and hospitalization during past 3 years from the Military hospital A&D book. In addition, she obtained the details from monthly health reports which were initiated by her SHO, as also AFMSF-73 from local formation HQ. She also had detailed discussions with the RMOs / MOs of central MI Rooms as regards their opinion of leading causes of ill health. Finally, she took the SEMO, Station Commander, Brigade Commander and Centre Commandants into confidence and carried out, in the next 4 weeks, a baseline survey on a convenience sample of 150 recruits (50 from each centre), 30 Officers, JCOs and 90 NCOs / Sepoys (5 offrs, 10 JCOs and 20 NCOs / Sep each from the Area HQ / Area Units, Brigade group, 3 centers, and Ordnance establishments) and 75 ladies (randomly selecting 25 officers wives and 50 JCO / NCO / OR wives). She developed a simple one-page structured Performa to obtain information about lifestyle factors, personal hygiene and personal protection and food / water hygiene. Another one page questionnaire obtained data on knowledge regarding HIV / AIDS & other STDs, attitudes towards sexual promiscuity, and sexual practices; this Performa was administered only to recruits and Officers / JCOs / NCOs Instructors from training centers.

Maj 'X' worked out the rates per 1000 strength of ten leading causes of death / hospitalization separately for serving personnel, recruits, ladies and children. In an adjoining column, she displayed the rates per 1000 for the entire Indian Army (average of past 3 years) to get a quick visual comparison. She could make out that the maximum morbidity problems were with the recruits; among them the leading causes were chicken pox, URTI, LRTI, mumps, gastro-enteritis, viral hepatitis A and E, enteric fever, training related injuries, nervous breakdown and lastly, STDs. There was no significant difference in the rates of various diseases or their pattern between 'J' station and the overall rates seen in Army. Among ladies and children, the mortality and morbidity was very low; the major causes of ill-health were malaria and gastrointestinal infections. Among serving personnel also, the rates of morbidity and mortality were quite low, with malaria, mild gastrointestinal infections, overweight, hypertension, road accidents being the leading health issues.

The results of quick sample survey showed interesting results. Substantial percentage of JCOs / NCOs showed low levels of organised physical exercise, a definite problem of overweight and habit of tobacco use. While indulgence in promiscuous sex was not reported by this category, they did demonstrate an attitude of "permissiveness" relating it to manliness and something that could be condoned in a soldier. Officers and ladies were well aware of basic lifestyle and personal protective factors and were positively inclined. Recruits showed a concerning proportion of tobacco use (they started the habit only after joining as recruits), were largely unaware of HIV / AIDS / STDs, and did show an inclination in indulging in sex, mainly due to inquisitiveness as well as due to the tacit condonation which was likely to be given to them by the immediate superior NCO / JCO instructor if they indulged in promiscuous sex. However, actual indulgence in promiscuous sex among recruits was very low.

On further studying the available research project reports, 'X' realized another interesting phenomena : that the level of HIV seropositivity among recruits wass extremely low (0.045%); however, the highest proportion of HIV cases was among the young personnel, aged between 20 to 29 years. Is it possible, then, that attitudes which lead a young person towards promiscuous sex are developed during the recruit period and these actually indulge in promiscuity once they become full fledged soldiers. If that be so, education and motivation for healthy behaviour during recruit period may be of much value in preventing indulgence in promiscuity (and resultant HIV/STIs) later on? There

providing health care (both curative as well as preventive) as are available to the community. This is undertaken by describing, firstly, the formally recognized health institutions (as government and private hospitals, dispensaries, health centers, sub-district hospitals, preventive health care programmes and institutions executing them). Secondly, informally recignized practitioners as those of traditional systems are described. The medical and paramedical manpower is thereafter described, as number of physicians, surgeons, according to sub-specialties, nursing personnel, health / sanitary workers, laboratory trained personnel and so on. The organization of service delivery, referral systems, and local health departments are studied. Finally the "grey areas" in health care, including communities / locations which are underserved or disadvantaged are identified. The last step is important since community groups who are actually in maximum need of health education are usually also the ones who are underserved / disadvantaged or living in inaccessible areas (Box - 3).

(d) : Analysis of Community's Social Organization and Support System

In this step, the social structure and the social support systems are studied and analyzed. The overall organization of the community, the major community groups, the interaction between various community groups, the peers / leaders, the opinion formers, and the political climate is studied. In addition, the various "Support Systems" available in the community (Voluntary organizations, NGOs, agencies which can organize

Box - 3

In our example : Maj 'X' undertook a detailed assessment of the health care facilities available for personnel and families in her area of responsibility. She noticed that Health facilities in 'J' station are fairly well organised and include a large (zonal) military hospital commanded by a Brigadier (who was also the designated Senior executive Medical officer(SEMO) of the station), 4 central MI Rooms, one in each centre and in the Ordnance depot, a large SHO for all duties pertaining to public health and preventive medicine cover (of which 'X' is the OC) and a 100 bedded cantonment hospital for civilian population of cantonment. For the sake of preventive health care the area had already been divided into 5 sectors, serially numbered from 'A' to 'E', as already described. The casualty department of military hospital was functional 24 hours. Road communications are good and each sector had ambulance / modified vehicles for transporting patients to the hospital and back. All MI Rooms also had an ambulance each. However, there were problems regarding transportation for the families living in separated family quarters, with no particular unit being made responsible to organize the transport and other welfare measures for separated

financial assistance, charitable organizations, and so on) are studied, with a particular reference to how these can be gainfully utilized in relation to the proposed health education programmes.

(e) Analysis of Strengths, Weaknesses, Opportunities and Threats (SWOT)

Strengths are advantages that are of a permanent nature and exist in the community ethos or in the general environment, and they must be gainfully utilized by the health provider; e.g., conservative attitude of a community is a strength for anti-alcohol educational programme. Weaknesses are disadvantages of permanent nature in the community ethos or environment which will need to be neutralized or bypassed for success of the programme; e.g., conservative attitude in the community may be a disadvantage while launching a sex education programme for school children. Opportunities are temporary, often flitting occurrences which the health provider should always be on the look-out for and utilize them to her benefit; e.g., if an outstanding sportsperson becomes the mayor of the city, it is an opportunity to contemplate launching a community educational program for healthy lifestyle and physical fitness. Threats are temporary phenomena which may be inimical to the programmes; recent occurrence of vaccine related adverse effects among children may be a threat to educational program for promoting vaccination coverage and this would need to be either circumvented or else tackled energetically (Box - 4).

**Step – 2 : Making the "Community Diagnosis"**

This is a vital step, wherein we identify the "target populations" and their health problems. The first step in making the community diagnosis is to summarize the

Box - 4

The overall social organization in 'J' station was similar to any other military station. The Area commander was the senior most Officer. The 3 centers, military hospital and ordnance depot was under the control of Area Commander while the brigade group was under his control only for local administration. There was cordial relationship between all the senior officers and among the units. The senior officers were, in general, well disposed to preventive health care. The Commandant of military hospital, who was also the SEMO had made a good reputation through good provision of medical care. The Army Wives welfare association (AWWA) was very active in the station and was mainly organizing vocational classes for wives of jawans. The lady wife of Area commander was the President AWWA. Common platforms for meeting all senior officers were a monthly social get together in officers institute, the station commander's monthly conference, the annual sports meet of Kendriya Vidyalaya, and raising days of individual units. The training centers had hectic schedules, especially due to excessive strength of recruits, which gave very little time for any other health education or even any other welfare activity

In general, the social climate was commensurate with the overall ethos of the Indian Army, i.e., to keep troops and families in the best state of health and physical fitness and to prevent disease. The new Area Commander had recently arrived on posting. He had particular liking for healthy lifestyle, particularly physical exercise and abstinence form tobacco. His lady wife was greatly interested in organizing preventive health care activities for ladies and children. She had particular interest in AIDS prevention, and had earlier worked as chairperson of a NGO undertaking AIDS prevention activities. During one of the social get together, Maj 'X' had an informal discussion with the Area Commander and his lady wife, who got quite impressed and promised her all help in any preventive health care activity that she wanted to undertake in the station. However, Maj 'X' also realized that there were some stumbling blocks, in that the society was quite conservative and not quite open at discussing about AIDS, especially in the forum for school children. She also knew that one of the staff officers dealing with AWWA was known for his "obstructionist" and "delaying" attitude. With this totality, Maj 'X' summarized the SWOT as

**Strengths :** The organization ethos accepting healthy and fit life as essential and motivation towards disease prevention; The cordial relationships between the various senior officers and various units.

**Weaknesses :** Hectic training schedules, leaving little available time for recruits to be available for health education; conservative climate tending to inhibit school health education on sensitive issues.

**Opportunities :** Highly motivated Area Commander and his lady wife; Good reputation of the SEMO as medical administrator.

findings of the earlier step of "situational analysis" (community analysis), through sub-steps 1 (a) to 1 (e). This summary will give us an idea of the "needs" of the community. The needs so identified are of 2 categories; firstly the "professionally assessed needs" i.e., those needs which are worked out by the health care provider, based on community analysis data. This would include the leading causes of morbidity and mortality (as, chicken pox, hepatitis, injuries, etc.) and leading determinants of diseases (as smoking, inadequate levels of physical exercise, dietary patterns, sexual promiscuity, etc.). Secondly, equally important are the "felt needs" of the target population, i.e., those areas of concern which are articulated most commonly by the target population. These felt needs are the most pressing problems experienced by groups and individuals in the target population and usually reflect the problems currently in focus (1 - 4) (Box - 5).

In short, in the step of community diagnosis, we clearly define the following aspects. A consolidated statement clarifying these under mentioned issues would serve as the basic guideline for further planning of our health education programme :

(a) What are the "target communities" which are to be addressed by our proposed health education, or by other health care programmes or by a combination of health education and health care programmes? Delimiting the target audience (s) will define premises of our proposed programme and help us focus our entire energies on to these defined groups, with a view to get the maximum results. Target communities are those groups or subgroups which have the maximum ill-health (mortality, morbidity or unhealthy lifestyle) and are likely to give significant results if concerted health education programmes are focused on them.

(b) What are the major health problems as assessed by us which need to be addressed by health education programmes or health care programmes?

(c) Besides our assessed needs, what are the other "felt needs" of the target audiences, which also need to be addressed either by health education or other health care programmes.

**Step – 3 : Defining the "Premises" and "Goal" of the Proposed Programme**

Premises are the outer boundaries within which our proposed programme will function; we will not be going out of these limits in so far as the particular programme is concerned. Thus, this helps us focus our attention our programme and our goal and not mix up our actions with other issues. Premises are generally defined in terms of the population characteristics, place, time and the broad issues which will be the concern of the programme. While defining the premises and the goal, one should be clear that while a number of issues may be identified as major "needs", it is not necessary (and also not usually feasible) to address all these identified needs through health education programmes. Some of the needs would be better resolved using public health or other medical care approaches. It is therefore important to clearly delineate at this stage, which of the needs will be addressed by health education programme and which would be addressed by other public health / medical care steps.

Once we have defined the premises and sorted out the

Box – 5

Continuing with our example : Having collected and analysed the information form the first step of situational analysis, Maj 'X' finally summarized the community diagnosis as :

**Primary Target Audience** : Firstly, the highest amount of morbidity was noticed among recruits. Secondly, there were a very large number of recruits in 'J' station. Thirdly, was the fact that recruits are actually adolescents, who have just left their traditional family life and whose health related behaviour and lifestyle is in the formative process. Thus a concerted and focused health education programme for recruits was likely to pay rich dividends. For these reasons, the "primary target Audience" for the proposed programme was defined as "Recruits undergoing training in any of the 3 training centers in "j" station.

**Secondary target Audience** : While primary target audience was identified as "recruits", it was realized that without providing the knowledge and obtaining favourable changes in attitudes of those who were the "Instructors" for recruits at the training centers, the results may be limited. These instructors were not only teachers but also formed a "peer group" for the recruits and their own behaviour was likely to have much impact on the development of attitudes and practices by recruits. "Therefore, a secondary target audience was also identified as "JCOs and NCOs Instructors posted at the 3 training centers". In addition, the lady wife of the Area Commander as well as the DDMS of the Area HQ were of the view that a programme for education the ladies in the station as regards food and water hygiene, healthy lifestyle and HIV / AIDS should also be launched. Thus, another secondary target audience was identified as "Wives of serving personnel, including separated families, staying in 'J' station".

**Professionally Assessed Major Health Issues** : The major health issues which required action, either by health education programme or by public health improvements or a combination of both were gastrointestinal infections due to overcrowding and consequent load on existing water supply, sanitation and accommodation facilities. In addition, keeping in view the low level of knowledge and young age of recruits (when lifestyle habits are formed), lifestyle factors related to sexual promiscuity and tobacco use were also identified as important issues.

**Additional Felt Needs of target Audience** : Various Officers, JCOs and NCOs, during the survey had also suggested that overcrowding, adequate water supply and increase in sanitation facilities was a pressing requirement. Hence, these aspects were also noted for

"needs" according to which all will be addressed by our proposed health education programme, we enunciate the overall "goal" of the programme. Goals are broad statements which reflect the end result that we desire to achieve, i.e., they are the intended consequences of the program (5). Program goals should not be confused with "educational goals", which will be discussed later under step – 6 (Box - 6).

Box - 6

Continuing with our example:- After going through various details, Maj 'X' could make out that the needs related to improvements in overcrowding, water supply and additional sanitary facilities would need major engineering efforts and sanction of works, and additional public health surveillance efforts, for which she would need to constantly undertake advocacy with the commanders and engineering authorities. Health education program for this need may not be an effective approach. On the other hand, an IEC program addressing Lifestyle, particularly HIV / AIDS, food / water hygiene, and tobacco use would adequately address one of the major identified needs. The ideal target audiences for such an educational program would be all recruits, all JCO & NCO Instructors and all ladies. With this conviction, she defined the premises of her proposed health education programme as " IEC program for lifestyle and behavioural factors concerning Sexual Health (particularly HIV / AIDS), Personal Hygiene (particularly food and water hygiene) and tobacco use, proposed to be undertaken among all recruits, all JCO & NCO Instructors, and all wives of serving personnel posted at 'J' station, over a two year period from Jan 2001 to Dec 2002".

Having defined the premises of her proposed programme, Maj 'X' defined the goals as "to provide universal knowledge regarding hazards of sexual promiscuity, transmission and prevention of HIV / AIDS, hazards of cigarette smoking and elements of food and water hygiene, and to achieve a positive change in the attitudes among the target populations, as regards HIV /

**Step – 4 : Consolidating data on knowledge, attitudes and behaviours**

It is apparent that the ultimate goal of any health education program is to increase the knowledge and obtain a favourable change in attitudes and behaviour by the target population. Hence, we will need data as regards the current state in respect of the knowledge, attitudes and behavior, for the goals that have been identified. Behaviour should be assessed in terms of "events" and "outcomes". An event is the actual behaviour (e.g., smoking, sexual promiscuity); an outcome is the result of that event (e.g., IHD, AIDS). A sample survey of the target population, if the same has not been done in step 1 (b), should be now undertaken and data on current levels should be recorded (6 – 9) (Box - 7).

**Step – 5 : Assemble the Planning Group / Coordination Council**

Community health education cannot be accomplished by a single health educator. All representatives form the community, especially those who can facilitate the program should be approached to consent being a part of the planning group (also sometimes called as coordination council or governing board). From this step onwards, all plans are discussed and finalized, progress monitored and difficulties sorted out by personal involvement of members of this group. This group should include the public health / health education specialist, who should be the secretary of this group. The chairperson is usually an eminent / influential political or administrative person. The members include technical specialists, administrators, and above all, representatives of each of the target populations identified earlier.

Box – 7

Continuing with our example :- Maj 'X' had already collected data on relevant headings during step -1 (b). However, some data was further required and the same was collected through a sample survey on 50 subjects from each of the 3 target populations. Analysis of the data revealed that approximately 30% of the recruits, 50% of the ladies and 70% JCO / NCO Instructors were aware about the seriousness and transmission modalities of HIV AIDS. 100% ladies, 65% JCO / NCOs and 75% recruits looked at sexual promiscuity as UNDESIRABLE; Only 30 to 40% of all the 3 target audiences could list 5 common and serious diseases caused by tobacco use. 10% recruits and 45% JCO / NCOs were using tobacco in some form or the other. Only 20 to 30% of all the 3 target audiences could correctly narrate

Once a planning group has been constituted, all members should be given an initial briefing to orient all members as regards the various aspects of the program. This activity is relevant since many of the members may not be very aware about the technical intricacies of health education and medical care, as also about the details and sequence of planning process (Box - 8).

**Step – 6 : Reconfirming the program goals, enunciating the educational goals and the objectives**

Once a planning group has been formed, one of the first activities to be undertaken by this group is to firstly, reconfirm that the original program goal (vide step – 3) is finally acceptable or else it needs to be changed. Secondly, the group should enunciate broad statements, for different identified "needs" and different target groups, as to what the educational process aims at finally achieving. The overall program goal should be kept in mind when formulating the educational goals. The educational goals should be stated in precise language so that all members of the planning group thoroughly understand the exact intention of the statements (5,10).

Having specified the educational goals, the educational objectives are enunciated. As compared to goals, which are generalized & broad statements, objectives are precise statements which indicate as to how the goal will be realized. For one goal, there could be a number of objectives. Objectives should be specific, measurable and

Box – 8

Continuing with our example : Maj 'X, by now, was ready with the basic data, list of identified target populations and the broad goals which she had kept for the proposed health education program. She first of all personally briefed the SEMO, the DDMS of Area HQ and the Station Commander with an outline of the program. Having convinced and obtained assurance of their support, she took an appointment with the lady wife of the Area Commander, who asked her to come in the evening at tea time. The Area Commander, DDMS, Station Commander, and Col 'A' were also present during tea. Maj 'X' briefed them on her laptop computer, backed up with hard data from the survey, the broad goals and a outline of the proposed health education activities. All were very impressed and the Area Commander directed all to extend support to Maj 'X' as regards the programme. A programme steering council was also drafted out, which included DDMS Area, SEMO, Station Commander, Commandants of the 3 centers, Brigade Commander, lady wife of Area Commander, and lady wives of Brigadiers in the station. Thereafter, a "program planning committee" (PPC) was worked out, which included the Station Commander as chairman, the SEMO, the Col 'A', Maj 'X' (secretary), Deputy Commanders of the training centers and the Brigade, lady wives of Commanding Officers of training battalions and Infantry battalions, 2 JCOs and 2 NCOs Instructors from each training centers. This PPC was empowered to develop and implement the program and to meet once a fortnight to review the progress. The Area Commander asked Maj 'X' to brief him and his wife once a month as regards the progress of the program. The PPC met after 3 days during which Maj 'X' gave detailed briefing about the current situation, the target groups, the identified educational goals and the tentative plan. Finally the PPC promised an "in-principle" support and asked Maj 'X' to develop the draft objectives, the possible methods and activities, the time-table and details of implementation, to be discussed in the next

quantifiable in terms of magnitude of change and time-line. Within each objective, the parameter which will measure change is called the "indicator" and the magnitude of change proposed to be achieved is called the "target". For example, in an objective "Proportion of persons who are smokers should reduce from current 45% to 25% in next 2 years", the statement "Proportion of persons who are smokers" is an indicator while the part "reduce from current 45% to 25% in next 2 years" is a target (Box - 9).

**Step - 7 : Resource Analysis**

The important issue at this stage is how we can convert the desired objectives into an effective "action plan" so that the objectives can be achieved. For this purpose, we have to now analyze our resources, i.e., what all do we have to take action. In general, resources are analyzed in terms of 3 broad headings, viz., men, money and material. Resource analysis for manpower would include the

Box – 9

Continuing with our example : The PPC reviewed the broad program goal initially developed by Maj 'X' and generally agreed with the same. Having verified the program goals, the planning group defined the **educational goals** as :

- All the 3 target audiences to be made fully aware about the hazards of sexual promiscuity, and about mode of transmission, seriousness and prevention of HIV / AIDS.
- The recruits and JCO / NCO instructors should develop a healthy change in their attitudes, and genuinely identify sexual promiscuity as an undesirable lifestyle which should not be condoned, and definitely not encouraged.
- All the three target audiences should be aware of the health hazards of tobacco use; there should be significant decline in the proportion of tobacco users among JCO / NCO Instructors; there should be significant decline in the proportion of recruits starting tobacco habit;the target audience of ladies should talk to their husbands & children about hazards of tobacco use.
- All the 3 target audiences should be aware of the basic principles of food and water hygiene.

Against the background of these stated educational goals, the group developed the following **objectives** (timeline for all objectives was Jan 2001 to Dec 2002) :

- At least 90% of recruits, JCO and NCO instructors should be aware of the diseases transmitted by sexual route, the sequelae of HIV / AIDS infection, the modes of transmission and preventive measures as against a current level of 30% among recruits and 70% among JCOs / NCOs
- At least 90% of the recruits, JCO and NCO instructors should identify sexual promiscuity as UNDESIRABLE (current level 65% among JCOs / NCOs and 75% among recruits)
- 100% of all 3 target audience should be able to name 5 common and serious diseases due to tobacco use (current level 30 to 40%)
- Proportion of tobacco users should come down to less than 25% among JCOs / NCOs and less than 5% among recruits (current levels 45% and 10%).
- 100% tobacco users should voluntarilty agree that tobacco use is an undesirable habit (current level not known).
- At least 80% of all 3 target audience should name 5 basic principles of water and food hygiene. (current level 20 to 30%).

medical and paramedical personnel, and other key personnel as epidemiologists, trained health educators, data operators and statisticians, along with their locations, who would be available for the health education program, either full-time or part-time. This aspect of

manpower also includes the 'supportive manpower" as political leaders, administrative authorities and peers who would support the program. Money refers to assessment of funds / finances which will be required for development of health education material, training material, communications and transport, purchase of health educational and medical equipment if required, payment of salaries, etc. The source of finances could be government (public funds) or funds generated by voluntary / non-governmental organizations. Finally, material refers to technical equipment, expendables and logistics. This would need assessment of various aspects like availability of class-rooms, lecture halls, buildings, electricity, announcement systems, projection systems as slide / overhead projectors, computers, LCD projectors, mobile panels, posters and charts for exhibitions, models, and so on. In addition, equipment pertaining to "logistics" as vehicles for transportation of target population, petrol, tentages, generators, etc., would also need to be assessed, as required. It is only after making a detailed assessment of resources (already available and expected over reasonable period of time), that the program planner would be able to decide as to how best can an action plan be drawn to meet the objectives; at this stage, it may also be a consideration to drop one or two objectives if adequate resources are not available (Box - 10).

### Step – 8 : Identify Methods and Activities for Health Education

In the earlier chapter, we have deliberated on the various types of methods (as lectures, focus group discussions, exhibitions, mass media communication methods, etc.) and the activities that are conducted within each of these methods. Detailed decisions should now be taken to see which particular method(s) will be most appropriate to address the objectives for different target groups, and

Box - 10

**Continuing with our example**

Having drawn a list of goals and objectives, Maj 'X' undertook a detailed analysis of the resources, which she listed as follows :

**Technical manpower** : Maj 'X' was herself a well qualified specialist in PSM, having required training in epidemiology, statistics, health education and program management. The SEMO was a highly qualified super specialist in Immunology. The military hospital had 10 general medical officers and 10 specialists in all basic specialities. There were 6 Regimental Medical Officers (RMOs), one in each centre, two in the brigade group and one in the ordnance establishment, who were ready to get involved in the program in their respective locations. The SHO, which Maj 'X' was commanding had 4 sanitary inspectors and one lab assistant, all well trained in health education and program implementation. Each of the centre , brigade group and ordnance establishment had, besides RMOs, 2 to 3 trained nursing assistants, who could also be drawn into the program.

**Other manpower** : A potential source of Non-medical manpower were the JCO / NCO instructors of the various centers a total of approximately 100 in strength, who were responsible for giving military instructions to recruits and could be trained as trainers. Higher level "manpower support systems" included the Area Commander, DDMS of the Area, Station Commander, SEMO, Center Commandants and Brigade Commander, who had all assured Maj 'X' of their full support. Within her SHO, Maj 'X' had a clerk and Store Keeper and Drivers, besides various other supportive manpower who could help in organizing office procedures & physical assistance in laying out health educational venues.

**Finances** : There was no formal governmental funds available for the program. Maj 'X' had visualized that she would need to run the program within existing resources of manpower and logistics, though the lady wife of the Area Commander had promised that upto Rs 10,000/- would be made available out of welfare funds for miscellaneous expenses. One of the Centre Commandant had assured that any printing of technical pamphlets would be done free at the press which his centre was running. All Centre Commandants and the Brigade Commander had promised that tea and snacks would be served to all participants, after the educational sessions, out of their resources.

**Technical Equipment** : The SHO at 'J' station had been upgraded by the DGAFMS into an "IEC node". As result, the SHO had been equipped with a computer system, slide projector, overhead projector. Mobile panel-boards for exhibitions, and a large variety of health educational material including booklets, posters, charts, flip charts, pamphlets, transparencies, slides and hand bills for AIDS prevention. The computer was equipped with various software including software for developing educational material in Hindi and other regional languages, thus making educational material other than AIDS also quite feasible. In addition, she also had a well laid out health museum with various charts and models on prevention of various diseases as a part of her SHO.

**Other Equipment and logistics** : Maj 'X' had a dedicated light vehicle as well as a heavy vehicle in her SHO, thus facilitating movement of her personnel and health educational equipment. The Station Commander, Brigade Commander & Centre Commandants had also assured her that personnel and families who would be attending he health education program would be transported to the venue and back under their arrangements. All the Centres and the Brigade had large lecture theatres fitted with computer and LCD projection systems and their availability was assured to Maj 'X'. Besides, 2 open air theatres and a large central "Mela Ground" were also available for holding exhibitions

Box - 11

In our Example : Maj 'X' reviewed the target audiences (step-2) and the objectives (step-6) that had been decided, and matched them with the assessed resources (step-7). She then concluded that the following methods and activities should be used for different target audiences :

**For Recruits, in respect of all the three educational objectives (HIV / AIDS, Tobacco, and food & water hygiene) :**

- Respective Centre RMOs to give lecture of 20 minutes followed by 10 minutes of two-way discussions, for 100 to 125 recruits, according to training battalions / companies, so as to cover all recruits once in two months. Posters developed by AIDS Control Organization of Armed forces and distributed by SHO to be utilized. Lectures to include hazards of sexual promiscuity, sequelae of HIV infection for individual, family and community, modes of transmission and methods of prevention; hazards of tobacco use and methods of giving up tobacco use; basic principles of food hygiene.
- JCO / NCO Instructors, after being trained, within two months of start of programme, to talk daily for 5 minutes to their respective recruits, during their training schedules, on all the three aspects. They will use flip-charts, to be provided by OC SHO, for such informal talks.
- Central exhibition during station mela, during Diwali and Holi festival times, organised by Station HQ. OC SHO to be given two stalls in these melas (festival camps) to put up an exhibition on all these 3 areas, using appropriate charts and models. The mela is organised for 3 days and is attended by all personnel and families in the station.
- Maj 'X' to be invited by respective unit commanders / training battalion commanders to speak for 10 minutes on the three aspects, during their monthly sainik sammelans for recruits / for all ranks. After 3 months of work experience in the program in question, the RMOs may, at times give the talks during these sammelans, instead of OC, SHO.

**For JCOs / NCOs Instructors and JCOs / NCOs of Infantry Brigade Units in respect of all the 3 educational objectives :**

- Maj 'X' to hold centre-wise Focus group Discussions of 30 to 45 minutes duration, for groups of 20 to 25 JCO / NCO instructors, within the location of each centers or infantry units, so as to cover each centre once a month, on all the three aspects outlined above. Computer projection system will be used as training aid. Power-point projection program in Hindi / Roman Hindi to be developed by Maj 'X'.
- Talks during sainik sammelans by Maj 'X' and exhibition during central mela to be additionally utilized by all JCOs / NCOs.

**For ladies in the Station**

- Each training centre / brigade group / ordnance establishment to constitute a "Core Resource Group (CRG)" of 20 to 25 ladies from within their respective resources. The ladies should be educated till 10th standard and should be communicative and socially motivated. Lady wife of Dy Commander, Lady wives of Commanding Officers of battalions, 1 young lady wife of an officer, 5 to 7 JCOs wives and 8 to 10 NCOs / Sepoys wives to be part of this group.
- The ladies to collect at a central place in their respective centre / brigade once a month, on a fixed day (Thursday) at 1400 hrs. Maj 'X' along with her team and educational aids to reach the concerned location and undertake focus group discussion on the three objectives, as also on various other aspects of health and disease prevention, for about 1 hour. Power-point projections, charts and handbills to be used as aids.
- The 20 to 25 ladies of the CRG to become "Resource Persons" and visit families within their respective centre / units during the next one month (i.e., till the next educational session with Maj 'X') and educate other ladies as regards what they have learnt, by personal discussions and small, domestic level groups. They will also carry pamphlets and handbills, provided to them by OC SHO, for distribution to the ladies.

**For the Peers, Supporters and Program Functionaries**

- Briefing on the progress & difficulties, for all senior officers involved with the program. To be undertaken once a quarter by Maj 'X' during the quarterly station anti-malaria and health committee meeting, to be chaired by station commander and attended by Colonel 'A', Dy Commanders of the training centres and commanding officers of all other units. Circular to be issued by Maj 'X' and records of proceedings to be maintained. Teaching aids : powerpoint presentation and LCD projector in station Commanders office, followed by minuted record of the meeting.
- Briefing of senior ladies, including lady wives of following senior officers : Area Commander, Centre commandants, brigade commander, commandant of ordnance establishment & commanding officers of major units in station. To be held once a quarter. Briefing by Maj 'X'.
- Monthly meeting of medical functionaries. To be chaired by SEMO and attended by Maj 'X', all

within each method, what all educational activities will be undertaken. The details of the decided methods and activities for each target group should be written down (Box - 11).

**Step – 9 : Writing and disseminating the Action Plan (Implementation plan)**

Having clearly enunciated the methods and activities, a detailed action plan should be written down. This is a detailed document which clearly specifies as to who will do

what, to whom all, where, in what manner and how frequently. The document should specify all details of :

(a) Dates / days of the week or month and timings, on which the educational sessions will be held for the duration of the program.

(b) The locations at which the sessions will be held.

(c) Who all will attend the sessions at the particular locations, dates and time?

(d) Who will be administratively responsible for ensuring that the target audience reaches the particular location of educational session, well in time?

(e) Who will conduct the session

(f) Who will be responsible for technical aspects of the session.

(g) Who will be the overall coordinator for the educational activities?

The details should be discussed by the program planning committee (PPC) and then issued by a senior administrative officer to all concerned (Box - 12).

**Step - 10 : Implementation and Evaluation**

Once the instructions for implementation have been issued, the health educator's responsibilities further increase since he is now not only responsible for providing health education to the various target populations but also often responsible for coordination of the various administrative aspects, to see that all aspects of the program progress as scheduled in the action plan. In real

Box - 12

Continuing with our example : Maj 'X' developed the draft action plan for implementation as follows :

- Total duration of the health educational program will be two years (Jan 2001 to Dec 2002).
- Respective RMOs of the regimental training centers and battalions of the brigade group will give lecture on the stipulated educational areas on every Saturday after the drill period, to a company strength of recruits/infantry personnel. Thus, all training companies of the centers/infantry companies on brigade group will be covered once in a month. Audio-visual aids as stipulated (in step-8) will be collected by the RMOs from the SHO. Adjutants of the battalions will be responsible to ensure that the concerned company of recruits / soldiers is made available for health education at the designated location and time.
- All Training battalions/infantry battalions will invite Maj 'X' to deliver a lecture of 10 minutes duration during the monthly sainik sammmelan on the decided topics. Arrangements for conveyance of Maj 'X', her team and educational equipment will be of the concerned Commanding Officer.
- All JCOs/NCOs Instructors will talk to their respective student recruits informally, daily for about 5 minutes on the decided topics, starting from April 2001. The Subedar Majors will give a weekly confirmation on this aspect to their respective adjutants.
- All training battalions/infantry battalions will invite Maj 'X' to deliver a talk to their Instructor JCOs/NCOs, once a week on every Wednesday, between 1200 to 1300 hrs. This will be done in rotation, covering the JCO/NCO instructors of a particular training company on a given Monday. The rotational program will be prepared by Maj 'X' and forwarded to the battalions at least 3 months in advance. Responsibility of ensuring that the JCOs/NCOs are available at the location and/for transportation of Maj 'X', her team and equipment will be of the concerned battalion commanders, who will also ensure that a proper lecture hall with LCD projection system is made available.
- Respective lady wives of centre commandants and brigade commander will select a core resource group of 20 to 25 ladies (as per details discussed in step-8). Maj 'J' will issue a program according to which she will discuss the educational aspects of selected topics with the ladies of core resource group, in rotation on every Thursdays, from 4 to 5 p.m. The location will be a central hall of the concerned centre/brigade. The respective centre adjutants/Staff captain of Brigade will ensure that the core group of ladies are provided transport and reach the venue well in time on the decided date and also provide transport for conveyance of Maj 'X' , her team and equipment.
- Maj 'X' to keep lady wife of Area commander and other senior ladies duly apprised about the progress of educational activities for ladies. Senior ladies may also visit the venue and participate, once in a while, as desired by them.
- Station HQ will earmark a place for SHO, during Diwali and Holi station melas, where Maj 'X' will put up the health exhibition. Logistic requirements will be catered to by station HQ.
- Once in 3 months, a evaluation test will be taken from all recruits and JCO/NCO instructors, by Maj 'X'. For ladies of Core resource Group, Maj 'X' will take a oral test to monitor progress.
- All instructions will be issued by Col 'A' of the Area HQ, on behalf of the Area Commander. Coordination of all activities and regular feed back on technical and administrative matters will be drafted by Maj 'X' and forwarded once a month to Area HQ and Station HQ for information of Area Commander & Station Commander respectively.

The above draft action plan was approved by the SEMO, Station

life scenarios, everyday there will be problems, which would need an action and to be rectified. Sometimes the vehicle may not turn up to ferry the health educators team and equipment, sometimes the officer responsible for administrative coordination for one of the target populations may simply forget that there was a session planned for that day; sometimes a holiday may be announced suddenly on the day of planned session. All these issues need to be visualized and addressed. In health education programmes, and for that matter in any public health program, perseverance and determination always pays.

Along with implementation of action plan, evaluative process also needs to be planned and conducted. As explained in detail in the section on principles of epidemiology (planning & evaluation of programs), evaluation is undertaken for six different aspects, viz., relevance, adequacy, process, and outcome (including efficacy, effectiveness and efficiency). In the usual settings of health education programs, evaluation is undertaken for "process" (i.e., whether the activities are being undertaken as planned) and for outcome (i.e., to what extent the objectives have been met). Evaluation for process is to be undertaken concurrently, say once in 3 months for a program planned for 1 to 2 years. Outcome evaluation is undertaken both, concurrently (e.g., what percentage of target population have shown improvement in knowledge and behaviour) and terminal evaluation at the end of the program (whether targets as envisaged at the planning stage have been achieved). It should be remembered that evaluation should always be an analytic process, with the drawbacks / deficiencies noticed further analyzed and change in program actions undertaken to rectify defects that have been identified(Box - 13).

**Step – 11 : Writing the Final Report** : Once the program has been completed or terminated for whatsoever reasons, the program planner must write down a detailed report of the program, including the background, the target audience, the educational and program objectives, the action plan,

Box - 13

Continuing with our example : Maj 'X' continued to collect data on each and every activity that was planned in the action plan, including the administrative aspects. Any acute deficiency (e.g., one of the days the target group of recruits were diverted to some other place for working, at the last moment) was immediately brought to the notice of the concerned commanding officer, personally, with an element of advocacy for his personal directives in ensuring that the details of action plan are complied with by all concerned. As another part of process evaluation, Maj 'X' compiled and analysed the ongoing data about changes in the health awareness level among different target groups, along with difficulties observed, and gave briefings to members of PPC, during the quarterly conferences. In addition, she also constantly kept the lady wife of Area Commander informed as regards the progress and the difficulties, on a monthly basis, with a request for her help, which, quite obviously was forthcoming since the lady wife of Area commander had herself given a very high priority to the program. After initial "teething problems", all concerned became convinced about the usefulness of the program and their motivation to make the program a success increased.

In Oct/Nov 2002, I.e., two months before the program was scheduled to end, Maj 'X' undertook a sample survey of the target population and obtained data on the knowledge and attitudes regarding sexual promiscuity, transmission and prevention of HIV / AIDS, hazards and prevention of tobacco use, and food / water hygiene. She analysed the data and compared the results with the baseline (which she had earlier collected in step-6). The results showed that there was tremendous success achieved. The program had achieved uto 80 to 90% of the stipulated targets. Another important result that happened and which was, in fact, not visualized earlier was that all the training centres and brigade group were finally so impressed with the program that they identified the program as an essential training and welfare need and incorporated the program action plan in their respective training and welfare Standing Operative Procedures (SOPs). Thus the program became an automatically operated program with little requirement of coercion from the side of Maj 'X'. Soon thereafter, the Area Commander was posted out; Maj 'X' was also posted out and so were the various centre

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Mr SSL Parashar

## Socio-Behavioural Sciences and Health

Social, cultural, psychological and behavioural factors are important variables in the etiology, prevalence and distribution of disease. The way the people live, their habits, beliefs, values and customs are significant determinants of individual and collective health. The behavioural sciences (sociology, social psychology, cultural anthropology) have made significant role in developing better understanding about the social etiology of health problems. It is recognized that causation and spread of a disease does not depend entirely upon biological organism. The cultural and social factors which govern human behaviour also have dominant role to play in the disease process.

### Sociology

Sociology is the science concerned with the organization of social groups. It studies the kinds and cause of variation in social structure, and the processes by which intactness of social structure is maintained. Sociology deals with the study of society. Society is a group of individuals who have organized themselves and follow a given way of life. The behaviour of man depends very much upon his relationship with other fellow beings. Man is a subunit of a small group; the family, while the family is the basic unit of society. Man's behaviour is affected not only by his physical and biological environment but also, to a larger extent by social environments represented by his family.

### Community

In the simplest terms, a community can be defined as a group of people who have some common characteristics and are bound together by "WE" feeling. This sense of 'we' feeling (i.e., shared togetherness) may be due to a place where they all stay or due to some other common interest.

Accordingly, communities can be either "structural" or else, "functional" communities. Functional communities are non-geographical aggregates which are bound together by some common factor other than geographical place of residence or work; e.g., religion (as, Hindu community), occupation (as medical community), special interest (as cricket lovers) or need (as socially backward communities). Structural communities are organised by geographical or political boundaries. It could be as small as an "indoor patient's community in a hospital" or increasingly larger, according to a "Mohalla", village, slum, city, district, state or even a nation.

Community affiliations often provide a source of support for individuals and groups. The sense of group identity creates motivation. For this reason the community is ideal for focal point of programme.

### Culture

Culture is defined as learned behaviour which has been socially acquired. Culture includes all that man acquired in the mental and intellectual sphere of his individual and social life. It is a product of human societies. Culture is necessary for human being; it makes life worth living and socializes man. A culture denotes total way of life. It is recognized that cultural factors are deeply involved in all the affairs of man including health and sickness. The cultural factors such as customs, beliefs values and religious taboos create an environment that helps in the spread or control of certain diseases and affect health of the community. The various causes for sickness, as understood may be classified in two categories : Supernatural causes and Physical causes. Supernatural causes include diseases caused by (a) breach of taboos e.g. leprosy, sexually transmitted diseases; (b) wrath of god and goddesses e.g. small pox and chicken pox ; (c) spirit intrusion, ghost intrusion and evil eye. The physical causes include excessive heat or cold, wrong combination of foods and impurity of blood etc. Prevention of disease and bringing improvements in the health conditions in any society is dependent upon our ability to understand and improve the social or environmental factors.

### Family

The family is a primary unit of all societies. A family can be defined as a group of individual biologically related to one other, staying under a common roof and eating from a common kitchen. It can also be defined as :

"The Family is a group defined by a sex relationship precise and enduring to provide for the procreation and upbringing of children" (MacIver).

Family is the reproductive nucleus of society, a fundamental and social institution whose primary and essential task is to socialize the new born so that they may be placed in life as mature and independent. Through the family, human beings maintain physical continuity by reproduction and maintain social and cultural continuity through training and education.

#### Family in Health and Disease

The health of the child is bound up with the family's internal and external environment even before it is born, and the foetus in the womb can be harmed by the health, nutrition and behaviour of the mother. Subsequent experiences in infancy, in the quality of feeding and method of training for instance may further influence development, physique, stature and personality.

The members of family share a pool of genes and a common environment as well as common modes of thoughts and behaviour and family material and social environment which includes housing, sanitation and diet. A damp overcrowded house encourages streptococcal infections and Tuberculosis. It is not only infective agents that pass between the members of a family. Parents may transmit distorted cultural perceptions and behavioural norms to their children, and thus create deviant behaviour and failures of adaptation among them.

#### Family life cycle stages

(a) Married couple - beginning of family

(b) Child bearing family

(c) Family with pre- school children
(d) Family with school age children
(e) Family with teenage children
(f) Middle age
(g) Aging family members/ retirement

As families enter each new developmental stage, transition occurs. Events such as marriage, childbirth, releasing members as adolescents and young adults, and continuing as a couple or single person and aging years move families through new stages. Each new developmental stage requires adaptation and new responsibilities. Each new stage presents opportunities for health promotion and intervention. There are certain functions which are relevant to health behaviour, and are important from the medical sociology point of view, as follows :

**Child rearing**

one of the important functions of the family with which medical and health workers are concerned, is the physical care of the dependent young in order that they may survive to adulthood and perpetuate the family. It is important to note that child care (e.g. feeding, nutrition, hygiene, sleep, clothing, discipline, habit training) are passed on from one generation to another.

**Socialization**

The second responsibility of the family is to socialize the stream of new-born barbarians. By socializing is meant teaching the values of society and transmitting information, culture, beliefs, general codes of conduct, by example and precept, in order to make them fit for membership in the wider society of which the family is a part. It is the family which imparts practical education to children concerning the customs in society, preservation of health, love, sympathy, cooperation etc.

**Personality formation**

The capacity of an individual to withstand stress and strain and the way in which he interacts with other people is to a large extent determined by his early experience on the family. The families acts as a placenta excluding various influences, modifying others and pass through it and contributes some of its own in laying foundation of physical, mental and social health of the child.

**Care of dependent adults**

The family is expected to provide care during sickness and injury of adults and dependents. From the public health point of view care of women during pregnancy and childbirth is an important function of the family. The family also provides support, security and encouragement to the aged and handicapped.

**Stabilization of adult personality**

The family provides an opportunity, both for adults and children, for release of tensions so that the individual can attain mental equilibrium and strive to maintain a stable relationship with other people. The family has an important function in stabilization of the personality of both adults and children, and in meeting their emotional needs.

Problem families

The factors in most problem families are usually those of personality and of relationship, backwardness, poverty, illness, mental and emotional instability character defects and marital disharmony. These families are recognized as problems in social pathology. There is a need to render useful service in rehabilitating such families in a community.

**Common terms used in sociological applications in health**

Social pathology

Social pathology is the systematic study of human disease in relation to social conditions and disease process outside the human body. The cause is to be found in the society. These include Social Problems (namely, poverty, destitution, illiteracy and ignorance, migration, lower status of women, child neglect and child abuse, child labour, drug abuse, juvenile delinquency); social conditions (as housing, environmental sanitation, crime and corruption, stress, suicide) and social circumstances (stigma, social isolation, vulnerable populations). The causes of social problems, conditions and circumstances which affect the health of the people are to be understood and actions are to be taken to prevent such problems through health education and rehabilitation.

Social Diagnosis

This is made by socio-medical surveys and by study of domestic and social conditions of individuals. This is a statement of the aberrations that are likely to result from the identified social pathologies.

Social therapy

Social therapy offers holistic therapeutic and support services. The approach addresses and supports the total social, emotional and educational needs of young and the entire family. Clinical treatment of any disease with drug should be supplemented with social therapy. Social security measures, link between hospital and community, health education and legislation serve as supportive measures.

Knowledge

Education is a process of learning undergone by individuals for gaining knowledge, developing attitudes and acquiring skills. Knowledge is the basis of health education where a person gets of information by many modes which becomes his knowledge.

Attitudes

Attitudes are mental habits acquired from social experiences that predispose us to react to specific objects, persons or situations in a definite way. They are the crystallized habits of thoughts that we develop relative to social situations and that set us to respond in a certain manner. An attitude is an enduring system that includes a cognitive component, an emotional (feeling) component and an action tendency.

Practices

Practices are application to particular and personal

situation. The individuals modify their behaviour and maintain the change for the rest of their life. E.g. the individual stops smoking after changing attitude.

Community's social support system

In medical practice the ability of a family and community to provide social support and material aid to dependent members is important.

Social assistance implies provision of relief to individuals at critical times without having received any contribution from them. Social assistance is a non-contributory benefit extended to vulnerable groups including women, children and aged.

Social environment

The social environment includes all those things which arise out of social relationships such as customs, traditions, institutions social conduct, rituals, diet, way of life and economic status. Health is profoundly influenced by the social environment which acts in many ways to shape the contours of disease, in populations as well as individuals. For promotion and protection of health and prevention and control of disease social environment should be free from harmful agents. Important measures for providing healthy social environment as :

(a) Social security against fear and want (ESI scheme, old age pension, life insurance, provident fund and health and medical facilities.)

(b) Fair distribution of food and other amenities of life such as housing

(c) Facilities for exercise and leisure

(d) Facilities for education for all

(e) Propagation of healthy customs, freedom of expression and thought

(f) Protection of property, life and honour

(g) Safe work place which involves establishing a stimulating work environment and making sure that the work place creates social contacts which do not interrupt the family networks.

**Non-Governmental Organizations (NGOs) and Voluntary organizations**

NGOs form a bridge between the government and community and provide platform for people's participation NGOs are many and diverse. There scale may be large, medium, and small. Their support may come from external sources, from their own fund raising or from government. Their principal activity may be direct service to those in need in the community, health education or research. Voluntary organizations could be defined as those organizations which are non- governmental and non profit making in character and not fully funded whether directly or indirectly only by government. Most voluntary organizations have four primary purposes

(a) Raise money to fund research and programmes

(b) Provide education to both professionals and the public

(c) provide services to individuals and families affected by the disease and health problem (iv) to advocate for beneficial policies, laws and regulations. (e.g. VHAI, Indian Red Cross Society, Hind Kusht Nivaran sangh, Tuberculosis Association of India etc.)

**Social Security**

Social security means public programmes designed to protect individuals and their families from income losses due to unemployment, old age, sickness or death and to improve their welfare through public services (e.g. medical care) and economic assistance. The term may include social insurance programme health and welfare services and various income maintenance programmes.

**Rehabilitation**

Rehabilitation has been defined as "the combined and coordinated use of medical, educational and vocational measures for training the individual to the highest possible level of functional ability". The following areas of concern in rehabilitation have been identified

(a) Medical rehabilitation - Restoration of function

(b) Vocational rehabilitation - Restoration of the capacity to earn a livelihood

(c) Social rehabilitation - Restoration of family and social relationships

(d) Psychological rehabilitation - Restoration of personal dignity and confidence

**Social class**

Socio-economic standard of people is conventionally expressed in terms of various social classes in which people are distributed which are referred to as social stratification. Social stratification is a horizontal division of society into several socio-economic layers : each layer or social class has a comparable standard of living and life style. Social class is determined on the basis of three parameters of development, namely education, occupation and income. Education determines the knowledge, attitude, and value system of individuals and their socio-economic growth potential. Occupation determines the income generating capacity of individuals and their life style, Income determines the purchasing power of individual and their socio-economic status. On the basis of these parameters populations are divided in to social classes—upper, upper middle, middle, upper lower and lower.

(a) The socio-economic status scale (urban) developed by Kuppuswamy attempts to measure the socio-economic class of family in urban community. It is based on three variables - education, occupation, and income. A weightage is assigned to each variable according to seven point predefined scale. The total of three weightages gives the socio-economic status score which is graded to indicate the five classes. The level of income is generally updated on the basis of consumer price index (CPI). Current income group, as given in Textbook of community medicine,2007, by Dr (Brig) Sundarlal are taken in Kupuswamy's scale.

Kupuswamy's scale

| Education of head of household | | Occupation | | Income Per Capita per month | |
|---|---|---|---|---|---|
| Educational level | Weigh | Occupation | Weigh | Range | Weigh |
| Professional degree or Hons / MA & above | 7 | Professional | 10 | Above Rs 20000 | 12 |
| B A or BSc degree | 6 | Semi-professional | 6 | Rs 10000 to Rs 19999 | 10 |
| Intermediate or post high | 5 | Clerical, shop-owner, farm- | 5 | Rs 7500 to Rs 9999 | 6 |
| HSC | 4 | Skilled workers | 4 | Rs 5000 to Rs 7499 | 5 |
| Middle school certificate | 3 | Semiskilled workers | 3 | Rs 3000 to Rs 4999 | 4 |
| Primary school or literate | 2 | Unskilled workers | 2 | Rs1001 to Rs 2999 | 2 |
| Illiterate | 1 | Unemployed | 1 | Below Rs 1000 per | 1 |

**Total Score is calculated as**

Education(A) + Occupation(B) + Income(C). Depending on the score, the status is as follows :

**Total Score**

| | |
|---|---|
| 26 – 29 | I (upper class) |
| 16 – 25 | II (upper middle) |
| 11 – 15 | III (lower middle) |
| 5 – 10 | IV (upper lower) |
| Below 5 | V (lower) |

**(b) Dr. B G.Prasad's social classification**

The income group can be used by applying P Kumar's conversion factor i.e.

$$\frac{\text{Value of CPI X 4.93}}{100} = (\text{conversion factor})$$

Value of all India consumer price index in 2003 was 496

$$\frac{496 \text{ X } 4.93}{100} = 24.45$$

This 24.45 conversion factor is multiplied by Rs 1000 of social class I income of 1991 data to get corresponding value of social class I in 2003 i.e.Rs 24450. Likewise it can be calculated in other income group also.

Dr. B G.Prasad's social classification

| Social class | Updated by 1991 | By applying conversion factor (2003) |
|---|---|---|
| I | 1000 and above | 24450 and above |
| II | 500-999 | 12225-24449 |
| III | 300-499 | 7335-12224 |
| IV | 150-299 | 3667-7334 |
| V | <150 | <3667 |

(c) The Socio-Economic Scale (rural) developed by Pareek attempts to measure socio-economic status of a rural family. It is based on the nine items as follows. The combined score for the nine items is graded to indicate socio-economic class categories.

(i) Caste (ii) Occupation of head of family
(iii) Education (iv) Levels of social participation
(v) Land holding (vi) Farm power (prestige animals)
(vIi) Housing (viii) Material possessions
(ix) Family type

**Juvenile delinquency**

There was a time when even small children were severely punished if they committed some crime. But as psychologists proceeded to draw the attention of the civilized world to the causes of juvenile delinquency, the tradition of punishing children lost favour, to be replaced by efforts of improving and rehabilitating them. To make the deviant once again a healthy and responsible person of society, efforts are made through reformatory schools, probation and other measures. Juvenile delinquency involves wrong doing by a child or a young person who is under an age specified by laws of the place concerned. In this manner, juvenile delinquent is one who forcibly possesses the property of another, or causes it damage, indulges in antisocial activities, creates danger to another's life or hinders the activities of others.

Causes of juvenile delinquency

(a) Social causes e.g. death of parents, separation of parents, step mothers, and disturbed home conditions, attitude of parents.
(b) Biological causes such as hereditary defects, feeblemindedness, physical defects and glandular imbalance.
(c) Psychological causes : Intellectual weakness, mental disease, emotional instability.
(d) Economic causes and other causes : Poverty, absence of recreation facilities, defective recreation, bad company, living in crime dominated areas, urbanization and industrialization.

Thus, a child becomes a criminal through the interaction of many causes, social and individual, familial, psychological and economic. In order to rehabilitate the juvenile delinquent as a healthy member of society, it is necessary to understand all these causes and remove them through improving family life, proper schooling, reducing harmful peer influences, social welfare services

Col RajVir Bhalwar & Mr SSL Parashar

# Medico-Social Case : History Taking

It is abundantly clear by now that every disease has a tremendous social component. It is the various components of sociology, as described in previous chapter, which decide whether a given human being will be exposed to the disease process or not; if exposed, whether disease process will perpetuate or not; and finally, what will be the outcome of the disease process. It is therefore extremely important that every Doctor should work up the psycho-social and behavioural components of a patient and not simply the clinical findings / laboratory investigative results, to effectively treat the patient and to prevent recurrence of the disease. For example, going simply by the clinical picture, we may treat a child with dehydration, with i.v. fluids and supportive therapy, and discharge her after a few days as "cured". However, if we did not work up the details of environmental sanitation and water supply at the child's house, the knowledge attitudes and health related practices of the mother, the family size, and so on, for certain the child will keep coming to us. Thus, for having a totalistic or holistic overview of our patient and to really treat the disease effectively, "from the root causes", we must take a proper medico-social history, work out the various sociological parameters and treat, not only the clinical disease, but also the social causes.

Medico-social history taking is, therefore, also an essential requirement at the undergraduate and postgraduate level of medical curriculum, with a view to prepare the general and specialist Doctors to function effectively as Community physicians. In the present chapter, we shall be dealing with the details of medico-social history taking and how to draw conclusions from such history.

### Approach to the patient

Introduce yourself with a friendly greeting, giving your name and status. Explain the purpose of your visit, ask for and remember the patient's name and request permission to interview and examine the patient. Some patients rapidly tire of being questioned or examined, and others may be depressed because they are ill or apprehensive. If there are difficulties in establishing a rapport, try to determine the reason; if in doubt, consult the medico-social worker or nursing staff. Show tolerance, particularly with the elderly and the challenged. Seek first to understand and not judge the patient so that you don't react to patients with criticism, anger or dismissal. Some additional tips for effective medico-social case taking are :

(a) Maintain good eye contact.
(b) Listen attentively.
(c) Facilitate verbally and non-verbally.
(d) Touch patients appropriately.
(e) Discuss patients' personal concerns.
(f) Give the patient your undivided attention
(g) Keep your note-taking to a minimum when the patient is talking
(h) Use language which the patient can understand
(j) Let patients tell their own story in their own way
(k) Use open questions initially and specific (closed) questions later
(l) Clarify the meaning of any lay terms which patients use. (A patient may use the term hypertension to refer to excess mental stress).
(m) Remember that the history includes events up to the day of interview
(n) Summarize (reflect back) the story for the patient to check
(o) Utilize all available sources of information

### The fundamental principles underlying medico-social case work-up

The basic principle which must be kept in mind while undertaking a medico-social work-up is that while the patient is the core issue, his disease is actually a result of complex psycho social interactions between the patient, his / her family members, the environment at the workplace (including school), the immediate community members comprising of friends and close associates, the community at large within which the patient lives, and the larger society which consists of the governmental and non-governmental systems. A systematic assessment of all these factors is therefore necessary to be able to reach the root of the problem and to effectively plan a holistic therapy, taking care of not only the biological cause of the disease but also the wider social reasons that lead to the causation and perpetuation of the disease. The factors to be considered at various levels are :

(a) Factors Within the Individual

The following variables should be recorded in detail :

(i) Age
(ii) Education
(iii) Occupation
(iv) Level of protection against common infectious diseases, by way of immunization or previous infection
(v) Lifestyle : details of habitual physical exercise, diet, tobacco, alcohol and substance abuse, sexual promiscuity
(vi) Knowledge, Attitudes & Practices (KAP) as regards common diseases and their prevention
(vii) Psycho-Emotive state : whether cheerful and optimistic or anxious / depressed or concerned.

(viii) Separation from family members / near & dear ones.

(ix) Attitudes towards

- Personal protection, as use of helmets, use of mosquito-nets, etc.
- Personal hygiene, as regular bathing, hand washing, oral care, etc.
- Attitudes towards Health Care System, whether positive and trusts the health care system or unhappy / skeptical.
- Attitudes as regards the disease from which the patient is suffering, and his / her concerns as regards it's perceived future course / management / rehabilitation

(b) Factors in the family

These will include three broad categories of factors, viz. , social factors, environmental factors and psycho-emotive factors.

**(i) Social Factors Within the Family**

- Type : Whether joint, three generation or nuclear
- Organization & Composition : Total number of members, head of the family, and description of family members by name, age, sex, and position relative to the head.
- Religion / caste
- Education : general level of education; attitudes towards formal education; proportion of members who are professionally qualified / having degree / educated / illiterate
- Occupational patterns in the family
- Income : Total family income; income of the index case; Per capita per month income
- Socio Economic Status according to acceptable scales as Kuppuswamy or Prasad scale.
- Knowledge, Attitudes & Practices in the family, in general towards healthy lifestyle, personal protection and prevention of common diseases.
- Health Care services for the family. These should be assessed in terms of availability, accessibility, affordability, quality and utilization
- Social aberrations if any in the family, as promiscuity, alcoholism, delinquency

**(ii) Environmental Factors in the Family. These will include :**

- Housing: General description, type of construction, area & space, ventilation, overcrowding, lighting, other comforts.
- Water Supply : Source, hygienicity, adequacy, storage
- Disposal of night soil, solid wastes, animal wastes, waste water.
- Food hygiene : methods of cooking, storage of raw and cooked food, food hygienic practices.
- Nutrition : Assessment of intake of overall calories and major macro / micronutrients; deficiency diseases; relative distribution of food among various members; percentage of monthly income spent on food.
- Exposure to and protection from insect vectors of diseases.

**(iii) Psycho-Emotive Factors in the Family : these include**

- Level of interactions / bondages between family members and between the index case and other family members
- Family Support Systems : In terms of financial support, physical support (as readiness to physically assist the patient in activities of daily living) and emotional support.
- Readiness of family members to provide "support"
- Understanding, by the family members, of the disease and it's determinant psycho-social problems that the patient is facing

(c) Factors in the workplace (note that for children, school is to be considered as workplace)

(i) General description

(ii) Attitude & Support (Emotional, Physical, Financial) on part of

- Employers / Superiors / Teachers
- Colleagues / Classmates
- Subordinates / ancillary staff in school

(iii) Availability of facilities, in school / workplace, to cater to special needs of the patient

(d) Factors in the Immediate Community

(Immediate community consists of the Village / Mohalla in which the patient is living. In case of Armed Forces personnel staying in barracks, it also means the military sub-unit as platoon / section in which they routinely live, sleep and eat).

(i) General description (income levels and standards of living in general, major occupations, general types of housing, educational levels, social aberrations as alcoholism, delinquency, etc.)

(ii) Community Organization, strength of community feeling, cohesiveness between the families in the community.

(iii) Interactions, of various community members, with the Index Case and his / her family members.

(iv) General attitude of community towards disease prevention & health care

(v) Availability of Physical, Financial & Emotional Support Systems within the community.

(vi) Health care facilities available

(vii) Availability of School / Special School catering to the special needs of the index case.

(viii) Availability of NGOs / Voluntary Bodies and description of their capabilities.

(ix) Availability of organised public health & social services as central water supply and it's

purification, disposal of wastes, transportation and communications.

(x) Internal political will and external influence on the political will

(xi) Identification of peers & influential leaders and their capabilities.

(e) Factors in the Community at Large

This includes the larger social environment as the District / State where the patient is living. In case of armed forces personnel, this would include the overall structure, organization and policies of the armed forces.

(i) General Attitude

- Towards Health maintenance, Disease Prevention & Rehabilitation
- Towards the disease in question

(ii) Availability of treatment facilities

(iii) Availability of Rehabilitation facilities

(iv) Statutory and Administrative provisions to protect / facilitate the index case.

(v) Availability of VHAs / NGOs

(f) Summarize The Medico-Social Findings

(i) What are the "**Key Psycho-Social Issues**" in the index case, his / her family, workplace, immediate community and the community at large.

(ii) What is the "**Social Pathology**", i. e. , the major "weaknesses" ; for example, in a medico-social case of an adolescent polio affected girl child, the major weaknesses could be summed up as "Alcoholism in the family" with "Poor purchasing power" with " Adverse attitudes towards the girl child"

(iii) What is the "**Social Diagnosis**" i.e. , those adverse psycho-social effects that the social pathology (major weaknesses) would lead to; for example, in the hypothetical example of the case of polio affected girl child, "Gross Physical handicap with Poor Rehabilitation facilities with Broken family and adversely predisposed community" may be identified as the social diagnosis, which will result from the identified social pathology, & will therefore need to be "treated", the way we treat a disease diagnosed by us.

(iv) What are the "**major strengths**" in our case. This will be worked out by analyzing the support systems – Physical, Social, Vocational, Emotional, Financial, which are available within the family, workplace, and community systems, as also the strengths within the index case (as determination, residual abilities, etc.).

**(g) Write down the Plan of Management & Social therapy**

(i) Write down in a line each, the following, for the case being worked up :

- The social pathology
- The social diagnosis

(ii) Write down your summarized analysis of the Strengths, Weaknesses, Opportunities and Threats (SWOT) in this case.

(iii) Write down what all

- Should be done, ideally, in this case
- Can be done in this case ("DO-ABILITY" analysis), after considering the SWOT.

(iv) Write down the overall aim and key objectives for the medical management part as well as the psycho-social management for the case.

(v) Now, write down a detailed plan for each of the following aspects, indicating "who will do what, how, and in what time-frame"

- Medical management
- Prevention of Other Diseases and for leading a healthy life
- Disability Limitation
- Physical rehabilitation, e. g. , physical help for activities of living, for going till the health care centre, etc.
- Vocational rehabilitation – training, education, earning a livelihood, reservation in job and education, etc.
- Emotional Rehabilitation
- Social Security

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# Family Health Sciences


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# Reproductive and Child Health (RCH)

## Introduction

It is the legitimate right of the citizens to be able to experience sound reproductive and child health and therefore, the RCH programme seeks to provide relevant services for assuring Reproductive & Child Health to all citizens. It is now well established that parents keep the family size small if they are assured about the health and longevity of the children and there is no better assurance of good health and longevity of the children than health care for the mothers.

## History and Background

Government of India in 8th plan period integrated all related programmes such as UIP, ORT & various other programmes under MCH into Child Survival and Safe Motherhood (CSSM) programme on 20 Aug 1992. In 1994, International Conference on Population and Development held in Cairo recommended that participant countries should implement unified programmes for RCH. Accordingly Govt of India, during 9th Plan period unified CSSM with two other programmes i.e. one related to sexually transmitted diseases and other related to reproductive tract infections and launched a unified, integrated programme of RCH on 10th October, 1997. Reproductive and Child Health (RCH) Program is the flagship program of the Department of Family Welfare, Government of India. It is the amalgamation of Maternal and Child Health (MCH), Child Survival and Safe Motherhood and Family Planning. The program is primarily offered through the Primary Health Infrastructure. It is re-oriented and refocused version of the family welfare programme, with the involvement of health of men. In 1998, ICMR set up a task force in Male reproductive health, so that equal emphasis could be given to Male Reproductive Health. RCH Phase II has been launched on 1st April 2005 with an objective to bring about a change in mainly three critical health indicators i.e. reducing total fertility rate, infant mortality rate and maternal mortality rate.

## Definition of RCH

Reproductive Health is defined by WHO as a state of complete physical, mental and social well being and not merely the absence of disease or infirmity in all matters relating to the reproductive system, its functions and processes.

## RCH Approach

RCH approach has been defined as “a state in which people have the ability to reproduce and regulate their fertility, women are able to go through pregnancy and child birth safely, the outcome of pregnancies is successful in terms of maternal and infant survival and well being and couples are able to have sexual relations free of fear of pregnancy and of contracting diseases" (1)

## Concept of RCH Programme

The concept of RCH is to provide to the beneficiaries need based, client centered, demand driven, high quality and integrated RCH services. This is a paradigm shift from the earlier approach under the National Family Welfare Programme, as shown below :

| Family Welfare Programme | RCH |
|---|---|
| Top down approach | Bottom up approach |
| Target centered | Target free |
| Centralized planning | Need based decentralized and participatory planning |
| Promoted specific method | Various methods offered |
| Method centered | Consumer or client centered |
| Quantity centered | Quality centered |
| Single objective | Concern for quality of life |
| Focus on targets | Focus on unmet needs |
| Gender insensitive | Gender sensitive (men) |
| Accountability to bureaucracy and | Accountability to clients workers |

## Objectives of RCH

(a) Reduction of Maternal Morbidity and Mortality (MMR)

(b) Reduction of Infant Morbidity and Mortality (IMR)

(c) Reduction of Under 5 Morbidity and Mortality (U5MR)

(d) Promotion of adolescent health

(e) Control of reproductive tract infections and sexually transmitted infections.

## Components of RCH Programme

(a) Family planning

(b) Maternal & child health

(c) Safe abortion service.

(d) Effective control of sexually transmitted diseases and reproductive tract infections.

(e) Prevention and management of infertility.

(f) Prevention, detection cum treatment of reproductive tract malignancies (WHO, 1990-91).

## Components of Male Reproductive Health

(a) Health care of male infants, children and adolescents.

(b) Adolescent education and the development of healthy and fulfilling male sexuality.

(c) Prevention and Control of RTIs, STDs & AIDS.

(d) Greater and more effective male participation in family planning and contraception

(e) Ensuring gender equity through free reproductive choice.

(f) Prevention & management of male infertility and other reproductive disorders.

(g) Reproductive health care of the elderly male.

**Highlights Of RCH Programme**

(a) Integration of all interventions of fertility regulation, maternal and child health with reproductive health of both men & women.

(b) The services are client-centered demand driven and based on the needs of the community.

(c) Decentralized planning involving community.

(d) Services are of high quality and based on "target free" approach.

(e) Upgradation of the level of facilities such as First Referral Units (FRUs) at sub divisional level to provide emergency obstetric & newborn care.

(f) Upgradation of RCH facilities in PHCs.

(g) Improvement of the access of the community to commonly required services such as MTP facilities at PHCs, counseling & IUD insertion at sub centres.

(h) Improving the out reach of services to the vulnerable groups of population such as urban slums, tribal population and adolescents.

(i) Involvement of NGOs in improving outreach and acceptance of programme.

(j) Upgrading the skills of practitioners of Indian systems of Medicine (ISM) by training.

(k) Support of research & development in ISM to improve the range of RCH services.

(l) To provide greater role to the Panchayati Raj System (District to village level) in planning, implementation and assessment of client satisfaction.

**Financial Assistance For Direction & Administration at State Level and District level officers**

With effect from 01 Apr 1998, states with more than 1 crore population are entitled to receive from the Govt of India, financial assistance upto 8% of the grants given by Dept of Family Welfare for FW programme in the states, whereas for states, with less than 1 crore population the financial assistance will be 12%. The funds given by Central Govt assistance will not be spent on purchase/maintenance of vehicles & construction activities. RCH implementation & flow of funds will be either through State Finance Dept or through SCOVA. (State Committee on Voluntary Action)

**Organisation of RCH services**

(a) State level

(i) Addl/Joint/Deputy Director for Maternal Health.

(ii) Addl/Joint/Deputy Director for Child Health

(iii) Addl/Joint/Deputy Director with qualifications in population science/statistics for monitoring, evaluation & statistical analysis.

(iv) Addl/Joint/Deputy Director for Finance

(v) Addl/Joint/Deputy Director for population control

(vi) Addl/Joint/Deputy Director for Admin/pers.

(vii) Engineer/Asst Engineer for State Cold Chain.

(viii) State media officer.

In smaller states posts at S. Nos 1 &2 can be combined & similarly posts at S. No 4 & 6 and 3 & 5 can be combined.

(b) District Level

| | |
|---|---|
| Dist Health & family Welfare Officer | 1 |
| RCH Officer | 1 |
| Population control officer | 1 |
| Training officer | 1 |
| Refrigeration Mechanic | 1 |

## Programme Interventions

Differential approach: RCH status of the districts is reflected on the basis of crude birth rate and female literacy rate. Based on these indicators, the districts have been categorised into three categories A, B & C. The RCH programme proposes to strengthen and streamline the basic facilities in weaker districts and provide more sophisticated facilities for the relatively advanced districts. These services are proposed to be provided in a phased manner for 3 years since inception of the programme. These interventions are as follows :

**RCH Interventions in all Districts (1)**

(a) Safe motherhood and child survival interventions under CSSM programme.

(b) Facilities for operationalisation of Target free approach.

(c) Institutional development.

(d) Integrated training package.

(e) Modified Management Information system (MIS).

(f) Information, Education & Communication (IEC) activities & counseling on health, sexuality & gender.

(g) RCH package for urban & tribal areas.

(h) District subprojects under local capacity enhancement.

(j) RTI/STI clinics at district hospitals.

(k) Facilities for MTPs at PHCs by providing equipment & contractual doctors.

(l) Enhanced community participation through Panchayats, women's groups and NGOs.

(m) Provision for lab technicians for lab diagnosis of RTI/STI & EsOC.

(n) Adolescence health & reproductive hygiene.

**RCH Intervention in Selected States/Districts**

(a) Screening and treatment of RTI/STI.

(b) EOC (emergency) at selected FRUs by providing drugs.

(c) Essential obstetric care by providing drugs and PHN/Staff Nurse at PHCs.

(d) Addl ANMs at subcentres in selected districts for ensuring MCH care.

(e) Improved delivery services and emergency care by providing Equipment, Kits, IUD insertions and

ANM kits at sub centres.

(f) Rental to contracted PHNs/ANMs, not provided Government Accommodation

(g) Facility of referral transport for pregnant women during emergency to the nearest referral centre

**Immunization**

UIP will continue to provide vaccines for Polio, Tetanus, DPT, DT, Measles & TB. The achievements so far all are 80-90% coverage. The objective in 9th Plan is to achieve 100% coverage for all vaccine preventable disease. After achieving about 95% coverage, special campaigns like PPI may be taken up later in the 9th plan for achieving near Zero incidence for Tetanus among pregnant women and newborns & for measles.

Inputs for Immunization & related CSSM Programme:

(a) Cold chain equipment for all PHCs in the country

(b) Supply of vaccines

(c) Repair of cold chain items which are already about 10 years old - Rs 500 / PHC / year

(d) Provisions of Dai kits

(e) Provisions of needles and syringes

(f) Procurement & supply of Disposable Delivery kits.

**Drug & Equipment kits**

Drug & equipment kits earlier supplied to CHCs/FRUs, PHCs & Sub Centres under CSSM programme will continue to be supplied under the RCH programme. In addition, drugs kit for essential obstetrics will be supplied to PHCs in category 'C' districts.

**Essential Obstetric Care (EsOC)**

Essential obstetric care includes those items of obstetric care, which any pregnant woman requires if there is no complication during pregnancy or delivery (3).

These items are

(a) Registration of pregnancy in the first 12-16 wks of pregnancy.

(b) At least 3 prenatal check ups by ANM or in dispensary.

(c) Assistance during delivery.

(d) At least 3 postnatal check ups.

Inputs for EsOC

(a) Training of ANMs & provision of equipment and drugs to them

(b) Supply of equipment kit to PHCs in category B & category C districts.

(c) Supply of Es OC drug kit to category B & C districts

(d) PHCs in category C Dists will engage PHNs / Staff Nurse on contract basis during the RCH project (Pay + DA+ Rs 400 HRA).

(e) In category C districts in remote sub centres an additional ANM will be provided on contract basis.

(f) 25% of ANMs working in sub centres will be provided loan for Mopeds to increase their mobility.

Emergency Obstetric Care (Em OC)

Em OC is an intervention for preventing maternal morbidity and mortality. Early detection and management of complications such as anaemia, haemorrhage, obstructed labour and sepsis can substantially reduce maternal mortality & morbidity. This requires competent supervision and check ups by ANM during antenatal & post natal period. ANM should refer all cases having complications during pregnancy or at the time of delivery to PHCs / FRUs (3).

Inputs

A total of 1748 FRUs have been identified & equipped under CSSM programme. Some of the FRUs are lacking in manpower or infrastructure. Under RCH programme, a provision has been kept for strengthening these FRUs through

(a) Supply of drugs kits worth 1.65 lakh to 3 FRUs in Category C & 2 FRUs in Cat B districts annually.

(b) Provision for appointment of contractual staff ie. PHN/Staff Nurses, ANM & Lab Assts. (Each Dist can engage only 2 Lab Tech.)

(c) Provision of Laparoscope at district and sub divisional hospitals/FRUs.

(d) Provision for providing EmOC requiring surgery, blood transfusion and anaesthesia at the FRU level.

(e) Provision for consultant anaesthetist for EmOC (Rs 500/- per case)

(f) Funding training for Diploma in Anaethesia.

**24 Hour Delivery Services at PHCs/CHCs**

Under RCH, arrangements have been made that a doctor on call duty, a nurse and cleaning staff are available beyond normal working hours to encourage people to seek deliveries in PHCs/CHCs. For this doctor could be paid Rs 200/- per delivery & other staff could be hired on contractual basis.

**Referral Transport to Indigent Families through Panchayats**

In category C districts of eight weakly performing states, communication infrastructure is weak and economic status of families in remote villages is poor. Because of this, even if there is a complication identified during pregnancy or delivery, the women have the delivery conducted in the village and frequently through untrained Dais. This is one of the causes of high maternal mortality and morbidity.

Inputs

25% subcentres of Category 'C' districts of 8 weakly performing states (UP, Bihar, MP, Rajasthan, Orissa, Assam, Nagaland & Haryana), a lump sum financial assistance is made available to Panchayats through District Family Welfare Officers.

**Blood Supply to FRUs/PHCs**

Dept of family welfare will be taking up pilot projects with the assistance of European Commission under the RCH programme for setting up of regular and reliable supply of

blood to PHCs/CHCs by linking them with the nearest blood bank.

### Essential New Born Care

Under CSSM programme, essential new born care equipment has been supplied to all Dist Hospitals, CHCs incl all FRUs & PHCs. The strategies for the essential new born care are as follows :

(a) Training of medical and paramedical staff in essential Newborn care.

(b) Provision of basic facilities for care of LBW babies in FRUs and District Hospital.

(c) Creating awareness among health care providers pregnant women and mother of newborn child about essential New born care,

(d) Use of low cost, effective and locally available equipment for newborn care.

(e) Improve maternal care and promote birth spacing

### MTP

MTP by untrained or experienced persons is responsible for high maternal mortality and morbidity. Therefore, increasing and improving facilities for MTP is an important component of the RCH programme at PHC level.

Inputs

(a) Need based training in MTP by NIHFW.

(b) Supply of MTP equipment to District Hospitals, CHCs & PHCs where trained staff is available.

(c) Assistance for engaging doctors trained in MTP to the PHCs once a week on fixed days for performing MTP (Pay Rs 500/- day). These doctors will also provide ANC and PNC to patients during their visit.

(d) Supply of MTP equipment to Private clinics if they have OT & trained doctors.

### RTI/STI Clinics

The incidence of RTI/STI is 20-30% in most parts of the country. Under RCH programme, all district hospitals and 3 FRUs in Category A district, two in category B district & one is Category C districts will be assisted for setting up RTI/STI clinics by imparting training through NIHFW and supply of drug kits(2).

### Indian System of Medicine

About 50% of population depends on the Indian systems of Medicine for health care.

About 5 lakh practitioners of Ayurveda & Unani systems are spread out in different pasts of the country especially rural areas.

Inputs

(a) **Training of ISM Practitioners** : Short term training of 2-4 weeks to ISM practitioners through ISM Medical Colleges, in areas relevant to RCH.

(b) **Improving awareness and availability of ISM remedies** : NGOs will be assisted for raising nurseries of medicinal plants and educate local population about the uses of locally available medicinal plants for preventive health & for curative purposes.

(c) **Research in ISM** : Research projects through ISM research institutions will be supported financially in areas of relevance to RCH.

(d) **Vanaspati Van** : Plantations of medicinal plants in the form of the vanaspati Van over wastelands or denuded forestland of 3000-5000 hectares of contiguous area is proposed.

### Additional Programme for the Urban Slums

About 9 crore people are living in urban slums. Slum population of Mumbai & Delhi is more than 30% of total population. An appropriate and effective Family Welfare set up for the Urban slums is being planned to cater for prevention and treatment of diarrhoea, malnutrition and vaccine preventable diseases apart from improving the RCH status (4).

### Special Programmes for Tribal Areas

The tribal areas have poor communication, low educational level & economic status. Hence the RCH status of tribal population is low. A committee of experts under Dept of Family Welfare is working out appropriate package of programmes for the tribal Areas.

### Special Programmes for Adolescents

The special package of programmes for adolescents includes.

(a) One more booster dose of TT at the age of 16 & immunisation of females against Rubella.

(b) Sex education to promote responsible and healthy reproductive & sexual behaviour.

(c) Prevention of STD/HIV and AIDS.

(d) Adult Literacy especially among women.

(e) Vocational training.

(f) Pre marital counseling

(g) Gender equality

(h) Family life education. It is defined as " an educational process designed to assist young people in their physical, social, emotional and moral development as they prepare for adulthood, marriage, parenthood, ageing as well as their social relationship in their socio cultural context of the family and society". (UNESCO).

### Research and Development

(a) Dept of Family Welfare will continue financing R&D through ICMR (at Bombay & at Hyderbad / National Institute of Nutrition (NIN)).

(b) Dept will provide support to basic research and operations research in areas relevant for RCH.

(c) Holding of conferences and seminars for researchers. The dept will extend financial assistance to well established NGOs and research institutes to the extent of upto Rs 1.5 lakh for seminars / workshops and upto 3 lakhs for national conference & 5 lakh for International conference.

## Training

This involves :

(a) Training for awareness generation & skill upgradation.

(b) Training of Panchayati Raj functionaries & other related depts. NIHFW will be the nodal agency for co-ordinating all training programmes of the Dept of Family Welfare. 15 collaborating institutions on regional basis will assist in implementation of RCH Training.

**Information, Education and Communication (IEC)**

Dept of Family Welfare is implementing a large IEC programme by making extensive use of Doordarshan, AIR, DAVP, and Directorate of field publicity Song & Drama division and film divisions under Ministry of Information and Broadcasting. In addition, 80,000 Mahila Swasthya Sanghs (MSS), opinion leaders & Nehru Yuvak Kendras are being involved. Use of print media is also being made to give a boost to the image of the programme particularly among youth.

**State Level**

Apart from the activities of Central Govt, State Govts are provided funds at the rate of Rs 25 lakh to large states, Rs 15 lakh to medium states & Rs 10 lakh to smaller states for IEC activities

**District Level**

At district level IEC programme is proposed to be linked up with National Literacy Mission which works through Zila Saksharta Samities as both these programmes are mutually supportive. For this, Rs 3-5 Lakh annually are provided to Zila Saksharta Samities.

## Management Information System (MIS) under RCH programme

An efficient MIS should provide regular & reliable information about the implementation of various activities of RCH programme & their impact in improving the health status of women & children.

"Target free approach" manual has been renamed as "Community Needs Assessment" manual & distributed to all districts for distribution among all health facilities and workers.

Under the RCH Programme, the following mechanisms have been proposed for getting information on selected RCH indicators on annual basis with district level estimates of the indicators.

**(a) Routine Reporting**

The reporting system on revised reporting format will be as follows :

(i) Health worker to report to PHC by 7th of every month.

(ii) PHCs worker to report to District HQ by 10th of every month.

(iii) Districts worker to report to state HQ by 20th of every month.

Community Needs Assessed by Health Worker
↓
Sub Centre Action Plan prepared by involving LHV/MO
↓
PHC Action Plan (Under supervision of next supervisory officer)
↓
District Action Plan - To be formulated annually

**(b) District Surveys**

It has been proposed to conduct district level surveys in half of the districts of the country every year by sample surveys. These surveys will provide information on selected indicators just in a few months time after the field work is completed.

**(c) Concurrent Surveys**

Under this scheme, evaluation of the availability and utilisation of RCH services will be done in at least one district per month in larger states, one sub division in the middle sized state and one block in the smaller state. These surveys will also be undertaken in selected population of these districts to ascertain quality of services and community satisfaction. The above surveys will help in effectively monitoring RCH programme & wherever gaps are found, Centre/State districts can take timely corrective action. The surveys will also help in accountability vis-à-vis the district health and family set up.

## RCH Phase II

The second phase of RCH program i.e. RCH – II has been commenced from 1st April, 2005 & will last till 2010. The main objective of the program is to bring about a change in mainly three critical health indicators i.e. reducing total fertility rate, infant mortality rate and maternal mortality rate.

**Highlights of RCH - II Program**

(a) Adoptions of Sector vide approach which effectively extends the program reach beyond RCH to the entire Family Welfare sector.

(b) Building State ownership by involving states and UT's from the outset in development of the program. Decentralization through development of District and State level need based plans. Flexible programming with a view to moving away from prescriptive scheme based micro planning and instead allowing States to develop need based work plans with freedom to decide upon program inputs.

(c) Capacity building at the District, State and the Central level to ensure improved program implementation. In particular, the emphasis being on strengthening financial management systems and monitoring and evaluation capabilities at different levels.

(d) Adoption of the logical frame works as a program management tour to support and outcome driven approach.

(e) Performance based funding to ensure adherence to program objectives, reward good performance and support weak performers through enhance

technical performance.

(f) Pool financing by the development partners to simplify and rationalized the process of assessing external assistance.

(g) Convergence, both inter sectoral as well as intra sectoral to optimize utilization of resource as well as infra structural facilities.

**Vision**

To bring about outcomes as envisioned in the

(a) Millennium Development Goals

(b) The National Population Policy 2000 (NPP 2000)Goals

(c) The Tenth Plan Goals

(d) The National Health Policy 2002

(e) Vision 2020 India

**Interventions**

Maternal Health

(a) 260 Primary Health Centres are proposed to be taken up for improving access to Essential Obstetric and New Born Care services round the clock. All CHC, & 50% PHCs to be made functional for 24 hrs delivery services,& 2000 FRU are proposed

(b) Improving quality of antenatal, neonatal and postnatal care by providing increased number of antenatal checkups, fixed day antenatal clinics, linking visits of neonates with postnatal care, empowering the ANMs in performing obstetric first aid and newborn care.

(c) Improvement of the referral networking systems by establishing emergency help line.

(d) Regular conduct of blood donation camps for the continued availability of blood in the blood banks.

(e) Universalizing the concept of birth companionship during the process of labour in all health facilities conducting deliveries.

(f) Operationalisation of maternal death audit to address the issues that have led to maternal deaths

Infant and Child Health

(a) Reduction of new-born deaths, infant deaths and child deaths by providing continuous health care and strengthening of new-born care infrastructure facilities.

(b) Organizing counselling sessions for the mothers.

(c) Implementing integrated management of neonatal and childhood illness as a pilot initiative in selected districts

(d) Operationalising infant death/stillbirth verbal autopsy.

(e) Addressing the issue of female infanticide and foeticide.

Adolescent Health

(a) Focusing adolescents as receivers and providers of knowledge and function as link volunteers in the community.

(b) Utilising the services of trained adolescents for propagating Indian System of Medicines.

(c) Broadcasting and Telecasting of programme by AIR/TV focusing adolescent, gender & health related subjects.

RCH – I & II, Differences

| RCH I | RCH II |
|---|---|
| Multiple fragmented projects | Common framework for entire Family Welfare sector |
| Centrally driven schemes - one size fits all | State plans based on district plans appraised by Centre |
| No incentive for better performance | Performance based funding |
| Inputs based monitoring services | Results focused on saving lives, stabilising population & improving |
| Limited engagement with private sector | Framework for public private partnership |

Table - 1 : Targets of Major Policies / Projects Relevant to MCH

| Indicator | Tenth Plan Goals (2002 – 2007) | RCH II Goals (2005 – 2010) | National Population Policy 2000 (by 2010) | Millennium Development Goal (by 2015) |
|---|---|---|---|---|
| Population Growth | 16.2% (2001-2011) | 16.2% (2001-2011) | - | - |
| Infant Mortality rate | 45 / 1000 | 35 / 1000 | 30 / 1000 | - |
| Under 5 Morality rate | - | - | - | Reduce by 2/3rds from 1990 levels |
| Maternal Mortality Ratio | 200 / 100,000 | 150 / 100,000 | 100 / 100,000 | Reduce by 3/4rds from 1990 levels |
| Total Fertility Ratio | 2.3 | 2.2 | 2.1 | - |
| Couple Protection Ratio | 65% | 65% | Meet 100% needs | - |

(d) Formation of co-ordination committee at the district level and monitoring committee at the State level for overseeing the AIR/TV programme.

Family Welfare

(a) While sustaining the ongoing family welfare interventions in all districts, 19 districts with higher order births will be targeted for intensified interventions.

(b) Social marketing programme for condom and other health commodities, promotion of IUD insertions, familiarizing the concept of one-stop Family Welfare Centre.

(c) Increasing access to safe abortion services by popularising manual vacuum aspiration (MVA) technique.

(d) Establishment of one-stop family welfare services at Comprehensive Emergency Obstetric and New Born Care (CEMONC) Centres.

(e) Popularizing No Scalpel Vasectomy.

Reproductive tract infections/ sexually transmitted infections/ cancer control.

(a) Establishment of Reproductive Tract Infection / Sexually Transmitted Infection, early Cancer detection clinics.

(b) Strengthening RCH outreach services.

(c) RTI/STD clinic in selected 70 primary health centers

**Other salient features of RCH II**

Infrastructure strengthening for service delivery:

(a) Construction of HSC buildings where HSCs are currently functioning in rented premises

(b) Rebuilding HSCs which are unfit for occupation.

(c) Taking up of repairs/renovation and provision of water supply/electrical works to PHCs/HSCs.

(d) Need-based supply of equipment/ furniture to the HSCs and PHCs as per the standard list including gas connections.

(e) Provision of Cell phones to HSCs where large number of deliveries take place.

(f) Provision of telephones to PHCs

**Training**

(a) Skill upgradation training with focus on improving / upgrading the skills of health care providers.

(b) Integrated skill training for peripheral health functionaries such as ANMs, SHNs, medical officers and health inspectors.

(c) Improving managerial and communication skills of health staff.

Behavioural change communication (BCC)

(a) Social mobilisation activity against female infanticide and foeticide by preventive counselling.

(b) Formation of HSC, Block, and District level committees for saving female babies.

(c) Conducting of travelling street theatre to promote social mobilization and to improve health care among the target population

(d) Telecasting of TV serials, Radio broadcasts, wall paintings, hoardings and glow signs for popularizing health and reproductive health messages in important places.

Health management information systems

(a) IT-enabled HMIS for planning and monitoring health services at the State/District /Block levels are introduced.

(b) Teaching Institutions are strengthened for providing optimum obstetric, family welfare, neonatal child health services.

(c) Urban Health Posts are established to provide an integrated and sustainable system for primary health care service delivery catering to the requirements of urban slum population and other vulnerable groups

**RCH II - Challenges**

Lead time for institutional strengthening

(a) Institutional mobilisation phase – strengthen management functions

(b) Institutional strengthening phase – financing linked with performance

(c) Institutional consolidation phase – Increased emphasis on performance

(d) Reduce inequities by increased focus on Empowered Action Group(EAG) states, urban and tribal areas

**Conclusion**

RCH programme has been evolved by integrating various related programmes such as Family Planning, ORT, RTI, STD and CSSM with a view to implement the unified programmes for reproductive child health. The RCH programme has a participatory approach of all communities including ISM practitioners, Dais, opinion leaders, NGOs apart from intersectoral co-ordination of Govt agencies at all levels. The programme lays great emphasis on training, IEC and Research & Development activities related to RCH. Procurement procedures & audit arrangements have been streamlined to ensure uniformity in accounting. The modern system of management information and evaluation system will ensure accountability especially at District Level. RCH programme is a comprehensive programme aimed at improving the Maternal and Child health all over the country.

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# Maternal Care

## Care during pregnancy - antenatal care

### Early registration

The first visit or registration of a pregnant woman for ANC should take place as soon as the pregnancy is suspected. Ideally, the first visit should take place in the first trimester, before or at the 12th week of pregnancy.

### Record-keeping

Complete the antenatal card for every woman registered / examined by you. Instruct her to bring the card with her for all subsequent check-ups/visits. Record this information in the PHC / CHC antenatal register.

## Antenatal check-up

### Number and timing of visits

Ensure that every pregnant woman makes at least 4 visits for ANC, including the first visit/registration and any home visits by the ANM/lady health visitor (LHV). The first visit is recommended as soon as the pregnancy is suspected; the second visit should be scheduled between the 4-6 months (around 26 weeks). The third one should be planned in the 8th month (around 32 weeks) and the fourth one in the 9th month (36-40 weeks).

### History-taking

During the antenatal visits, take a detailed history of the woman:

(a) To diagnose the pregnancy (first visit only, if required)

(b) To identify any complications during previous pregnancies which may have a bearing on the present one

(c) To identify any medical or obstetric condition(s) that may complicate the present pregnancy (first and subsequent visits).

The LMP is used to calculate the gestational age at the time of check-up and the EDD. If the period of the menstrual cycle is more than 30 days, add the additional number of days in the cycle (beyond 28 days) to the EDD as calculated below.

EDD = LMP + 9 months + 7 days (+ additional days, if any)

Ask for age of woman, order of pregnancy and birth interval and any symptoms.

Previous pregnancies

It is essential to ask a woman about her previous obstetric history, this is important as some complications may recur during the present pregnancy.

History of any systemic illness

Rule out any personal history of systemic illnesses.

Family history of systemic illness

Ask for a family history of hypertension, diabetes and tuberculosis, thalassaemia, delivery of twins and/or the delivery of an infant with congenital malformation.

History of drug intake or allergies

Ask for history of drug intake during pregnancy, allergy to any drug, or drug taken for infertility.

History of intake of habit-forming or harmful substances

Ask the woman if she takes tobacco or alcohol. If yes, she needs to be counseled to discontinue.

### Physical examination

This activity will be nearly the same during all the visits. Initial readings may be taken as a baseline and compared with the later readings.

General examination

Specifically examine and record weight, blood pressure, pallor, respiratory rate, generalized oedema and also carry out breast examination.

Vaginal examination

(a) Vaginal examination is required, especially during the first visit, to confirm the pregnancy and to measure the gestational age.

(b) A per speculum (P/S) examination may be done especially if the woman complains of discharge P/V.

Abdominal examination

Examine the abdomen to monitor the progress of the pregnancy and foetal growth, and to check the foetal lie and presentation.

Assessment of the pelvis

Examination of the pelvis is required to assess if it is adequate for delivering the baby vaginally and is done during the last ANC visit (at about 36 weeks of gestation) to rule out any cephalopelvic disproportion (CPD).

### Laboratory investigations

The following laboratory investigations are recommended at the primary health care provider level to be carried out as a part of ANC.

(a) Haemoglobin estimation

(b) Blood grouping

(c) Testing the urine for the presence of sugar

(d) Testing the urine for bacteriuria

## Interventions

### Common symptoms and their management

See details in Table - 1

Iron-folic acid supplementation

All pregnant women need to be given one tablet of IFA (100 mg elemental iron and 0.5 mg folic acid) every day for at least 100 days. This is the prophylactic dose of IFA. If a woman is anaemic (Hb <11 g/dl or she has pallor), give her two tablets of IFA per day for three months.

This means a woman with anaemia in pregnancy needs to take at least 200 tablets of IFA. This is the therapeutic dose of IFA.

Table - 1 : Common symptoms during pregnancy and their management

| Symptoms | Signs / investigations | Most probable diagnosis | Action(s) to be taken |
|---|---|---|---|
| Excessive vomiting, especially after the first trimester; inability to retain anything | The woman may be dehydrated | Hyperemesis gravidarum | Admit her for a few days at the PHC and manage as given under the management of Hyperemesis gravidarum. |
| Palpitations, easy fatiguability, breathlessness at rest | ✐Conjunctival and / or palmar pallor present<br>✐Hb level <7 g/dl | Severe anaemia | ✐Start the woman on a double dose of IFA tablets.<br>✐Give her albendazole(second trimester onwards only).<br>✐Monitor the Hb level after one month. |
| Puffiness of the face, generalized body oedema | ✐BP >140/90 mmHg<br>✐Proteinuria absent<br>✐BP >140/90 mmHg<br>✐Proteinuria present | ✐Hypertensive disorder of pregnancy<br>✐Pre-eclampsia | ✐If the BP is <160/110 mm Hg, advise home management with rest and regular follow up.<br>✐If the BP is >160/110 mmHg, start on Nifedipine.<br>✐Start the woman on antihypertensive medication.<br>✐Refer to an FRU for further management.<br>✐Advise her on the danger signs of imminent eclampsia and eclampsia and refer to an FRU. |
| Heartburn and nausea | Reflux | Hypertensive disorder of pregnancy | ✐Advise the woman to avoid spicy and rich foods.<br>✐Ask her to take cold milk during attacks.<br>✐If severe, antacids may be prescribed. |
| ✐Increased frequency of urination up to 10-12 weeks of pregnancy<br>✐Increased frequency of urination after 12<br>✐weeks, or persistent<br>✐symptoms, or burning<br>✐on urination | Tenderness may be present at the sides of the abdomen and back.<br>The body temperature may be raised | ✐May be physiological due to pressure of the gravid uterus on the urinary bladder<br>✐Urinary tract infection | ✐Reassure her that it will be relieved on its own<br>✐Manage as given under the management of "UTI" |
| Constipation | | Physiological | ✐Advise the woman to take more fluids, leafy vegetables and a fibre rich diet.<br>✐If not relieved, prescribe Isabgol, 2 tablespoonful to be taken at bedtime, with water or with milk.<br>✐Do NOT prescribe strong laxatives as they may initiate uterine contractions. |
| ✐Bleeding P/V, before 20 weeks of gestation ·<br>✐Bleeding P/V, after 20 weeks of gestation | ✐Check the pulse and BP to assess for shock<br>✐Ask for history of violence<br>✐Check the pulse and BP to assess for shock | ✐Threatened abortion / spontaneous abortion / hydatidiform mole / ectopic pregnancy<br>✐Spontaneous abortion due to violence<br>✐Antepartum haemorrhage | ✐Carry out an MVA to evacuate the retained products of conception. · Ask the ANM to put the woman in touch with local support groups.<br>✐Do NOT carry out a vaginal examination<br>✐Refer to an FRU. |
| Fever | ✐The body temperature is raised<br>✐Blood peripheral smear is positive for malarial parasite | ✐ Site of infection somewhere, including possible sepsis<br>✐ Malaria | ✐Try to ascertain the cause of fever. Start the woman on antibiotics.<br>✐Manage according to the NAMP guidelines for malaria in pregnancy. Treat the malarial fever. |
| Decreased or absent foetal movements<br>(NOTE: Foetal movements are felt only after about 4 months of<br>gestation) | ✐FHS heard, and within the normal range of 120-160 beats/minute<br>✐FHS heard, but the rate is <120 beats / minute, or >160 beats / minute<br>✐FHS not heard | ✐Baby is normal<br>✐Foetal distress<br>✐Intrauterine foetal death | ✐Reassure the woman.<br>✐Re-check the FHS after 15 minutes.<br>✐If the FHS is still out of the normal range, manage as given under the management of "foetal distress."<br>✐Inform the woman and her family that the baby might not be well.<br>✐· If labour pains are present, conduct the delivery in the usual manner.<br>✐· If there are no labour pains, refer to an FRU for induction of labour to terminate the pregnancy. |
| Vaginal discharge, with or without abdominal pain | | ✐RTI / STI | ✐Start treatment as per the GoI Guidelines for<br>✐RTI/STI.<br>✐If there are no labour pains, refer to an FRU for induction of labour to terminate the pregnancy. |
| Leaking of watery fluids P/V | Wet pads/cloths | ✐Premature or prelabour | ✐Manage as given under the management of<br>✐"PROM". |

A woman with severe anaemia (Hb <7 g/dl, or those who have breathlessness and tachycardia due to anaemia) should be started on the therapeutic dose of IFA and also be investigated to detect the cause of anaemia. She may require injectable iron preparations.

Injection tetanus toxoid (Inj. TT) administration

Inj. TT is to be given as 0.5 ml per dose, deep intramuscular (IM) in the upper arm, administration of two doses of Inj. TT to an unimmunised pregnant woman. The first dose of TT should be given just after the first trimester, the second dose is to be given one month after the first dose, but preferably at least one month before the EDD.

Malaria prophylaxis

Guidelines of the National Anti-Malaria Programme (NAMP) should be followed.

Counselling

Counsel the mother for birth preparedness and complication readiness. The woman and her family/caretakers should be informed about potential danger signs during pregnancy, delivery and the postpartum period. She must be told that if she has any of the following she should immediately visit an FRU or the PHC, WITHOUT WAITING, be it day or night.

Danger signs : Visit an FRU (First referral unit) / MH

(a) Any bleeding P/V during pregnancy & heavy (>500 ml) vaginal bleeding during or following delivery
(b) Severe headache with blurred vision
(c) Convulsions or loss of consciousness
(d) Labour lasting for more than 12 hours
(e) Failure of delivery of the placenta within 30 minutes of delivery
(f) Preterm labour (onset of labour before 34 weeks of gestation)
(g) Cases with leaking P/V (PROM)
(h) Continuous severe abdominal pain
(j) All cases of medical illnesses associated with pregnancy, such as diabetes mellitus, heart disease, asthma, etc. at the onset of labour pains.

Danger signs: Visit a 24-hour PHC / MI room with MO

(a) High fever with or without abdominal pain, and the woman is too weak to get out of bed (indicating infection/sepsis)
(b) Fast or difficult breathing (dyspnoea)
(c) Decreased or absent foetal movements
(d) Excessive vomiting, wherein the woman is unable to take anything orally, leading to a decreased urinary output

Diet and rest

The woman should be advised to eat more than her normal diet throughout her pregnancy as she needs about 300 extra kcal per day compared to her usual diet.

(a) If a woman has PIH, she should be encouraged to eat a normal diet with no restrictions on fluid, calorie and/or salt intake; such restrictions do not prevent PIH from converting into pre-eclampsia, and may be harmful to the foetus.
(b) The woman should be advised to refrain from taking alcohol or smoking during pregnancy.
(c) The woman should be advised NOT to take any medication unless prescribed by a qualified health practitioner.
(d) The woman should be advised to sleep for 8 hours at night and rest for another 2 hours during the day. She should be advised to refrain from doing heavy work.
(e) All pregnant women should be told to avoid the supine position and should sleep in left lateral position.

Sex during pregnancy

(a) It is safe to have sex throughout the pregnancy, as long as the pregnancy is "normal".
(b) Sex should be avoided during pregnancy if there is a risk of abortion (h/o previous recurrent spontaneous abortions), or a risk of a preterm delivery (h/o previous preterm labour).

**Infant and young child feeding**

Pregnancy is the ideal time to counsel the mother regarding the benefits of breastfeeding.

Initiation of breastfeeding

(a) Counsel the mother that breastfeeding should ideally be initiated within half an hour of a normal delivery or within two hours of a caesarean section.
(b) Colostrum not to be thrown away.
(c) Exclusive breast feeding for 6 months.
(d) Demand feeding : This refers to the practice of breast feeding the child whenever he/she "demands" it.
(e) Rooming in: This refers to the practice of keeping the mother and baby in the same room and should be encouraged.

Complementary feeding at 6 months

The mother should be told that after 6 months of age, the baby needs supplementary food, IN ADDITION TO BREAST MILK. Advise the mother to begin with semi-solid soft food devoid of spices, supplemented with a small amount of ghee/butter/oil. The frequency of feeds and the quantity of each feed should be increased gradually.

**Contraception**

The woman should be advised regarding birth spacing (or limiting, as the case may be) Chapter on contraception may be referred.

**Compulsory institutional deliveries**

Every pregnant woman should be advised and encouraged to go in for an institutional delivery.

There are medical/obstetric conditions during a

pregnancy when the chances of a complication occurring are increased. Such conditions/complications where institutional delivery is must are:

24-hour PHC

(a) Mild pre-eclampsia
(b) PPH in the previous pregnancy
(c) More than 5 previous births
(d) Previous assisted delivery
(e) Maternal age less than 16 years
(f) H/o third-degree tear in the previous pregnancy
(g) FRU
(h) Severe anaemia
(j) Severe pre-eclampsia/eclampsia
(k) APH
(l) Transverse foetal lie or any other malpresentation
(m) Caesarean section in the previous pregnancy
(n) Multiple pregnancies
(o) Premature or prelabour rupture of membranes (PROM)
(p) Medical illnesses such as diabetes mellitus, heart disease, asthma, etc. during pregnancy.

## Care during labour and delivery - intrapartum care

### Diagnosis of labour

The onset of labour can be confirmed by the following:

(a) Cervical effacement-progressive shortening and thinning of the cervix during labour
(b) Cervical dilatation

### Stages of labour

(a) The first stage of labour starts with the onset of labour pains to full dilatation of the cervix. This stage takes about 12 hours in primigravidas and half that time for subsequent deliveries.
(b) The second stage starts from full dilatation of the cervix to the delivery of the baby. This stage takes about 2 hours for primigravidas and only about half an hour for subsequent deliveries.
(c) The third stage starts after the delivery of the baby and ends with the delivery of the placenta. This stage takes about 15 minutes to half an hour, irrespective of whether the woman is a primigravida or multigravida.
(d) Frequent monitoring for one hour immediately after delivery is critical to detect PPH. This period is sometimes referred to as the fourth stage of labour.

### Assessment of the progress of labour

The progress of labour is assessed by:

(a) Assessing the changes in cervical effacement and dilatation (by conducting a P/V examination)
(b) Assessing the progress in foetal descent (by conducting an abdominal and/or a P/V examination).

Abdominal examination to assess the descent of the presenting part

If the head is above the symphysis pubis it is fully palpable and mobile. If the head is entirely below the symphysis pubis it is not palpable abdominally.

Vaginal examination to assess the stage and progress of labour

Carry out the vaginal examination under strict aseptic conditions, and determine the following:

(a) Cervical effacement
(b) Cervical dilatation in cm
(c) The presenting part.
(d) The position or the station of the presenting part.
(e) Feel for the membranes. Are they intact?
(f) If the membranes have ruptured, check whether the colour of the amniotic fluid is clear or meconium-stained.
(g) Feel for the umbilical cord. If it is felt, it is a case of prolapsed cord. If the cord pulsations are felt, refer the woman to an FRU immediately.

### Supportive care to the woman during labour

(a) Explain all the procedures; keep the woman informed about the progress of labour.
(b) Praise the woman, encourage her and reassure her that things are going well.
(c) Encourage the woman to bathe or wash herself and her genitals at the onset of labour.
(d) Always wash your hands with soap and water before examining the woman
(e) Ensure cleanliness of the birthing area.
(f) Enema should be given only when needed.
(g) Encourage the woman to empty her bladder frequently. Remind her every 2 hours or so.
(h) Non-pharmacological methods of relieving pain during labour include:
    (i) Calm and gentle voice of the birth attendant
    (ii) Offering the woman encouragement, reassurance and praise
    (iii) Relaxation techniques performed by the woman such as deep breathing exercises and massage
    (iv) Placing a cool cloth on the woman's forehead
    (v) Assisting the woman in voiding urine and in changing her position.
(j) Women who are not at risk of requiring general anaesthesia can have light, easily digested, low-fat food during labour, if they wish.

### Normal delivery

Management of the first stage of labour

Not in active labour

The cervix is dilated 0-3 cm and contractions are weak, less than 2 in 10 minutes.

(a) Monitor the following every hour:
  (i) Frequency (once in how many minutes), intensity (how strong), and duration of contractions.
  (ii) FHR
  (iii) The presence of any sign that denotes an emergency (such as difficulty in breathing, shock, vaginal bleeding, convulsions or unconsciousness)

(b) Monitor the following every 4 hours
  (i) Cervical dilatation (in cm), temperature, pulse, BP

(c) Record the time of rupture of the membranes and the colour of the amniotic fluid.

(d) Never leave the woman alone.

(e) If after 8 hours, the contractions are stronger and more frequent, but there is no progress in cervical dilatation with or without rupture of the membranes, this is a case of non-progress of labour. Refer the woman immediately to an FRU.

(f) On the other hand, if after 8 hours, there is no increase in the intensity/frequency/duration of contractions, and the membranes have not ruptured and there is no progress in cervical dilatation, ask the woman to relax. Advise her to send for you again when the pain/discomfort increases, and/or there is vaginal bleeding, and/or the membranes rupture.

(g) If the membranes were already ruptured on admission, but even after 8 hours there is no increase in the frequency/intensity of contractions, refer the woman to an FRU (prolonged latent phase) for induction of labour.

In active labour

The cervix is dilated 3 cm or more:

(a) Monitor the following every 30 minutes:
  (i) Frequency, intensity and duration of the contractions
  (ii) FHR
  (iii) Presence of any emergency sign

(b) Monitor the following every 4 hours:
  (i) Cervical dilatation (in cm)
  (ii) Temperature, pulse, BP

(c) Again, do not leave the woman alone.

(d) Start maintaining a partograph once the woman is in active labour.

**Simplified partograph**

The partograph is a graphic recording of the progress of labour and salient features of the mother and foetus. It involves recording of FHR every half-an-hour, cervical dilatation (in cm) when the woman first reports in labour and then every four hours, maternal pulse and systolic and the diastolic BP every half-an-hour, food items and liquids consumed by the woman during that period.

Management of the second stage of labour

(a) If the cervix is fully dilated or the perineum is thin and bulging with the anus gaping and the head of the baby visible at the vaginal introitus, it is the second stage of labour.

(b) Monitor every 5 minutes: Frequency, duration and intensity of contractions, FHR, Perineal thinning and bulging, Visible descent of the foetal head during contractions, Presence of any signs indicating an emergency.

(c) The woman should be allowed to push down. Bearing down efforts are required after the cervix is fully dilated, and even more so when the head is distending the perineum.

(d) Asking the woman to hold her breath and bear down in the second stage of labour should NOT be done.

(e) Giving the woman oxytocics to shorten the second stage of labour is NOT advisable.

(f) Avoid ironing the perineum (or using the "Sweep and stretch" technique) to hasten delivery.

(g) Episiotomy: There is no evidence that routine episiotomy decreases perineal damage, future vaginal prolapse or urinary incontinence. Remember, whenever an episiotomy is required, a right paramedian episiotomy is preferred.

Indications for conducting an episiotomy
  (i) Complicated vaginal delivery (refer to a higher health facility in case of a malpresentation)
  (ii) H/o third or fourth - degree perineal tears
  (ii) Foetal distress
  (iii) Instrumental/assisted delivery

(h) Ensure a controlled delivery of the head by taking the following precautions:
  (i) Encourage the woman to push only during pains (a contraction).
  (ii) Keep one hand gently on the head as it advances with the contractions.
  (iii) Support the perineum with the other hand during delivery and cover the anus with a pad held in position by the side of the hand.
  (iv) Leave the perineum visible (between the thumb and the index finger).
  (v) Ask the mother to breathe steadily and to not push during delivery of the head.
  (vi) Encourage rapid breathing with the mouth open.
  (vii) Do NOT apply fundal pressure to hasten delivery of the head.

(j) Feel gently around the baby's neck for the presence of the umbilical cord around the neck. If the cord is present around the neck:
  (i) And if it is loose, deliver the baby through the

loop of the cord, or slip the cord over the baby's head.

(ii) If the cord is tight, clamp it and cut the cord, and then unwind it from around the neck.

(iii) Wait for spontaneous rotation and delivery of the shoulders. This usually happens within 1-2 minutes.

(iv) Perineal tears can be prevented by delivering one shoulder at a time. If there is difficulty in delivering the shoulder, suspect shoulder dystocia. Ask the woman to take a position with extreme flexion at the knees and hips with the knees wide apart. The shoulder may be released from behind the symphysis pubis and may deliver. If not, then refer the woman immediately to an FRU.

(k) In case of shoulder dystocia:

(i) Apply gentle pressure downwards to deliver the anterior shoulder.

(ii) Then lift the baby up, towards the mother's abdomen, to deliver the lower (posterior) shoulder.

(iii) The rest of the baby's body smoothly follows out.

(iv) Place the baby on the mother's abdomen or in the baby tray.

(l) Note the time of delivery.

(m) Cutting the cord:

(i) Tie and cut the cord after 2-3 minutes of delivery, during which time the cord will normally stop pulsating.

(ii) Put ties tightly around the cord at 2 cm and 5 cm from the baby's abdomen.

(iii) Cut between the ties with a sterile blade.

(iv) Look for oozing of blood from the stump. If these is oozing, place a second tie between the baby's skin and the first tie.

(n) Give immediate newborn care.

(o) Rule out the presence of another baby by palpating the abdomen and trying to feel for foetal parts.

(p) It is recommended that the umbilical cord stump be left dry, and only routine daily care be given with clean safe water. Do not apply any substance to the stump.

(q) Care of the newborn: The newborn needs to be taken care of. The elements of essential newborn care are given below.

#### Elements of essential newborn care

(a) Maintain the body temperature and prevent hypothermia

(b) Maintain the airway and breathing

(c) Breastfeed the newborn

(d) Take care of the cord

(e) Take care of the eyes

(f) Leave the baby on the mother's chest for skin-to-skin contact.

(g) Cover the baby to prevent loss of body heat. If the room is cool, use additional blankets to cover the mother and the baby.

(h) Encourage the mother to initiate breastfeeding.

#### Active management of the third stage of labour

The active management of the third stage of labour consists of the following three activities.

Uterotonic drug

Giving a uterotonic drug has been shown to be effective in preventing PPH.

Although Inj. Oxytocin (in a dose of 10 U IM) is the drug of choice for preventing PPH, due to administrative difficulties, Misoprostol can now be used for the same purpose. Three tablets of 200 mcg each of Misoprostol (a total dose of 600 mcg) should be given immediately after delivery of the baby. It should be given either sublingually or orally.

Before giving Misoprostol, ensure that there is no additional baby(ies). This can be done by palpating the abdomen and ruling out the presence of foetal parts.

Controlled cord traction (CCT)

This is a technique to assist the expulsion of the placenta and helps to reduce the chances of a retained placenta and subsequent PPH. Do NOT exert excessive traction on the cord while performing CCT.

Uterine massage

This technique helps in contraction of the uterus and thus prevents PPH. Immediately after delivery of the baby; massage the uterus by placing your hand on the woman's abdomen until it is well contracted. Repeat the massage every 15 minutes for the first 2 hours. Ensure that the uterus does not become relaxed (soft) after the massage is stopped. If the placenta is not delivered within 30 minutes of giving Misoprostol, and the woman is not bleeding, try and remove the placenta again by CCT. Empty the bladder, and encourage the woman to breastfeed. If the placenta cannot be delivered after another 20 minutes, and the woman is not bleeding, empty the bladder, initiate breastfeeding and repeat CCT. The placenta may separate. If it does not separate and the woman is still not bleeding, refer her to an FRU.

## Post Partum Care

#### Immediate postpartum care

(a) After delivery of the placenta, check that the uterus is well contracted, i.e. it is hard and round, and there is no heavy bleeding. Repeat the checking every 5 minutes. If the uterus is not well contracted, massage the uterus and expel the clots.

(b) Examine the perineum, lower vagina and vulva for tears. If present, manage the tears by suturing.

(c) Estimate and record the amount of blood lost throughout the third stage and immediately afterwards. If the loss is around 250 ml, but the bleeding has stopped, observe the woman for the next 24 hours.

(d) Monitor the following every 10 minutes for the first 30 minutes, then every 15 minutes for the next 30 minutes, and then every 30 minutes for the next three hours: BP, pulse, temperature, vaginal bleeding, uterus to make sure that it is well contracted.

(e) Clean the woman and the area beneath her. Put a sanitary pad or a folded cloth under her buttocks to collect blood. This will also help in estimating the amount of blood lost, by counting the number of pads/cloths soaked. Help her change her clothes, if necessary.

(f) Dispose of the placenta in the correct, safe and culturally appropriate manner. Use gloves while handling the placenta. Put the placenta into a leak-proof bag. Incinerate the placenta or bury it at least 10 m away from a water source, in a 2 m deep pit.

(g) Keep the mother and the baby together; do not separate them. Encourage early breastfeeding.

(h) Encourage the woman to eat and drink, and rest.

(j) Encourage the woman to pass urine. If the woman has difficulty in passing urine, or the bladder is full (as evidenced by a swelling over the lower abdomen) and she is uncomfortable, help her pass urine by gently pouring water over her vulva.

(k) Weigh the baby.

(l) Ask the birth companion to stay with the mother. Do not leave the mother and the newborn alone. Ask the companion to watch the woman and call for help if any of the following occurs:
   (i) The bleeding increases.
   (ii) The woman feels dizzy.
   (iii) The woman has severe headache.
   (iv) The woman has visual disturbance.
   (v) The woman has epigastric distress.
   (vi) The woman complains of breathlessness.
   (vii) The woman complains of increased abdominal or perineal pain.

(m) Enter the following information in the labour register:
   (i) Date & time of delivery
   (ii) Name of the woman
   (iii) Age of the woman
   (iv) Parity
   (v) ANC received (or not): mention the number of ANC visits
   (vi) Mode of delivery (normal or assisted)
   (vii) Birth weight of the baby
   (viii) Apgar score of the baby at 1 minute and 5 minutes after delivery.

(n) Do not discharge the woman before 24 hours after delivery. This is a crucial period for the occurrence and management of PPH. The woman must be kept under observation during this time.

**Counselling**

Counsel the woman regarding the aspects discussed below:

Postpartum care and hygiene

Advise and explain to the woman

(a) To always have someone near her for the first 24 hours after delivery to respond to any change in her condition.

(b) Not to insert anything into the vagina.

(c) To wash the perineum daily and after passing stools. Wash in an anteroposterior direction from the vulva to the anus.

(d) To change the perineal pads every 4-6 hours, or more frequently, if there is heavy lochia.

(e) To wash cloth pads, if used, with plenty of soap and water and dry them in the sun.

(f) To bathe daily.

(g) To have enough rest and sleep. For the first 6 weeks postpartum, advise the woman to not do anything except look after herself and her baby.

(h) To avoid sexual intercourse for the first six weeks or until the perineal wound heals, whichever is later.

(j) To wash her hands before handling the baby.

Nutrition

Advise the woman to eat a greater amount and variety of healthy foods. Give her examples of the types of food and how much to eat.

Contraception

Advise the woman regarding birth spacing or limiting as the case may be.

Breastfeeding

As discussed above.

Registration of birth

Emphasize to the woman that she must get the birth of the baby registered with the local Panchayat, or any other appropriate registering authority.

Postpartum visit

(a) Inform the woman about the next routine postpartum visit.

(b) As the woman is kept under observation for the first 24 hours after delivery, the first postpartum visit is taken care of during her stay at the PHC/health facility.

(c) The second postpartum visit should be planned within 7-10 days after delivery. Either ask the ANM of that area to pay a visit to the woman and her baby, or ask the woman to return to the PHC for a postpartum check-up.

(d) If the woman misses her postpartum visits, inform her regarding the danger signs and when to return.

(e) Danger signs

(f) For the following symptoms and signs in the mother, advise the woman and her family to go to an FRU immediately, day or night, WITHOUT WAITING.

(i) Excessive vaginal bleeding, i.e. soaking more than 2 or 3 pads in 20-30 minutes after delivery, or bleeding increases rather than decreases after the delivery

(ii) Convulsions

(iii) Fast or difficult breathing

(iv) Fever and weakness; inability to get out of bed

(v) Severe abdominal pain

(g) Advise the woman that she should visit the PHC as soon as possible, in case she suffers from any of the following symptoms:

(i) Fever

(ii) Abdominal pain

(iii) The woman feels ill

(iv) Swollen, red or tender breasts, or sore nipples

(v) Dribbling of urine or painful micturition

(vi) Pain in the perineum, or pus draining from the perineal area

(vii) Foul-smelling lochia.

Research has shown that more than 50% of maternal deaths take place during the postpartum period. Conventionally, the first 42 days (6 weeks) after delivery are taken as the postpartum period. Of this, it is the first 48 hours, followed by the first one week, which are the most crucial periods for the health and survival of both the mother and her newborn, as most of the fatal and near-fatal maternal and neonatal complications arise during this period.

**Postnatal check-ups**

The number and timing of PNC visits

(a) The first 48 hours following delivery are the most important. Take a history and do a quick examination, as described later to find out possible complications that could have arisen.

(b) The next most critical period is the first week following delivery. Ask the mother to pay another visit on day 3rd and day 7th, or ask the ANM in charge of that area to pay a home visit during this period.

The first postpartum visit

As explained earlier, the first postpartum visit should take place within the first 24 hours after delivery.

**History-taking**

The following questions should be asked:

(a) Where did the delivery take place?

(b) Who conducted the delivery?

**Maternal symptoms**

(a) H/o heavy bleeding P/V

(b) H/o convulsions or loss of consciousness

(c) H/o abdominal pain

(d) H/o fever

**Examination**

(a) Check the pulse, BP, temperature, pallor.

(b) Examine the abdomen to see if the uterus is well contracted.

(c) Examine the vulva and the perineum for the presence of any foul-smelling lochia, tear, swelling or pus discharge and also the pad for bleeding and any purulent discharge.

**Neonatal symptoms**

Check for signs of possible diseases and take appropriate action as given in Table - 2, Table - 3 & Table - 4.

The schedule of subsequent visits is based on birth weight. The recommended schedule for home visits is outlined below:

**Advise the Mother and the Family on Home Care**

(a) To breastfeed the infant frequently

(b) To ensure that the infant is kept warm at all times by placing the baby in skin to-skin contact with the mother

(c) Advise the mother not to apply anything on the cord and keep the cord and umbilicus dry.

(d) Also teach the mother to return immediately, if the young infant has any of these signs:

(e) Breastfeeding or drinking poorly

(i) Becomes sicker

(ii) Develops a fever or feels cold to touch

| | |
|---|---|
| All babies | 3, 7 days |
| Low birth weight babies (weight less than 2.5 kg) | 3, 7, 14, 21 and 28 days |

(iii) Fast breathing

(iv) Difficult breathing

(v) Blood in stool

**The second and third postpartum visits**

This is similar to the history yaking and examination conducted during the first visit

**Counselling**

Diet and rest

(a) Inform the woman that during lactation she needs approximately 550 kcal extra in a day during the

Table - 2 : Possible serious infections in neonate

| **Signs** | **If any one sign is present, Refer the child** |
|---|---|
| ✎Convulsions<br>✎Not able to feed<br>✎Fast breathing<br>✎Severe chest indrawing<br>✎Nasal flaring<br>✎Grunting<br>✎Feels hot or unusually cold<br>✎Lethargic or unconscious<br>✎Blood in stool. | ✎Explain the need for referral<br>✎Calm her fears and discuss possible solutions for any difficulty in referral<br>✎Advise the mother to continue to breast feed the baby and keep the sick young infant warm<br>✎Write a referral slip<br>✎Give first dose of cotrimoxazole if able to take orally (½ Pediatric tablet for an infant upto 1 month and 1 tablet for an infant 1-2months) |

Table - 3 : Care of Skin and umbilical cord

| | |
|---|---|
| ✎Umbilical redness or umbilicus draining pus<br>OR<br>✎Skin pustules (Less than 10 skin pustules) | ✎Give oral co-trimoxazole (or amoxicillin) for 5 days<br>✎Teach the mother to apply GV paint twice daily for skin pustules and umbilical infection<br>✎Advise mother to give home care for the young infant |

Table - 4 : Check for feeding problem

| | |
|---|---|
| ✎Not able to feed: If a mother says that the infant is not able to feed, watch her try to feed the infant to confirm if infant is able to feed.<br>OR No attachment at all | |
| ✎Not well attached to breast or not suckling effectively. | ✎If not well attached or not suckling effectively, teach correct positioning |
| ✎Less than 8 breastfeeds in 24 hours | ✎If breastfeeding less than 8 times in 24 hours , advise to increase frequency of feeding. |
| ✎Receives other foods or drinks | ✎If receiving other foods or drinks, counsel mother about breastfeeding more, reducing other foods or drinks, and using a cup and spoon. |
| ✎If not breastfeeding at all | ✎If not breastfeeding at all, advise mother about giving locally appropriate animal milk and teach the mother to feed with a cup and spoon. |
| ✎Thrush (Ulcers or white patches in mouth) | ✎If thrush, teach the mother to apply 0.25% Gentian Violet paint twice daily |
| ✎Breast or nipple problems | ✎If breast or nipple problem, teach the mother to treat breast or nipple problems.<br>✎Advise mother to give home care<br>✎(Breastfeed infant exclusively, keep infant warm, apply nothing to cord, |
| ✎No other signs of inadequate feeding | ✎Advise mother home care<br>✎Praise the mother for feeding the infant well. |

first 6 months, and then 400 kcal extra during the next 6 months, compared to her pre-pregnancy diet.

(b) The woman needs sufficient rest during the postpartum period to be able to regain her strength.

Resumption of sex

The couple should be advised to abstain from having sex during the first 6 weeks following delivery.

Contraception

This issue must be emphasized again

Infant and young child feeding

The issues that need to be discussed and the woman counselled about have been detailed above.

Infant care

You must talk to the mother about:

(a) Child development and milestones
(b) Maintaining the hygiene of the baby
(c) Feeding the baby
(d) When and where to seek help in case of illness. Explain the danger signs
(e) How to interact with the child, etc.

## Essential newborn care

### Preparing for birth

Make sure that the following materials / conditions are available for the newborn:

(a) Two clean and warm towels for thermal protection of the baby; one for drying and wrapping the baby initially, the other for covering the newborn to prevent heat loss
(b) A draught-free delivery room with a temperature of at least 25 °C
(c) Soap, water, clean gloves, cotton, gauze and a clean labour table for delivery to ensure the six "cleans" (i.e. clean hands, clean surface, clean cord cut, clean cord tie, clean cord stump and clean perineum) during delivery
(d) A clean delivery kit for cord care
(e) Self-inflating bags (two, of a size appropriate for a newborn) and masks (sizes zero and one) for resuscitation
(f) A suction device (mucus extractor)
(g) A radiant heater
(h) A blanket
(j) A clock/watch to note the time of delivery.

### Routine care at birth

Over 90% of newborns do not require any active resuscitation at birth. Efforts are directed to maintain asepsis, prevent infection and hypothermia, and to keep the airway patent.

### Asepsis

Deliver the newborn under aseptic conditions.

Clamping of the cord

Clamp the umbilical cord 2-3 minutes after the neonate is delivered completely.

Care of the cord

(a) Inspect the cord for bleeding 2 hours after ligation.
(b) Do NOT apply anything on the stump; keep the cord clean and dry.
(c) Inspect for discharge or infection till healing occurs.

### Maintaining the body temperature

Newborns may be hypothermic at birth. Heat loss at birth can be prevented by the following simple interventions:

(a) Receive the baby in a dry, warm, clean towel. Dry the baby well. While drying, make sure that the head is in a neutral position. Discard the wet towel immediately and wrap/cover the baby (except for the face and upper chest) in a fresh, clean dry towel.
(b) Place the baby near a source of warmth.
(c) Bathing the newborn soon after birth is not recommended. The mother or the birth attendant can clean the baby by wiping with a soft moist cloth. If cultural tradition demands bathing, this should not be carried out before 6 hours after birth, and preferably on the second or third day of life as long as the baby is healthy and its temperature normal and that too with lukewarm water.

### Airway and breathing

If the baby is crying and the breathing is normal, resuscitation is not needed. Provide normal care and clear the upper airway by wiping the nose and mouth of the baby, and removing the ecretions present therein. If the baby is not crying, assess the breathing; if the chest is rising symmetrically and the RR is >30 breaths/minute, no immediate action is needed.

### Care of the skin

Clean the blood, mucus and meconium on the newborn's body.

### Care of the eyes

The eyes should be cleaned at birth and once every day using sterile cotton swabs soaked in sterile water or normal saline.

### Feeding

Initiate breastfeeding within one hour of a normal delivery.

### Apgar score

The Apgar score indicates the newborn's well-being. It should be calculated at 1 minute and at 5 minutes after birth. Table - 5 gives the criteria for calculating the Apgar score. An Apgar score of >7 is considered satisfactory.

Table -5 : Criteria for calculating the Apgar score

**Essential postnatal care**

(a) Nurse in thermal comfort (the baby should be warm to the touch at the abdomen and pink in the soles of the feet.
(b) Check the umbilicus, skin and eyes.
(c) Ensure good suckling at the breast.
(d) Screen for danger signs.
(e) Advise the family, especially the mother, on immunization.

Danger signs in a newborn

| Parameters | 0 | 1 | 2 |
|---|---|---|---|
| **Respiratory effort** | Absent | Gasping | Good cry |
| **Heart rate** | Zero | <100/minute | >100/minute |
| **Colour (cyanosis)** | Central cyanosis | Peripheral cyanosis | Pink |
| **Muscle tone** | Flaccid | Partial flexion of the extremities | Complete flexion |
| **Reflex (response to nasal catheter)** | None | Grimace | Sneeze |

The signs mentioned below are particularly important signs to watch to Return Immediately:

(a) Breastfeeding or drinking poorly
(b) Becomes sicker
(c) Develops a fever or feels cold to touch
(d) Fast breathing
(e) Difficult breathing
(f) Blood in stool

Basic newborn resuscitation

Effective basic resuscitation will revive more than 75% of newborns with birth asphyxia.

Birth asphyxia

It is estimated that 4%-6% of babies fail to establish breathing at birth. Birth asphyxia is the second most common cause of neonatal mortality next to septicaemia.

Defining birth asphyxia

Traditionally, birth asphyxia is defined on the basis of the Apgar score. An Apgar score of <7 at 1 minute is considered as birth asphyxia. Such a baby needs immediate resuscitation.

Initial assessment

The five questions to ask are:

(a) Is the amniotic fluid clear of meconium?
(b) Is the baby breathing or crying normally?
(c) Is the muscle tone good?
(d) Is the colour of the baby pink?
(e) Was the baby born at term?

If the answer to any of these questions is "NO" immediately begin the initial steps of resuscitation.

Managing birth asphyxia

If meconium is present in the amniotic fluid, apply suction to ensure that it is removed from the mouth, posterior pharynx and nose before delivery of the shoulders.

Suction apparatus: These could be either De Lee mucus traps, foot or electrically operated suction machines. While using electrical suction machines, care must be taken that the pressure does not exceed 100 mm Hg.

Tactile stimulation

If necessary, appropriate forms of tactile stimulation (gently rubbing the baby's back, flicking the soles of the feet) may be provided.

Heart rate

If the heart rate is less than 100 beats/minute, it indicates the need for assisted ventilation.

Open the airway - position and suction

Put the baby on its back. Position the head so that the neck is slightly extended. Clear the airway by suctioning first the mouth and then the nose. A mucus trap or a foot-operated suction machine may be used for the same.

Assisted ventilation

Assisted ventilation is indicated in any apnoeic baby who is not responding to tactile stimulation, or any baby who, though breathing, has a heart rate of <100 beats/minute. Ventilation may be provided either with a bag and mask or a bag and an endotracheal tube.

Risk identification in the newborn

An important task of the attending MO in the labour room is the identification of newborns at high risk for morbidity and mortality. These newborns would need special care, either at the PHC where the delivery took place (if the facilities and trained personnel exist) or at the FRU where these babies should be referred to.

**Guidelines to detect newborns at risk are given below**

(a) Birth asphyxia: Newborns who are asphyxiated at birth, especially those who do not establish spontaneous respiration by 5 minutes of birth.
(b) Danger Signs: Newborn with following signs:
  (i) Convulsions
  (ii) Fast breathing (60 breaths per minute or more)
  (iii) Severe chest indrawing
  (iv) Nasal flaring
  (v) Grunting
  (vi) Bulging fontanelle
  (vii) 10 or more skin pustules or a big boil

(viii) If axillary temperature 37.5°C or above (or feels hot to touch) or temperature less than 35.5°C (or feels cold to touch)

(ix) Lethargic or unconscious

(x) Less than normal movements

(xi) Severe Jaundice

(xii) Blood in the stools

(xiii) Not able to feed

(xiv) No attachment at all

(xv) Not sucking at all

(c) Major Malformations

**Reference**

1. Extracted from Guidelines for Pregnancy Care. Maternal Health Division. Department of Family Welfare. Ministry of Health and Family Welfare. Government of India. 2005.

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# Integrated Management of Neonatal and Childhood Illnesses

The commonest causes of death in children below 5 years of age are acute respiratory illnesses (mostly pneumonia), diarrhea, measles, malaria, malnutrition and often a combination of these illnesses. In order to combat these illnesses, isolated preventive and treatment interventions such as antibiotics for pneumonia, oral rehydration therapy, prompt malarial treatment, vaccination etc have been employed over the years. It has been however recognized that childhood health programmes need to go beyond single diseases and should promote overall health and well being of a child. Moreover many sick children present with overlapping signs and symptoms of illnesses, and a single diagnosis may not be feasible or appropriate, especially in a primary care level with scarce resources. Accumulated evidence has also suggested that an integrated approach is needed in managing sick children to improve outcomes. Therefore, WHO in collaboration with UNICEF and many other agencies developed a strategy known as Integrated Management of Neonatal and Childhood Illnesses ( IMNCI) as a means of reducing morbidity and mortality in children below the age of 5 years. Apart from reducing deaths and frequency or severity of illnesses, this strategy addresses nutrition, growth, immunization and other important aspects prevention of disease and promotion of health.

The aim of managing children as per the Integrated Management of Neonatal and Childhood Illness (IMNCI) protocol is to use a syndromic approach to the common and serious problems affecting children. It is not based on arriving at a specific diagnosis and treatment but focuses on identifying a cluster of signs and symptoms most likely associated with serious, often life threatening diseases. Treatment can thereby be started at the earliest without the use of any laboratory tests or sophisticated investigations, and before referring the child to a higher centre. It involves triage to quickly decide and treat mild to moderate disease effectively while referring seriously ill children early and in a more stable condition.

A combination of symptoms and signs leads to an infant or child's 'classification', which indicates the severity of the condition, rather than a diagnosis. The specific action thereby can be either urgent referral to a higher level of care (colour coded pink), giving specific treatment in the primary health care facility (colour coded yellow) or safe home management (colour coded green). Pre-referral treatment, counseling of caretaker and follow up are unique components of the IMNCI programme.

Depending on the age of the child, various clinical signs and symptoms differ in their degree of reliability, diagnostic value and importance. The IMNCI guidelines therefore recommend case management procedures based on two age categories:

(a) Young infants age up to 2 months
(b) Children 2 months up to 5 years

## Outpatient management of the sick young infant Age up to 2 months

Neonates and infants below 2 months of age are considered as a special group in the IMNCI case management protocol for several reasons. They become sick rapidly and can die quickly due to serious bacterial infections. Certain general signs in these infants such as low body temperature, fever or less body movements may be the only manifestation of illness. On the other hand, a finding such as mild chest indrawing is normal in them due to a soft chest wall. Therefore the assessment and classification process is different from that in an older infant or child.

A young infant age up to 2 months brought to the primary health care facility is assessed as follows

(a) Assessment for possible serious bacterial infection or local infection
(b) Assessment for jaundice
(c) Assessment for low body temperature
(d) Assessment for diarrhea
(e) Assessment feeding problem or malnutrition and breast feeding
(f) Checking the immunization status and assessing other problems

### Assessment for possible serious bacterial infection

Any sick young infant who is brought to a health care provider should be first assessed for possible serious bacterial infection based on the following criteria:

(a) History of convulsions
(b) Presence of fast breathing (60 breaths per minute or more)
(c) Severe chest in-drawing
(d) Nasal flaring
(e) Grunting
(f) Bulging fontanel
(g) Skin pustules (10 or more)
(h) Large boil on the skin
(j) Abnormal axillary temperature ( more than 37.5$^{o}$C or less than 35.5$^{o}$C)
(k) Lethargy or unconsciousness
(l) Less than normal movements

If any one of these of these criteria is present the infant is classified as having possible serious bacterial infection. an infant is to be referred to hospital urgently for admission. The pre-referral treatment is important. It consists of administering first dose of antibiotics (intramuscular ampicillin 100 mg/Kg and gentamicin 5mg/Kg); giving expressed breast milk (or appropriate animal milk orally or by nasogastric tube) to prevent hypoglycemia and providing warmth by skin to skin contact (kangaroo care).

Assessment for local infection

The infant has local bacterial infectionif there is redness of umbilicus, pus discharge from ear or less than 10 skin pustules. all such cases an oral antibiotic is given (co-trimoxazole 6 mg/kg/day of trimethoprim or amoxycillin 30 mg/kg/day) for 5 days. The mother is taught to apply gentian violet and dry the ear by wicking. The infant is followed up after 2 days.

**Assessment and management of jaundice**

Jaundice should be looked for in any sick young infant. Jaundice in a neonate appearing at aless thanhours or after 14 days or associated with yellow discoloration of palms and soles is classified as severe jaundice. an infant

requires urgent referral to hospital after giving pre-referral treatment which includes oral expressed breast milk, skin to skin contact and advising mother to keep the infant warm en route to hospital. If the infant has jaundice but there are no signs of severity, mother is reassured and the infant is reviewed after 2 days. It is important to advice the mother to return immediately if the infant develops any signs of serious bacterial infection or jaundice on palms and soles.

**Assessment & management of low body temperature**

Axillary temperature should be recorded in every sick young infant and if it is 35.5 - 36.4°C, the infant has low body temperature. Such an infant should be warmed with skin to skin contact for one hour and reassessed. If there is no improvement, he is referred to hospital, while feeding expressed breast milk to prevent hypoglycemia.

**Assessment and management of diarrhea**

A young infant is said to have diarrhea if the stools have changed from the usual pattern and are increased in number and watery (more water then fecal matter). The normally frequent or loose stools of a breast fed baby are not considered as diarrhea.

Duration of diarrhea and history of blood in the stool are important questions in the history. Assessment for presence and severity of dehydration is done by looking at the infant's general condition, presence of sunken eyes and the response to skin pinch.

If the young infant has two of the following three signs, the classification is severe dehydration:

(a) Lethargic or unconscious
(b) Sunken eyes
(c) Skin pinch goes back very slowly.

If such an infant has low weight or any other severe classification, he is referred urgently to hospital. The pre-referral treatment comprises first dose of IM antibiotics (ampicillin and gentamicin), giving frequent sips of ORS on the way, continuing breast feeding and keeping the infant warm. If the infant does not have low weight or another severe classification, fluids are administered for severe dehydration as per **plan C** (Table - 1) and he is then referred to hospital after rehydration.

If the young infant has two of the following three signs,

(a) Restless, irritable
(b) Sunken eyes
(c) Skin pinch goes back slowly, he is classified to have some dehydration.

If the infant has low weight or another severe classification, first dose of IM antibiotics (ampicillin and gentamicin) are given and urgent referral to hospital is done, with mother giving frequent sips of ORS on the way, continuing breast feeding and keeping the infant warm. I f the infant does not have low weight or another severe classification, fluids are administered for some dehydration as per **plan B** (Table - 2). The mother is counseled to return for follow up in 2 days or return immediately if danger signs develop.

If there are not enough signs to classify as some or severe dehydration, the infant has no dehydration and is given fluids to treat diarrhea at home as per **plan A** (Table - 3). The follow up is done in 5 days and mother is also advised when to return immediately.

Severe persistent diarrhea is diarrhea lasting 14 days or more and the infant with this classification is referred to hospital. If there is blood in the stool, the young infant has severe dysentery and is similarly referred to hospital.

**Assessment and management of feeding problems and malnutrition**

Every sick young infant should be assessed for adequate feeding and weight. Mother should be enquired about any feeding difficulty, frequency of breast feeding, any other food or drink being given to the infant and frequency of such feeds. The present weight and birth weight should be noted and using the reference charts (Fig - 1), the infant is classified as very low weight for age, low weight for age or not low weight for age.

Feeding should be assessed immediately if the infant feeds less than 8 times in 24 hours, receives other foods or drinks, or is low weight for age and has no indications to refer urgently to hospital. The infant should be put to the breast and observed for attachment and effective suckling. Blocked nose, oral thrush and breast or nipple problems (flat or inverted nipples, sore nipples, engorged breasts or breast abscess) should be looked for.

If the young infant is not able to feed, has no attachment at all, is not sucking at all or is very low weight for age, he has a life threatening problem and needs urgent admission to hospital after administering pre-referral treatment.

If there are other feeding problems or the infant is low weight for age, counseling of the mother is done about correct position during breast feeding, increasing frequency of feeds, treatment of breast and nipple problems and treatment of thrush. The infant is followed up after 2 days for feeding problem and after 14 days for low weight for age.

**Checking the young infant's immunization status**

It is important to check whether OPV, BCG, DPT-1 and Hep B-1 vaccines have been administered in every sick young infant. An infant who is not sick enough to be referred to hospital should be given the necessary immunization before being sent home.

**Assessment of other problems**

The infant should be assessed for all other problems mentioned by the mother or observed during examination. If a potentially serious problem is found and there are no available means to manage the infant, he should be referred to hospital.

Case recording form for management of a sick young infant is as shown below.

## CASE RECORDING FORM FOR MANAGEMENT OF THE SICK YOUNG INFANT AGE UP TO 2 MONTHS

Name:_____ Age:____ Weight: ____kg Temperature:_____ °C Date:

ASK: What are the infant's problems? _____Initial visit? _____ Follow up Visit?_____

**ASSESS** (Circle all signs present) **CLASSIFY**

**CHECK FOR POSSIBLE BACTERIAL INFECTION / JAUNDICE**

- Has the infant had convulsions?
- Count the breaths in one minute. breaths per minute
- Repeat if elevated _____ Fast breathing?
- Look for severe chest indrawing.
- . Look for nasal flaring.
- Look and listen for grunting.
- Look and feel for bulging fontanelle.
- Look for pus draining from the ear.
- Look at the umbilicus. Is it red or draining pus?
- Look for skin pustules. Are there 10 or more pustules or a big boil?
- Measure axillary temperature (if not possible, feel for fever or low body temperature):
  - 37.5°C or more (or feels hot)?
  - Less than 35.5°C ?
  - Less than 36.5°C but above 35.4°C (or feels cold to touch)?
- See if young infant is lethargic or unconscious
- Look at young infant's movements. Less than normal?
- Look for jaundice. Are the palms and soles yellow?

**DOES THE YOUNG INFANT HAVE DIARRHEA?** Yes ___ No _

- For how long? ____ Days?
- Is there blood in the stool?
- Look at the young infant's general condition. Is the infant:
  - Lethargic or unconscious?
  - Restless and irritable?
- Look for sunken eyes.
- Pinch the skin of the abdomen. Does it go back:
  - Very slowly (longer than 2 seconds)?
  - Slowly

**THEN CHECK FOR FEEDING PROBLEM & MALNUTRITION**

- Is there any difficulty feeding? Yes __ No ___ . • Determine weight for age. Very low ___ Low ___ Not Low ___
- Is the infant breastfed? Yes _____ No ___
  If Yes, how many times in 24 hours? ____ times
- Does the infant usually receive any other foods or drinks? Yes ___ No ___
  If Yes, how often?
- What do you use to feed the infant?

**If the infant has any difficulty feeding, is feeding less than 8 times in 24 hours, is taking any other food or drinks, or is low weight for age AND has no indications to refer urgently to hospital:**

**ASSESS BREASTFEEDING:**

• Has the infant breastfed in the previous hour?

If infant has not fed in the previous hour, ask the mother to put her infant to the breast. Observe the breastfeed for 4 minutes.

• Is the infant able to attach? To check attachment, look for:
- Chin touching breast Yes ___ No ___
- Mouth wide open Yes _____ No ___
- Lower lip turned outward Yes ____ No ___
- More areola above than below the mouth Yes ___ No ___

*no attachment at all* *not well attached* *good attachment*

• Is the infant suckling effectively (that is, slow deep sucks, sometimes pausing)?

*not suckling at all* *not suckling effectively* *suckling effectively*

• Look for ulcers or white patches in the mouth (thrush).

• Does the mother have pain while breastfeeding? If yes, then look for:
- Flat or inverted nipples, or sore nipples
- Engorged breasts or breast abscess

**CHECK THE YOUNG INFANT'S IMMUNIZATION STATUS** Circle immunizations needed today.

Return for next immunization on:

_____ _____
BCG DPT 1

_____ _____
OPV 0 OPV 1

_____
HEP-B 1

_____
(Date)

**ASSESS OTHER PROBLEMS:**

## TREATMENT

_____
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Return for follow up in:

_____

Advise mother when to return immediately.

Give any immunizations needed today:

_____

Counsel the mother about her own health

## Outpatient management of the sick child - Age 2 months up to 5 years

A sick child aged 2 months to 5 years presenting to the primary health care facility is most likely to have pneumonia, diarrhea, fever or an ear infection. The child may in addition have malnutrition and anemia and should be evaluated in a comprehensive manner irrespective of the complaints as follows:

(a) Asking the mother about the child's problem.
(b) Checking for general danger signs.
(c) Asking the mother about the four main symptoms:
  (i) Cough or difficult breathing
  (ii) Diarrhea
  (iii) Fever
  (iv) Ear problem.
(d) If one of the above main symptoms is present:
  (i) Assessing the child further for signs related to the main symptom
  (ii) Classifying the illness according to the signs which are present or absent.
(e) Checking for signs of malnutrition and anemia and classifying the child's nutritional status.
(f) Checking the child's immunization status and deciding if the child needs any immunization immediately.
(g) Assessing for any other problems.

### Checking for general danger signs

A sick child brought to the primary health care facility may have signs that clearly indicate a specific problem. For example, a child may present with chest indrawing and cyanosis, which indicate severe pneumonia. However, some children may present with serious, non-specific signs called "general danger signs" that do not point to a particular diagnosis. For example, a child who is lethargic or unconscious may have meningitis, severe pneumonia, cerebral malaria or another severe disease. Great care should be taken to ensure that these general danger signs are not overlooked because they suggest that a child is severely ill and needs urgent attention.

The following general danger signs should be routinely checked in all children:

- Convulsions
- Repeated vomiting
- Inability to drink or breastfeed
- Lethargy or unconsciousness

If a child has one or more of these signs, he must be considered seriously ill and will almost always need referral. In order to start treatment for severe illnesses without delay, the child should be quickly assessed for the most important causes of serious illness and death - acute respiratory infection (ARI), diarrhea, and fever (especially associated with malaria and measles). A rapid assessment of nutritional status is also essential.

### Checking main symptoms

After checking for general danger signs, the health care provider must check for the following main symptoms:

(a) Cough or difficult breathing
(b) Diarrhea
(c) Fever
(d) Ear problems.

#### Cough or difficult breathing

Three key clinical signs are used to assess a sick child with cough or difficult breathing:

(a) Respiratory rate: A child's age cut-off rate for fast breathing that suggests pneumonia is:
  (i) 2 months up to 12 months: 50 breaths per minute or more
  (ii) 12 months up to 5 years : 40 breaths per minute or more
(b) Lower chest wall indrawing
(c) Stridor

Based on a combination of the above clinical signs, children presenting with cough or difficult breathing should be classified into three categories:

(a) Severe pneumonia or very severe disease
(b) Pneumonia
(c) No pneumonia (i.e. cough or cold).

Presence of any general danger sign or chest indrawing or stridor in a calm child classifies the child as **severe pneumonia /very severe disease**. This child should be urgently referred to hospital, after administering the first dose of injectable antibiotic (IM Chloramphenicol 40mg/kg/dose) or if not possible, oral amoxicillin 15mg/kg/dose.

If only fast breathing is present, the child is classified as having **pneumonia** and given oral antibiotics - cotrimoxazole (trimethoprim 8 mg/kg/day) for 5 days. Additional symptomatic treatment to soothe the throat and a safe cough remedy for children older than 6 months may be given. The mother is counseled to return for follow up after 2 days. However if danger signs develop or the child becomes sicker, the mother should be asked to return immediately.

If there are no signs of pneumonia, the classification is **no pneumonia: cough or cold**. Such a child is given symptomatic treatment, but followed up after 5 days if not improving, or immediately if danger signs develop or the child becomes sicker.

#### Diarrhea

A child presenting with diarrhea should first be assessed for general danger signs and the child's caretaker should also be asked if the child has cough or difficult breathing. A child with diarrhea may have three potentially lethal conditions:

(a) Acute watery diarrhea (including cholera)
(b) Dysentery (bloody diarrhea)
(c) Persistent diarrhea (diarrhea that lasts 14 days or more).

All children with diarrhea should be checked to determine the duration of diarrhea, if blood is present in the stool and if dehydration is present.

A number of clinical signs are used to determine the level of dehydration:

(a) Child's general condition ( lethargic, unconscious or restless /irritable).

(b) Sunken eyes.

(c) Child's reaction when offered to drink: Nable to drink /drinking poorly/ eagerly, thirsty

(d) Elasticity of skin : when released, the skin pinch goes back either slowly (longer than 2 seconds), or (skin stays up even for a brief instant), or immediately

Based on a combination of the above clinical signs, children presenting with diarrhea are classified into the three categories of **severe dehydration, some dehydration** and **no dehydration** and appropriate treatment should be given.

Presence of at least two of the following signs

(a) Lethargic or unconscious

(b) Sunken eyes

(c) Not able to drink or drinking poorly

(d) Skin pinch goes back very slowly

Classifies the child as having **severe dehydration**. Child should be managed in the primary health care facility with fluids as per **plan C** (Table - 1). However if the child has any other severe classification, he should be urgently referred to hospital. Oral doxycycline (5 mg/kg/day) should be administered if cholera is prevalent in the area.

If two of the following signs are present :

(a) Restless/ irritable

(b) Sunken eyes

(c) Drinks eagerly, thirsty

(d) Skin pinch goes back slowly.

The classification is **some dehydration**. The child should be treated as per **plan B** (Table - 2). Such a child is followed up after 5 days if not improving. Mother is however counseled to return immediatelyif child has any of the following signs: not able to drink or breast feed, becomes sicker, develops fever or passes blood in stool.

The child is classified as **no dehydration** if there are not enough signs to classify into some or severe dehydration. Treatment is given at home with fluids and feeds as per **plan A** (Table3). The mother is advised to return after 5 days or immediatelyif above danger signs develop.

Table - 1 : Plan C : Treat severe dehydration quickly

**If you can give IV fluid immediately**

- If the child can drink, give ORS by mouth while drip is set up.
- Give 100 ml/kg Ringers lactate solution or Normal saline as follows

| Age | First give 30 ml/kg in : | Then give 70 ml/kg in: |
|---|---|---|
| Infants( up to 12 months) | 1 hour ( repeat once if radial pulse is still very weak or not detectable) | 5 hours |
| Children (12 months – 5 years) | | 30 minutes( repeat |

- Reassess child every 1-2 hours. If hydration status is not improving, give the IV fluid more rapidly.
- Also give ORS (about 5 ml/kg/hour) as soon as the child can drink, usually after 3-4 hours(infants) or 1-2 hours( children)
- Reassess an infant after 6 hours and a child after 3 hours. Classify dehydration. Then choose the appropriate plan(A,B, or C) to continue

**If you cannot give IV fluids immediately and IV treatment is available nearby (within 30 min)**

- Refer urgently to hospital for IV treatment
- If the child can drink, provide the mother with ORS solution and show her how to give frequent sips during the trip \

**If IV treatment is not available immediately and you are trained to use nasogastric tube for rehydration**

- Start rehydration by tube (or mouth) with ORS solution: 20 ml/kg/hour for 6 hours (total of 120 ml/kg)
- Reassess the child every 1-2 hours
  - If there is repeated vomiting or increasing abdominal distension, give the fluid more slowly
  - If the hydration status is not improving after 3 hours, send the child for IV therapy
- After 6 hours, reassess the child. Classify dehydration. Then choose the appropriate plan (A, B, C) to continue treatment.

**If IV treatment is not available immediately ( within 30 min), you are not trained to use nasogastric tube and the child cannot drink**

Table - 2 : Plan B - Treat some dehydration with ORS

**Give recommended amount of ORS over a 4 hour period**

Determine the amount of ORS to give during next 4 hours as follows:

| Age | Up to 4 months | 4 months to 12 months | 12 months up to 2years | 2 years up top 5 years |
|---|---|---|---|---|
| Weight | < 6kg | 6<10 kg | 10 - <12 kg | 12-19 kg |
| In ml | 200-400 | 400-700 | 700-900 | 900-1400 |

- The approximate amount of ORS required (in ml) can also be calculated by multiplying the child's weight (in kg) times 75
- If a child wants more ORS than shown, give more.
- For infants who are not breast fed, also give 100-200 ml clean water during this period

**Show the mother how to give ORS:**

- Give frequent small sips from a cup
- If the child vomits, wait for 10 minutes. Then continue, but more slowly
- Continue breast feeding whenever the child wants

**After 4 hours**

- Reassess the child and classify for dehydration
- Select the appropriate plan and continue treatment
- Begin feeding the child in the clinic

**If the mother must leave before completing the treatment**

- Show her how to prepare ORS solution at home
- Show her how much ORS to give to finish 4 hour treatment at home
- Give her enough ORS packets to complete rehydration. Also give her two packets as recommended in plan A.

**Explain the 3 rules of home treatment:**

- Give extra fluids
- Continue feeding
- Return if child worsens, does not pass urine or refuses to drink

Table - 3 : Plan A - Treat diarrhea at home

Counsel the mother on the three rules of home treatment: Give extra fluids, continue feeding, return if child worsens

**Give extra fluids ( as much as the child will take)**

**Tell the mother :**

- If exclusively breast fed, breast feed frequently and for longer at each feed. If passing frequent watery stools: For less than 6 months age, give ORS and clean water in addition to breast milk. If 6 months or older, give one or more of the home fluids in addition to breast milk.
- If the child is not exclusively breast fed: give one or more of the following home fluids: ORS solution, yoghurt drink, milk, lemon drink, rice or pulse based drink, vegetable soup, green coconut water or plain clean water.

**It is especially important to give ORS at home when :**

- The child has been treated with plan B or Plan C during the visit
- The child cannot return to a clinic if the diarrhea gets worse

**Teach the mother how to mix and give ORS. Give the mother 2 packets of ORS to use at home.**

**Show the mother how much fluid to give in addition to the usual fluid intake:**

- Up to 2 years: 50 to 100 ml after each loose stool
- 2 years or more: 100 to 200 ml after each loose stool

**Tell the mother to :**

- Give frequent small sips from a cup
- If the child vomits, wait for 10 minutes. Then continue, but more slowly.
- Continue giving extra fluids until the diarrhea stops

**Dysentery**

A child is classified as having dysentery if the mother or caretaker reports blood in the child's stool. This should be treated with oral cotrimoxazole (8mg/kg/day of trimethoprim in 2 divided doses)for 5 days. The child is followed up after 2 days.

**Persistent diarrhea**

All children with diarrhea for 14 days or more are labeled to have persistent diarrhea. They should be classified based on the presence or absence of any dehydration. If dehydration is present, the child is classified as severe persistent diarrhea and urgently referred to hospital. If dehydration is not present, the mother or caretaker should be given feeding advice, and the child is given a single dose of vitamin A and oral zinc sulphate 20 mg daily for 14 days. The child is followed up after 5 days.

Fever

Body temperature should be checked in all sick children brought to an outpatient clinic. Children are considered to have fever if their body temperature is above 37.5°C axillary (38°C rectal). In the absence of a thermometer, children are considered to have fever if they feel hot or there is a history of fever.

A child presenting with fever should be assessed for common serious causes like malaria, meningitis and measles. The following information is important:

(a) Risk of malaria based on the geographic area endemic for it

(b) Presence of bulging fontanel or stiff neck suggesting very severe febrile illness such as meningitis

(c) Presence of runny nose, conjunctival congestion or rash suggestive of measles

A child with fever is classified as having **very severe febrile disease** if there is any general danger sign or stiff neck or bulging fontanel. He requires urgent referral to hospital. Prior to referral to a higher centre the child should be treated with first dose of IM quinine (10 mg/kg/dose) after making a blood smear; first dose of IV or IM chloramphenicol (40 mg/kg/dose or if not possible oral amoxicillin 15 mg/kg/dose), feeding to prevent hypoglycemia and one dose of paracetamol (15 mg/kg) for high fever (temp. 38.5°C or above).

**High malaria risk area**

Children with fever but without any danger sign or stiff neck or bulging fontanella are classified as Malariaand should be treated with antimalarials after making a blood smear. The antimalarials given are as follows:

(a) Presumptive treatment

(i) Oral chloroquine 10 mg/kg single dose on Day 1, 10 mg/kg single dose on Day 2 and 5 mg/kg single dose on Day 3.

(ii) In areas of high chloroquine resistance, give oral sulphadoxine (25 mg/kg) plus pyrimethamine (1.25 mg/kg) single dose.

(b) Radical treatment if P.vivax is positive on blood smear:

(i) Oral primaquin 0.25 mg/kg daily for 5 days.

**Low malaria risk area**

Children with fever but without any danger sign / stiff neck / bulging fontanella are classified as Malaria there are no symptoms of runny nose, measles or any other cause of fever. The antimalarials given after making a blood smear are as follows:

(a) Presumptive treatment:

(i) Oral chloroquine 10 mg/kg single dose on Day 1

(ii) In areas of high chloroquine resistance, give oral sulphadoxine ( 25 mg/kg) plus pyrimethamine (1.25 mg/kg)

(b) Radical treatment if P.falciparum positive on blood smear:

(i) Oral chloroquine 10 mg/kg single dose

(ii) Oral primaquin 0.75 mg/kg single dose

(c) Radical treatment if P.vivax is positive on blood smear

(i) Oral chloroquin 10 mg/kg single dose

(ii) Oral primaquin 0.25 mg/kg daily for 5 days

In a child being treated for malaria, the mother should be advised to return immediatelyif the child becomes sicker or is unable to drink or breast feed. The child should be followed up after 2 days if fever persists or recurs within 14 days. If fever is persists every day for 7 days the child should be referred for assessment.

Measles

A child with fever is assessed for signs of measles such as generalized rash with cough, runny nose and red eyes. If the child has measles or has had measles within the last 3 months, and there is any general danger sign or clouding of cornea or deep / extensive mouth ulcers, the classification is **severe complicated measles**. This child should be urgently referred to hospital after giving first dose of oral vitamin A, IM chloramphenicol and tetracycline eye ointment application.

If the child has measles now or has had measles within the last 3 months, and there is pus draining from eye or mouth ulcers are present, he is classified to have **Measles with eye or mouth complications**, and given first dose of vitamin A, tetracycline eye ointment and gentian violet for mouth ulcers. Follow up is done after 2 days.

If the child has **measles** now or has had measles within the last 3 months, with none of the above signs, only first dose of vitamin A is given.

Ear problem

Any sick child should be assessed for ear problems such as ear pain or ear discharge. If there is a tender swelling behind the ear, the child has **Mastoiditis**. He should be given first dose of IM chloramphenicol and urgently referred to hospital. If there is pus discharge or ear pain, the classification is **acute ear infection** and oral antibiotic

(cotrimoxazole) should be given for 5 days.

Malnutrition

Every sick child should be weighed and assessed for visible severe wasting and oedema of both feet. If there is visible severe wasting or oedema, the child is said to have **severe malnutrition** and given a single dose of vitamin A, kept warm and urgently referred to hospital. If the child has **very low weight** (malnutrition grade II, III or IV), the mother is counseled for feeding. The child is followed up in 5 days if there is a feeding problem or otherwise after 30 days.

Anemia

Palmar pallor is looked for in every sick child presenting to primary health care. If there is severe palmar pallor, the child has **severe anemia** and should be urgently referred to hospital. If some palmar pallor is present, the child has **anemia** and should be given iron and folic acid therapy in a single dose daily for 14 days (elemental iron 3-6 mg/kg/day and folic acid 100-200 mcg/day). All other sick children older than 6 months should be given prophylactic iron and folic acid (20 mg elemental iron + 100 mcg folic acid) for a total of 100 days in a year after the child has recovered from the acute illness.

Immunization

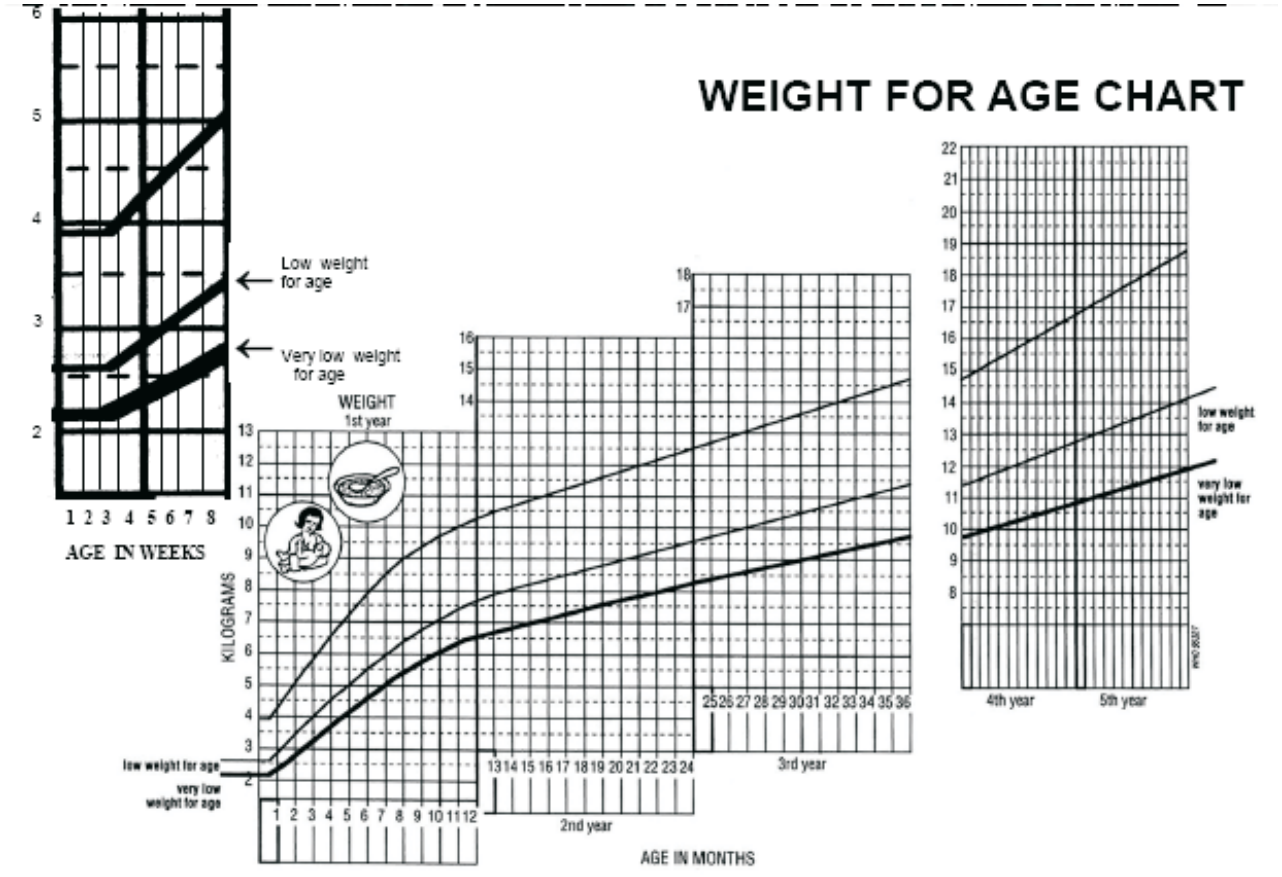
Immunization status of every sick child should be checked. Those being referred to hospital should not be immunized. All other children should be immunized as per schedule on the same day.

Assess other problems

Although the IMNCI guidelines focus on the main symptoms as enumerated above, every sick child should be assessed for other complaints, which can lead to severe or acute illness. In addition, the health of the caretaker should be also be addressed.

Case recording form for management of the sick child age 2 months up to 5 years is given on subsequent pages.

Fig. - 1: Reference weight for age chart from birth to 5 years age



# CASE RECORDING FORM FOR MANAGEMENT OF THE SICK CHILD AGE 2 MONTHS UP TO 5 YEARS

Name: _____ Age: ___ Weight: _____ kg Temperature: _____ °C **Date:**

**ASK:** What are the child's problems?_____ _____ Initial visit? ___ Follow-up Visit? ___
**ASSESS** (Circle all signs present) **CLASSIFY**

**CHECK FOR GENERAL DANGER SIGNS**
NOT ABLE TO DRINK OR BREASTFEED LETHARGIC OR UNCONSCIOUS
VOMITS EVERYTHING
CONVULSIONS

General danger sign present?
Yes___ No___
**Remember to use danger sign when selecting classifications**

**DOES THE CHILD HAVE COUGH OR DIFFICULT BREATHING?** Yes___ No___

- For how long? ___ Days
- Count the breaths in one minute
  _____ breaths per minute. Fast breathing?
- Look for chest indrawing.
- Look and listen for stridor._____

**DOES THE CHILD HAVE DIARRHEA?** Yes___ No___

- For how long? _____ Days
- Is there blood in the stool?
- Look at the child's general condition. Is the child:
  Lethargic or unconscious?
  Restless and irritable
- Look for sunken eyes.
- Offer the child fluid. Is the child:
  Not able to drink or drinking poorly?
  Drinking eagerly, thirsty?
- Pinch the skin of the abdomen. Does it go back:
  Very slowly (longer than 2 seconds)?
  Slowly?

**DOES THE CHILD HAVE FEVER?** (by history/feels hot/ temperature 37.5oC or above) Yes___ No___

Decide Malaria Risk: High Low

- Fever for how long? _ Days
- If more than 7 days, has fever been present every day?
- Has the child had measles within the last 3 months?
- Look or feel for stiff neck.
- Look and feel for bulging fontanelle.
- Look for runny nose

Look for signs of MEASLES:

- Generalized rash
- One of these: cough, runny nose, or red eyes

**If the child has measles now or within the last 3 months:** .

- Look for mouth ulcers
  If Yes, are they deep and extensive
- Look for pus draining from the eye.
- Look for clouding of the cornea.

**DOES THE CHILD HAVE AN EAR PROBLEM** Yes___ No___

- Is there ear pain?
- Is there ear discharge?

If Yes, for how long? ____ Days

- Look for pus draining from the ear.
- Feel for tender swelling behind the ear.

**THEN CHECK FOR MALNUTRITION**

- Look for visible severe wasting.
- Look for oedema of both feet.
- Determine weight for age.

Very Low _____ Not Very Low _____

**THEN CHECK FOR ANEMIA**

- Look for palmar pallor.

Severe palmar pallor? Some palmar pallor? No pallor?

**CHECK THE CHILD'S IMMUNIZATION, PROPHYLACTIC VITAMIN A & IRON-FOLIC ACID STATUS** Return for next immunization or vitamin A or IFA supplement on:

Circle immunizations and Vitamin A or IFA supplements needed today.

BCG DPT 1 DPT 2 DPT 3 DPT( Booster)DT

OPV 0 OPV 1 OPV 2 OPV 3 OPV IFA

HEP-B 1 HEP-B 2 HEP-B 3 MEASLES VITAMIN A

_____
(Date)

ASSESS CHILD'S FEEDING if child has VERY LOW WEIGHT or ANEMIA or is less than 2 years old

- Do you breastfeed your child? Yes___ No ___
  If Yes, how many times in 24 hours? ___ times. Do you breastfeed during the night? Yes__ No___
- Does the child take any other food or fluids? Yes___ No ___
  If Yes, what foods or fluids? _____
  How many times per day? ___ times. What do you use to feed the child and how? _____
  How large are the servings? _____
  Does the child receive his own serving? _____ Who feeds the child and how? _____
- During this illness, has the child's feeding changed? Yes___ No ___
  If Yes, how?

**ASSESS OTHER PROBLEMS:**

## TREATMENT

**Remember to refer any child who has a general danger sign and no other severe classification.**

Return for follow up in: _____
Advise mother when to return immediately.
Give any immunizations, vitamin A or IFA supplements needed today: _
Counsel the mother about her own health.
Feeding advice: _____

Col RajVir Bhalwar

# Planned Parenthood and Contraceptive Advise

As per the National population policy - 2000 and the RCH program in our country, the couples should be given a choice out of various contraceptive methods. Promotion of contraception purely on a voluntary basis, without any coercion, and with provision of due information about the various contraceptive alternatives is the central ethos of our national family welfare programme. The strategies and operational details of the programme and the various contraception facilities to the community are dealt with in the chapter on RCH program. The details of various methods of contraception are being dealt with in this chapter.

Broadly, methods of contraception would fall into the groups, viz. , "Natural Methods" and "Artificial Methods". Artificial methods are further grouped into Temporary and Permanent methods.

## Natural Methods of Contraception

These methods utilize either total avoidance of sexual intercourse (Abstinence) or by discharging the semen outside female genitalia (Coitus interruptus or withdrawal method) or else by utilizing methods which observe the naturally occurring signs / symptoms of fertile versus non-fertile periods of the menstrual cycle and avoiding sexual intercourse during the fertile period. These methods work on the principle that during one menstrual cycle, one ovum is discharged; very rarely, a second ovum can be discharged after 24 hours. Secondly, after intercourse, sperms stay alive upto 5 days (rarely 7 days) but can actually fertilize the ovum for at most 4 days. With this background the most fertile period of women is from 10th day to the 18th day, provided the cycle is of 28 days. Natural methods are based on detecting the fertile period and avoiding intercourse during the period. These are :

### (a) Rhythm Method

For women who have a regular 28 days cycle, the fertile period would be generally from day 7 to day 21.

### (b) Basal Body Temperature (BBT)

The woman should record her oral temperature first thing on getting up in the morning, daily and plot it on a graph paper with the day of menstrual cycle along horizontal axis and temperature along vertical axis. Immediately following ovulation there is increase in oral temperature by 0. 5 to 0. 8°F (0. 2 to 0. 4°C). Couples should avoid intercourse for 3 days, once the rise in temperature is noted.

### (c) Cervical mucus method

The woman notices daily, the quality of vaginal mucus discharge, by putting a finger into the vagina. Following cessation of menstrual flow, no mucus is felt in the vagina for couple of days. These are called the "dry days". Following the dry days, cloudy, white or cream colored mucus of sticky consistency with little moisture appears. This indicates that ovulation is approaching. Thereafter, just before and at time of ovulation the mucus becomes copious, clear and slippery, resembling the white of an egg and can be stretched into a thread if the thumb and finger on which the mucus is stuck, are gently moved apart. This persists for 3 days and is called the "wet days". Following this wet period, the mucus again becomes scanty, sticky and cloudy indicating the post ovulation phase, which persists till onset of next menstrual flow. The couple should abstain as soon as the first sign of mucus appears in the preovulatry phase, during the wet days in ovulatory phase and for 3 days after the completion of wet period.

### (d) Symptothermal method

This is based on combined observation of changes in BBT, mucus changes and also by palpating the cervix with a finger high up in the vagina. The cervix becomes softer and cervical os more open during the fertile period. If consistently and properly used, the failure rates per 100 women per year (HWY) (indicating the number of women who will become pregnant during one year out of 100 women who are using these method are :

(i) Calendar Method - 9 / 100 HWY (9%)
(ii) BBT Method - 1 - 2 / 100 HWY (1-2%)
(iii) Cervical mucus Method - 3 / 100 HWY (3%)
(iv) Sympto thermal Method - 2 / 100 HWY (2%)

### (e) Lactational Amenorrhoea Method (LAM)

Full or nearly full breast feeding means that at least 85% of the baby's food requirement is being provided by breast milk. For women who are fully breast feeding their infants, chances of pregnancy are very less for 6 months or when menstrual flow returns, whichever is earlier. If used correctly and consistently, the failure rate is 1 to 1. 5%. Chances of pregnancy are, however, more if the woman is not having full lactation or if not fully breast feeding the infant.

## Artificial Methods

The broad categories of contraceptives included in artificial (temporary) methods are Barrier methods, Spermicides, Intrauterine devices (IUDs), Oral contraceptives and Non-oral hormonal contraceptives.

### Barrier contraceptives

Condoms

Condoms are made of latex and are available as non-lubricated (Nirodh, Kohinoor), lubricated (Nirodh - Lubricated, Kamasutra, Kohinoor - Pink and Sawan) and more lately, coated with spermicidal jelly usually nonoxynol-9 (Share, Rakshak). The average shelf life is 5 years from date of manufacture and they should be stored in cool and dry place. If further lubrication is required then glycerin, K-Y jelly or a spermicidal jelly can be applied, but not Vaseline, oils or butter. Some couples may complain of initial reduction in pleasure due to slight decrease in sensations and interruption in sexual play (since the man has to put on the condom just before insertion). However,

it should be explained to them that this is only a transient phenomena, and most couples will adapt well with passage of time. Besides contraceptive effect, condoms are also very effective in preventing transmission of HIV, STDs, HPV infection (and amnionitic fluid infections while having sex during pregnancy).

The total "slippage" and "breakage" rate is 4% to 9%. The average failure rate is 12% to 14%, but if correctly used, it may be as low as 3%. Concurrent use of spermicidal jelly will further reduce the failure rate.

Condoms are very good choice as temporary method, especially for couples in whom use of hormonal contraceptives and IUDs is not indicated among the female partner. The only contra-indication to condom use is allergy to latex rubber in which case condom made of polyurethane or silicon rubber may be used.

Diaphragm, Cervical Cap (Check Pessary), Vault cap and Vimule

These are barrier methods to be used by the females but not much used now due to wide availability of other contraceptives.

Female Condoms

Available under trade name of "Femindon" and "Reality". The device is inserted like a vaginal diaphragm. At present it is not much used as contraceptive but has potential in prevention of HIV transmission.

Spermicides

Most commonly used spermicide is nonoxynol- 9. They are available as vaginal pessaries which are inserted high up in the vagina, 10 to 15mts before sex or as creams / jelly, as Delfen cream, Orthogynol jelly etc.

Foam Tablets

These are very commonly used. Marketed in our country as "Today" as a vaginal foam suppository containing nonoxynol-9. The tablet is to be inserted high in the vagina (may be moistened slightly with water if vagina is dry), 10 minutes before sex act and the action lasts for 1 hour after sex. If properly used, failure rates are as low as only 0. 5%.

**Intra Uterine Devices (IUDs)**

IUDs have been in use as contraceptives for many decades. However, their exact mode of action is still not clear. In all probabilities, they act by inducing mild inflammatory changes and foreign body reaction in the endometrium, which combined with alterations in prostaglandin levels, incapacitate the sperms and ovum, prevent sperm from fertilizing the ovum, and even if fertilization occurs, makes the uterine environment inhospitable for the blastocyst to be implanted.

The earliest IUDs, namely lippies loop, have now been almost phased out by copper-T and its subsequent variants.

Copper - T

Copper - T 200 (Gynae-T) is made of propylene impregnated with $BaSO_4$ and carries 120mg of 0. 25mm diameter copper wire wound around the vertical limb. The tail limb has a pair of threads (some variants have only one thread) which comes out of cervical os, into vaginal canal after the Copper-T has been inserted and can be felt with a finger to check that the Copper-T is in place. The copper has an exposed area of 200 sq. mm and hence the name Cu-T- 200. The US-FDA approved Cu-T-200 has an effective life of 4 years. Some additional variants available commercially in our country are Multiload ML Cu-T-250, ML Cu-T-375 and Nova Cu-T-200 (Nova T) which has a silver core added to the copper wire. The conventional Cu-T-200 has failure rate of 2%, while the newer variants have lower failure rate of 1-2%. In general Cu-T-200 is referred to a Group-I IUD; ML-250 and 375 as Group-II; while Nova-T and Cu-T-386A are referred to as Group-III IUDs.

The advantages of IUDs is the ease of insertion (can be inserted at Sub centre level by paramedical workers), the semi-permanency (Cu-T-200 can be left in place and remains effective for 3 years) and the ease of removal. However, before advising IUD, proper history should be taken from the couple and correct advice given as follows :

**Conditions which are absolute contra - indications to IUD insertion / continuation**

(a) Pregnancy
(b) Puerperal or Post abortal sepsis.
(c) Unexplained vaginal bleeding.
(d) Pelvic inflammatory disease within last 3 months.
(e) Known pelvic TB
(f) STD during the past 3 months.
(g) Suspected neoplasia of genital tract
(f) Uterine abnormalities

**Conditions which increase the risk due to IUD, and alternative contraceptive may be considered, if possible**

(a) Post partum 48 hours to 4 weeks (more chances of perforation).
(b) Women having increased chances of STD / HIV transmission (prefer condom).
(c) Age <20 years.
(d) Nulliparity
(e) Endometriosis
(e) Menstrual irregularities with increased bleeding or dysmenorrhoea.

Women who are best suited for IUD include those aged >20 years, who have given birth to atleast one child, have diseases or conditions like Obesity, Tobacco use, Headache, IHD, RHD, Diabetes, Thyroid disease, Benign breast disease and Irregular menstruation but without heavy bleeding and those who are breast feeding.

Timing of Insertion

(a) The best time to insert is during or soon after menstrual periods, post partum within 48 hours of delivery and after abortion.
(b) However, after delivery or abortion it is preferable

to insert IUD 6 weeks after the delivery / abortion and couple may be advised to use another method as condom for that period.

(c) It may be noted that as for as possible insertion should not be delayed just because of timing. In fact, the best timing is the one which is most convenient to the potential user, if it can be reasonably ascertained that she is not pregnant.

(d) It can also be inserted post coitus, even up to 5 days after coitus to prevent pregnancy.

Instructions to be given to the lady after insertion

(a) For the next few periods (at least for next 3 periods) she should watch her pads for any expelled IUD and, after the periods, should feel for the threads (tails) coming out of the cervical os, to ensure that the device is in place. She should report if she cannot feel the threads or sees the device on her pads, or feels the device to be in the vagina.

(b) She should come for a routine health check up after the next menstrual period.

(c) She should report in case of persistent irregular or heavy bleeding, severe pain in lower abdomen or abnormal vaginal discharge, or amenorrhoea (in which case pregnancy should be excluded).

(d) She should also report if she feels that she has been exposed to STD or HIV.

Indications for removal

(a) Abnormal or excessive bleeding.

(b) Persistent pelvic pain or cramping.

(c) Expiry of effective life span (3 to 4 years from date of manufacture for Cu-T-200)

(c) Pregnancy.

(d) Acute pelvic infection or neoplasm of genital tract.

(e) Displacement of IUD either inside the uterus or outside it.

(f) Personal reasons.

(g) After menopause (within one year).

Routine problems after insertion

The lady should be advised that she may face certain routine problems following insertion as follows, and she should not unduly worry about them :

(a) Some cramping abdominal pain for a few days

(b) Some vaginal discharge for a few weeks

(c) Heavier menstrual bleeding and possibly intra-menstrual bleeding for a few weeks

Complications of IUD

(a) Increased menstrual bleeding and sometimes inter- menstrual spotting.

(b) Cramping lower abdominal pain.

(c) Explusion: The overall expulsion rate is 2 - 8% in first year. It is commonest in first 3 months especially after the 1st period following insertion.

(d) Leucorrhoeic vaginal discharge

(e) Perforation of uterus (occurs in approximately 1 per 1000 insertion).

(f) Infection, especially during first month.

(g) Pregnancy due to failure (1 to 2%).

(h) Ectopic pregnancy (Rare, approximately 1 per 1000 women years. However, if pregnancy occurs with IUD in situ, then chances of its beings ectopic are very high, almost 30%).

**Oral contraceptives**

Hormonal Contraceptives have revolutionized the implementation of Planned Parenthood Programmes all over the world. Broadly, hormonal contraceptives could be either oral or parenterally administered. Oral contraceptives (OCs) can be further divided into two broad groups, viz, "Combined pills" (Containing both Estrogen & Progestogen) and "Progestogen only pills" (mini pills).

(a) **Combined pills** : These can be of two types, viz, Monophasic pill in which every pill has same amount of Oestrogen as well as Progestogen, and the multiphasic pill in which, in a given pack for one menstrual cycle, the pills will have variable amount of Oestrogen & Progestogen. An example is "Triquila" available in our country. Monophasic pills can be, in turn, low dose pills which contain less than 0. 05mg of ethinyl estradiol (EE) in each pill along with progestogen. The other variety, i. e. , high dose pills containing > 0.05mg EE per pill have been discontinued by now. Similarly, the earlier used sequential pills, which used only oestrogen in the tablets for first 14 days followed by combined Oestrogen & Progestogen for next 7 days have also been abandoned by now.

(b) **Progestogen only (Mini pill)** : These contain small amount of only a progestogen but no oestrogen. They are indicated for women >40 years age or who are lactating and not completed 6 months from delivery. They are available under trade names of Microval or Femulen; they are generally not available in our country.

(c) **Choice of pill** : Any of the low dose combined pill or else a triphasic pill (Triquilar) can be used. The choice will mainly depend on cost, since the triphasic pills are costly.

(d) **Commonly available pills** : In our country, the following pills are commonly available :

Common low dose pills

(a) Ovral-L or Mala-D - This contains L-norgesterol (L-NGL) 0. 15mg and EE 0. 03mg per pill. Mala-D is available at subsidized rates in our country under the FW program.

(b) Mala-N - This contains dl-NGL 0. 30mg and EE 0. 03mg per pill. This is available free of cost under the FW program in our country.

Triphasic pills

Triquilar contains L-NGL 0. 05mg and EE 0. 03mg for first

6 days, 0. 075mg and 0. 04mg for next 5 days and 0. 125mg L-NGL with 0. 03mg EE for the next 10 days.

Mode of Administration

(a) The day on which menstrual flow starts is taken as day-1. The first pill is taken on Day-6, one pill every day for next 21 days. Thereafter the pill is stopped and restarted after a gap of 7 days, irrespective of the onset or stoppage of menstruation during these pill free periods.

(b) **Very often the packet has 28 pills** - in such case the last 7 tablets are actually iron tablets. In this scenerio the next packet should be started on the very next day after the previous packet is finished, without any gap.

(c) **Action to be taken when a pill is missed** - If a pill is missed on a day, two pills should be taken on the next day, as soon as the woman remembers (preferably within 12 hours of last missed dose) and the other at bedtime; or else, if not remembered earlier, 2 tablets at bedtime on the next day. If 2 or 3 tablets are missed, the women should take 2 tablets on each of the consecutive 2 or 3 nights and continue with rest of the packet as usual. In all such cases, when the pills have been missed the next packet should be started as usual after a gap of 7 days from the time last 21 days packet is finished. In such cases where this prompt initiation immediately after 7 days is delayed by 1 or 2 days, the women should use additional barrier method till the time of starting the next normal course of 1 pill a day (from the 7th or 8th day). These rules apply to all OC users, whether using combined or triphasic pills.

(d) **Mechanism of Action** - Combined OCs produce contraceptive effect in different ways, viz. , inhibition of ovulation by bringing about changes in FSH & LH secretion, by altering the endometrium and by bringing about changes in cervical mucus.

(e) **Effectiveness** - Combined OC are very effective, with an overall failure rate of 0. 1% (1 per 1000 women year). Failures are maximum during first year of use and are mainly due to missed pills, delay in starting the next course exactly after 7 days of finishing the last 21 days pack, and due to stopping the pill abruptly due to side effects without taking any other appropriate contraceptive measure.

(f) **Side Effects** - These are of two categories, viz, minor side effects which are often temporary and the subject should therefore be properly counseled so that she does not unnecessarily discontinue the pills. The second category is the major side effects.

(i) Minor side effects include nausea vomiting and lack of appetite for the initial 2 or 3 months; breakthrough bleeding usually during first few months; menorrhagia, irregular bleeding or oligomenorrhoea; breast heaviness and tenderness; headache; weight gain; acne and oily skin; and rarely, depression and decline in libido.

(ii) Major side effects includes increased risk of IHD, and stroke especially if the woman is also a smoker or hypertensive or diabetic or has venous thromboembolism, raised blood pressure especially if age is >35 years; slightly increased risk of breast cancer and possibly cervical cancer; interference with insulin action in diabetics; execerabtion of existing hepatic conditions and reduction in lactation.

When to avoid OCs

(a) Smokers, especially if age >35 years.
(b) Breast feeding up to 6 months post partum.
(c) Hypertensive.
(d) Past H/o breast cancer.
(e) Unexplained vaginal bleeding.
(f) H/o stroke, thromboembolism or IHD
(g) Cirrhosis of liver or active hepatitis or liver tumors
(h) Using Rifampicin or anti-epileptics.
(j) Undergoing major surgery or prolonged immobilization.
(k) Diabetes with >20 years duration or with vascular complications.
(l) Hyperlipidaemia.

Warning Features

Women should be educated to watch out for following features and seek medical attention should they occur :

(a) Chest pain
(b) Shortness of breath
(c) Headaches which are severe or throbbing or occur on one side.
(d) Blurred or diminished vision.
(e) Swelling or severe pain in a leg
(f) Missed periods, especially if 2 periods are missed.
(g) Post coital or persistent irregular vaginal bleeding after 3 months of pill usage or excessive, white discharge especially if mixed with blood.
(h) Yellowness of eyes or urine.

Advantages of OC use

(a) Very effective, require minimal effort.
(b) Return of fertility on stopping the pills is very prompt.
(c) Can bring about relief in certain menstrual disorders as dysmenorrhoea.
(d) May be protective against endometrial cancer and ovarian cancer.
(e) May be protective against benign diseases of breast and ovaries.
(f) Likely to be protective against ectopic pregnancy,

PID, hirustism, acne, osteoporosis and progression of rheumatoid arthritis.

(g) At times, the increase in weight is quite welcome to women.

### Non-oral hormonal contraceptives

Non-oral Hormonal Contraceptive are of 3 broad categories :

(a) **Injectable** - These include the progesterone only (Depot Medroxy Progesterone Acetate - DMPA and Norethesterone Enanthanate - NETEN) or the combined ones (DMPA 25mg Plus oestradiol 5mg or NETEN plus oestradiol 5mg)

(b) **Contraceptive Implants** - These include Norplant (6 capsules of levo-norgesterol) and Implanon (single rod of 3-keto desogesterol).

(c) **Contraceptive Impregnated Devices** - as progesterone releasing IUD (progestinsert, LNG-20, Levonova); or contraceptive vaginal rings.

Of the above, DMPA (Depot provera) and NET-EN are often used and available in India. DMPA is given 150mg i. m. inj and remains effective for 3 months; NETEN is given 200mg as an oil based i. m. inj and remains effective for 2 months. These are most effective when given within first 1-5 days of menstrual cycle. The failure rate is only 0. 1 to 0. 4%.

Absolute contra-indications for their use are pregnancy, unexplained vaginal bleeding and current breast cancer. Relative contraindications include less than 6 weeks postpartum among breast feeding women, history of breast cancer, jaundice, cirrhosis, liver tumor, severe headache, undiagnosed breast disease, previous OC related liver diseases, and H/o IHD, hypertension or stroke. Fertility may take 6 to 12 months to return after discontinuation of this injection.

### Emergency (post-coital;morning-after) contraception

Emergency contraception pills (ECPs) are a very good method of preventing pregnancy likely to occur due to unprotected sex or else due to suspected failure, as rupture of a condom. The following are the salient features of ECPs :

(a) ECPs are hormonal oral contraceptives having the same hormones as used in OCs but in a higher concentration.

(b) ECPs come in a pack of two pills. The first should be taken as soon as possible, but certainly within 72 hours of an unprotected sex. The second should be taken 12 hours after the first pill.

(c) One ECP packet can protect only against one episode of unprotected sex.

(d) ECPs are available free of cost at PHCs and with ANMs at subcentres, under the name of "E-Pill". They are also commercially available under brand names like Ecee-2, Norlevo, E-P-72 and Pill72.

(e) ECPs are safe for all women including those who are breastfeeding.

(f) If the lady vomits within 1 hours of taking the pill, the dose should be repeated after taking an antiemetic as Meclizine HCL (Pregnidoxin)

(g) Some women may have minor side effects as breast tenderness, headache, nausea, vomiting, spotting, fatigue, and dizziness which may last for maximum of 24 hours.

(h) It should be clearly conveyed to the clientele that ECP is not an abortion pill since it cannot dislodge an implanted ovum.

(j) ECP is quite effective in that they may prevent up to 75% pregnancy which would have otherwise occurred following unprotected sex.

(k) After taking ECP, if onset of next menstrual cycle is delayed by more than 1 week of expected date, a pregnancy test should be done. She should also report if the period starts on time but the flow is scanty or is unusually foul smelling.

(l) ECP should not be used as a regular contraceptive method.

(m) In case E-pill or such ECP preparation is not available, the women can take 4 tabs of Mala-D at the earliest but within 72 hours of unprotected sex, followed by 4 Tablets of Mala-D after 12 hours of first dose.

(n) Reassure the women that her next period will start on the expected date or sometime 2-3 days earlier or later than expected date.

## Permanent methods

Permanent methods include male sterilization (Vasectomy) and female sterilization (Tubectomy). Any couple who has at least one child and is voluntarily motivated can be offered sterilization procedure. Medical officers should emphasize on the clientele that these procedures are perfectly safe and do not carry adverse effects like decline in libido, low backache, obesity and so on, as are commonly thought of. In fact the sexual performance and pleasure may improve since the fear of unwanted pregnancy is removed.

### Vasectomy

In the conventional procedure an incision is given on the scrotal skin and a piece of vas deferens 1 to 1. 5 cm long is removed. In the more recent technique of "No Scalpel Vasectomy" a puncture is made in scrotal skin using a reverse scissor and a hole of approx half a cm is created through which vas is ligated after removing a piece 1 cm long. The advantage of this method is that no stitches need to be given on the scrotal skin.

It must be emphasized on the acceptor that it will take 3 months for him to become completely sterile. For the duration, he or his wife should use an alternative temporary method. After 3 months seminal analysis should be done to confirm azoospermia.

### Tubectomy

In the conventional method, (Pomeroy's method) a piece of the loop of Fallopian tubes about 1 cm long on both

sides is removed. The same is done in minilaparotomy. In Laparoscopic tubectomy the tubes are either blocked by electrocoagulation or sealed with a silastic band.

The ideal time for tubectomy is soon after menstrual flow is over or in the post partum period. However, if it can be done in between the period at other times but the woman should continue to use alternative contraceptive till her next menstrual flow.

**Recanalisation**

For couples who have undergone sterilization operation but now need children, recanalisation operations are available. The success of recanalisation depends on many factors, the most important being the fertility state of both the partners. In case of tubal recanalisation it also depends on the original method by which tubectomy was done - if the original method was spring loaded clip, the pregnancy rate following recanalisation may be as high as 88%, while for Pomeroy method it is about 60%. As regards recanalisation of vas, in expert hands, the patency rate may be as high as 80% but actual pregnancy rate may be lower due to various other factors as fertility status of the husband and wife.

**Further suggested readings**

1. Hatcher RA, Rinechant W, Blackburn R, Galler JS. The essentials of contraceptive technology. John Hopkins School of Public Health, Baltimore, USA. Fist edition 1997.
2. Chaudhari SK. Practice of fertility control : A comprehensive text book. BI Chuchil Livingstone, New Delhi, 5th Edition 2001.

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# Preventive Health Care of the Elderly

With improvements in health care, there have been resultant increases in life expectancy and increase in the percentage of "elderly population". For instance, the current estimates are that in our country the percentage of population who are aged 65 years and above, which was 3% a few decades back, is now 5% and is likely to increase to 10% by 2025AD and 18% by 2050AD. These demographic changes will require shifting our focus to cater to the special preventive health care needs as well as medical care needs of the elderly population.

### Peculiarities of elderly population in context of Health needs

The peculiarities of health needs of elderly people is that their health problems cannot be seen in isolation. There is a wide gamut of social, psycho-emotional and physical correlates which determine the medical problems and this entire gamut of factors (and not simply the treatment of concerned condition) needs to be addressed. The important ones of these factors are as follows: -

Social

As industrialization expands, it will be difficult for the children to stay on with their parents and carry on with the conventional family processions. As children move out and take up the vocation in other places, the problems of isolation and lack of physical support will come up. Even day to day requirement of life like going out to pay the electricity / telephone bills, buying fresh fruits and vegetables and even, cooking a proper nutritious meal would become difficult.

Psycho-Emotional

With loneliness at home, isolation will occur which would get aggravated if one of the spouses passes away. Friend circle will also get restricted because friends would also get old. The problem of isolation would get worse because of retirement when the old persons would find it difficult to keep themselves occupied. This, complex interplay will not only increase the risk of mental stress and its consequences but also aggravate the impact of stress related diseases as IHD and hypertension.

Financial

Unless backed up by adequate financial savings or personal plans or else financially assisted by children, there will be definite reduction in income, to the extent that it may interfere with bare needs of life as adequate nutrition, clothing and shelter.

Health care system

At present we do not have a very effective health insurance system in our country, which coupled with the inadequacies of public / Govt funded general health care system and inadequate training of medical, paramedical personnel in geriatric medicine would adversely affect the health care of the elderly.

## Medical problems of the elderly

A description of medical problems of the elderly is given in this chapter. However, as said earlier, these problems should not be seen as isolated medical issues but should be viewed in the larger context of socio-economic-emotive determinants as an overall health issue. For example, organizing an eye camp for the elderly would have little benefit if the transportation system, traffic control and street / domestic lighting is not improved.

Medical officers of Indian Armed Forces should make special efforts to understand both the preventive as well as curative aspects of health care of the elderly since a significant proportion of our clientele (the ex-servicemen and their dependents) would belong to this age group, and the proportion is likely to further increase, given the steady increases in life expectancy that are occurring in our population.

The health problems of elderly can be divided into 3 groups

(a) Problems which are important for both genders.
(b) Problems which mainly concern the elderly males.
(c) Problems which mainly concern the elderly females.

### Problems which are important for both the genders

Ocular Diseases

Age related diminution of vision and cataracts are major issues among elderly and significantly compromise the quality of life as well as activities of daily living (ADL). Glaucoma also is an important cause of suffering among elderly.

Hearing Defects

Reduction in acuity of hearing not only compromises the quality of life but even drives an old person into emotional isolation because they find it difficult to communicate.

Reduced Muscular strength and coordination

Reduction in muscular strength due to reduction in lean mass coupled with reduced flexibility and neuromuscular coordination occur with age and result in increased proneness to accidents and injuries.

Accidents and Injuries

There is marked increases in risk of accidents and injuries among the aged. The major physio-pathological factors which contribute to such increased proneness are diminution of vision and hearing, reduced muscular strength and neuro-muscular coordination, and various environmental factors, notably wet, slippery floors and poor lighting. The commonest areas of accidents are the toilet (due to wet floor, and a large number of fixtures in small space), kitchen (mainly due to open flames), staircases and roads.

Nutritional Deficiencies

Both macro and micronutrient deficiencies are common among elderly. They result due to interplay of four major reasons, viz., lack of financial resources to buy nutritious food items; reduced ability to go out to the market and buy nutritious raw items; reduced physical abilities with resultant reduced ability to cook nutritious meals; and physical ailments especially oro-dental problems causing difficulty in mastication and reduced sense of tastes.

Dental Problems

Reduction in number of teeth / edentulousness interferes with mastication, digestive process and also with the desire to eat. Ill-fitting dentures further aggravate the problem.

Cardiovascular Disease

The end result of atherosclerotic process becomes most evident in the elderly age group. The incidence (as well as mortality due to) of IHD, Stroke and Hypertension is significantly increased in this age group.

Increased susceptibility to adverse effects of physical environment

People aged >65 years are more susceptible to adverse effects of heat (heat stroke and heat exhaustion) as well as environmental cold (generalized hypothermia and local adverse effects of cold).

Increased susceptibility to infections

Age >65 years increases the susceptibility to nearly all infections due to decline in immunologic defenses. More particularly, lower respiratory tract infections (pneumonia) and urinary tract infections are an important cause of morbidity and mortality among elderly.

Degenerative neurological Diseases

Alzheimer's disease and Parkinsonism are almost exclusively encountered among elderly. Besides morbidity, these diseases substantially reduce the quality of life.

Complication of Diabetes

The micro vascular as well as macro vascular complications are more prominent during advanced age.

Cancers

Oral, gastric, lung and colorectal cancers are more common in elderly age group.

**Problems which mainly affect the elderly male**

Benign Prostate hypertrophy (BPH)

This is one of the commonest diseases affecting males >50 years, particularly >60 years age.

Prostate Cancer

The incidence shows a steep climb after 50 years age. Yearly Digital Rectal Examination (DDE) is a good screening tool for both BPH and prostate cancer. In addition, prostate specific antigen (PSA) could be useful screening test for prostate cancer after 50 years of age. Levels of <4ng/ml can be considered as normal, 4 to 10 ng/ml as suspicious and >10 ng/ml as strongly suspicious and need to be followed up with a biopsy.

Male Sexual Dysfunction

Male sexual dysfunction among elderly may manifest as either libido, erectile or ejaculation problems.

**Problems which mainly concern with elderly females**

Menopausal Problems

There are five areas when are predominantly affected by menopause - increased risk of cardiovascular diseases; genitourinary atrophy; skeletal bone loss; skin and hair changes; and neuroendocrine and vasomotor changes. Skin changes include loss of elasticity (apparent as lagging and wrinkled skin), dryness of mucosal surface, minor facial hirsutism and voice changes. Uro-genital changes include atrophic vaginitis, dysparounia, pruritis vulvae and irritable bladder. Neuroendocrine changes include hot flushes (which may sometimes interfere with quality of life) and psychological / mood problems.

Urinary incontinence

The impact is considerable both from medical as well as psychological point of view.

Cancers of female genital tract

The 3 major cancers of genital tract affecting the elderly women are uterine (endometrial), ovarian and cervical cancers.

Osteoporosis

Osteoporosis occurs in both sexes (Type-II Osteoporosis) but the incidence as well as the impact is much higher among females especially after menopause (Type – I osteoporosis). Osteoporosis represents only a small proportion of the problem, in any community, for every case of osteoporosis there would be additional 3-4 cases of osteopenia. Osteoporosis results in a large number of low-trauma fractures. The major fracture sites are hip, spine, wrist and pelvis. Risk factors for primary osteoporosis include low body weight, history of prior fracture, family history of maternal hip fracture, lack of dietary calcium and vitamin D, menopause, lack of weight bearing exercise, smoking and excessive alcohol use, tall and thin stature and white-race. Weight of <58 kg may indicate risk. In fact, a rough guide is to calculate an index as 0.2 X (Body weight in Kg – Age in years); if the result is less than 2, the same indicate increased risk.

## Prevention & control

Prevention and control of health problems of elders would need multifaceted approach. A well coordinated approach from health, social welfare, rural / urban development and legal sectors is desirable

**Social Measures**

Developing social ethos wherein children voluntarily take the responsibility of looking after their aged parents is important. In fact, young people need to be educated and motivated to utilize the experience and support of their parents / grandparents in day to day household matters before passing on the cultural heritage to the children. There is also a need to develop regulatory mechanisms which make it obligatory for the members of society to look after their aged parents.

Developing a Health Insurance Scheme

A large majority of the elderly are those who are not covered by any formal public sector health care support, unlike retired govt. servant. The need is to develop an affordable health insurance scheme in which people contribute, along with the employer and the government, to cater to subsequent expenses on medical care during old age.

Pensionary Benefits

Similar to the health insurance scheme suggested above, there is need to develop pension schemes based on contribution from employee, employer and government, so that old people can feed for themselves during old age, even if not supported by their children.

Proper construction of Roads, Walkways, Stair cases and houses

Accidents and injuries are an important cause of morbidity and mortality among the elderly. Proper designing of roads / walkways, and stair cases, along with adequate enforcement of traffic rules is a clear need. In addition, construction of "elderly friendly houses", giving particular attention to construction of toilets, kitchens, bedrooms and common galleries is important. In general, the principles of construction and maintenance are that the floor should not be slippery / wet; that the fixtures and furnitures should be adequately separated giving enough space for movement; lighting should be adequate; and open flames should be restricted to the minimum and, preferably, enclosed.

**Health Measures**

This includes the following:-

Need to initiate Primary Preventive measures in early adulthood

While a number of diseases finally manifest in elderly age (as cardiovascular disease, osteoporosis, cancers), the basic pathologic processes start during early adulthood, even during adolescence. Therefore, it would be wise for children / young people to start prevention at young age itself through healthy lifestyle (adequate and regular physical exercise, healthy diet, avoidance of tobacco and alcohol use). The details are discussed in the section on healthy lifestyle.

Information, Education & communication strategies

Health education should focus towards three broad groups – firstly, the elderly persons, secondly, the middle aged who would move into elderly age group in near future and thirdly the younger people who are the potential care provider for their elderly parents / relatives. The major areas of education should address the issue of hygiene, nutrition, physical exercise, avoidance of tobacco and alcohol, accident prevention measures, awareness about recognition of early signs / symptoms of common geriatric problems and motivation to seek treatment, and education regarding periodic health check-up.

Training and re-training of medical and paramedical personnel

Regarding the special health needs of the elderly and updating their knowledge regarding prevention and treatment of common geriatric diseases.

Periodic Health Assessment

Ideally, all people, males & females, should undergo a detailed health assessment once they are 45-50 years of age. Subsequently, a thorough health evaluation should be done once in every 5 years till 65 years age and thereafter every year or at least once in 2 years. Assessment should include general clinical examination, assessment of hearing & vision, assessment of Dental health, nutritional status including obesity, cardiovascular status, musculoskeletal system including spine, per-rectal examination for males and for females, gynecological and breast examination. Depending on availability, important investigation would include Hb%, GBP, urine routine and microscope, stool routine microscopy and test for occult blood, blood sugar estimation, lipid profile, renal function parameters and an ECG if required. Depending on the requirement, bone densitometry, PSA, Colonoscopy, USG studies and histopathological studies may be undertaken as indicated

Ensure effective communication

Elderly people need special efforts for communication. Hence, medical personnel dealing with elderly should very effectively communicate their findings and advise to the group and ensure a system of feedback to verify that their communication has been correctly understood by the elderly subject

Lt Col Rajul K Gupta

# A Short History of Nutrition

***"Yuktahar Viharsya Yukt Chestsya Karmsu ;***

***Yukta Swapnav Bodhayasya Yogo Bhavati Dukh Ha."***

**"Yoga killeth out pain for him who is regulated in eating and amusement, regulated in performing actions, regulated in sleeping and waking"**

**~Shri Bhagavad Gita (1)**

No lesser book than the greatest of Hindu scriptures, Bhagavad Gita, highlights the importance of balanced, stable and regulated nutrition. The relationship between food and health dates as far back as the history of mankind. *Homo sapiens* and his predecessors *Homo erectus* and *Australopithecus* were primarily vegetarians. But over about a million years man gradually developed the art of hunting as he moved away from other primates and became omnivorous. There was no malnutrition, no obesity, no high cholesterol, no high blood pressure and no caries teeth. It was only about 10,000 years ago that the next stage of the 'technical' development of agriculture began. (2) Man started growing, rearing and consuming the 'concentrated' sources of energy - cereals, oilseeds and livestock! And with these, began the present era of nutrition and … disease.

The ancient Indians developed the discipline of life (Yoga), a system of medicine (Ayurveda) and a dietary philosophy of vegetarianism (Aahara), with one thing that was vital, common and central to each - diet. (3) Prudent food with a strict dietary discipline was the hallmark of ancient lifestyle and one of the secrets of a long and healthy life which the Indians enjoyed in the Vedic times.

6000 years ago, Imhotep, the ancient Egyptian father of medicine described the use of certain foodstuffs as prescriptions (4). It is amazing how close to modern scientific thinking these early historic practices were. Night blindness and xerophthalmia (called 'show' by ancient Egyptians) were treated by roasted beef liver or liver juice. Onion mashed with fat was described for the treatment of scurvy. The first report on the physiological effect of sunlight was given by Herodotus who reported that the skulls of Egyptian soldiers killed in wars, were stronger than their opponent, the Persian King Cambysus' soldiers, which were fragile. The reason given was that they go bareheaded since childhood exposing their skull to sunlight while the Persians have turbans on their heads (5). Ancient Egyptians advocated breastfeeding for 3 years to benefit from its virtues. If the mother was unable to nurse, wet nursing was advised (4).

A balanced diet for the wealthy was described in King Una's message (2600 BC), "eat good bread, ox flesh, wine, olive oil, fat, honey, figs, fish and vegetables everyday". Obesity was objectionable. Undernutrition and famine were described. A text in the 18th year of King Zoser's dynasty 5000 years ago recalls the holy book's story of Joseph; "I am overwhelmed with sorrow ... the Nile has not been full any time for seven years. Grain is lacking …there is a dearth of edible things ... children cry, young people waste, their legs give way to squatting on the ground." As a safeguard ancient Egyptians stocked grain in silos.

Later, Greek and Roman scholars started to write on the relationship between food and health. Scribonius Largus in the year 47 BC, insisted on the importance of diet for maintaining good health. Celsus classified foodstuffs and emphasized their role in maintaining health in his Latin treatise on medicine in the year 25 BC (3).

### Early pioneers of nutritional science

It is difficult to define the date when nutrition was recognized as a science and who exactly founded it. The term 'science of nutrition' was first used probably by Count Rumond in an essay on feeding poor people in 1795 (6). During the same period Lavoisier is also said to have founded nutrition as a science (2). Francois Magendi presented to the French Academy of Science his essay on "The nutritive properties of substances that do not contain nitrogen" in the year 1816, one of the first scientific works on nutrition (6).

The list of pioneers in the science of nutrition during the late nineteenth and early twentieth century is endless. The studies of Justus Von Liebig (Germany) in 1846 were basic for understanding the evolution of biochemistry and nutrition. Claude Bernard (France) in 1856 discovered glycogen and classified the digestive action of pancreatic juices. Marasmus was described in the year 1877 by Jules Poirot from France under the term "athrepesie". Sir Thomas Barlow (England) described infantile scurvy in 1883. Theodore Escherich (Austria) studied intestinal flora and discovered *E. coli* in 1885. Samuel Gee (England) described Coeliac disease in 1888. Otto Heubner (Germany) studied energy intake and expenditure in infants in 1903. The textbooks of Adalbert Czerny (Germany) in 1906 on child nutrition and of Heinrich Finklestein (Germany) on diseases of infancy in 1912 enjoyed great success. Lafayette B. Mender (USA) identified the nutritive value of proteins between 1909-1928. Casimir Funk (Poland) coined the name "vitamine" in 1912. Sir Archibald Garrod (England) wrote his path-breaking essay on "inborn errors of metabolism" in 1912. Clemens Von Pirquet (Austria) constructed the first percentile growth chart in 1913. Verner McCollum (USA) discovered fat soluble and water soluble factors that were essential for growth in l916 (6). Ciceley Williams (England) described Kwashiorkar in 1933.

### Nutrition science in the twentieth century

The science of nutrition bloomed during the 20th century. Vitamins and amino acids were discovered, human nutritional requirements were established and the relationship between diet, nutrition and the human body in health and disease were recognized. These scientific advances evolved through several phases. Initially knowledge of the various nutrients was attained. It was characterized by a great emphasis on vitamins and

mineral research.

An expansion of studies on proteins started in the 1960s the "protein era". Protein was considered as the critical factor required to overcome the prevalence of under nutrition. Autret, the head of FAO nutrition division stated that "deficiency of protein in the diet is the most serious and widespread problem in the world". Research on high protein yielding foods intensified; fortified cereals, fish protein concentrate, single cell protein, amino acid fortification all came into vogue. It was soon realized that energy is as important as proteins in the causation of malnutrition. Derrick Jelliffe, a pioneer in nutrition introduced the term 'protein- calorie' malnutrition, which was later modified to protein energy malnutrition and adopted by the FAO/WHO committee in 1971 to describe both kwashiorkor and marasmus.

Great debate started in the sixties and seventies on the causation and relationship between marasmus and kwashiorkor where eminent nutritional scientists; Waterlow, Gopalan, Scrimshaw, McLaren and others participated. Various studies on protein and energy requirements, the role of infection, metabolic and endocrine changes, adaptation were carried out and are still continuing.

The economic and sociopolitical dimensions of nutrition characterized the next phase. Studies on integrated nutritional planning, food resources, maldistribution and equity were reported. The relationship between nutrition and other disciplines was investigated. The effects of malnutrition on immunlogical, behavioral, cognitive and physical capabilities were documented. Nutrition was integrated into several United Nations programs; primary health care (WHO), GOBI, UNICEF programs, etc. Various integrated nutrition intervention programs were carried out at the national and international levels.

The role of nutrition in the development of chronic non-communicable diseases dominated the research work on nutrition during the later decades of the twentieth century. Diet was reported to account for more than one third of all cancers. The relationship between both overnutrition and under nutrition and various non-communicable diseases was studied. The relationship between obesity and cardio-vascular disease, diabetes and other chronic disorders was documented. Strong evidence suggested a relationship between in-utero under nutrition, adult onset diabetes and cardio-vascular disease (fetal origin hypotheses). Folate deficiency was reported to be associated with high levels of plasma homocysteine, one of the determinants of coronary heart disease.

Along with these advances the science of therapeutic nutrition developed. Drug and food companies contributed to research in this field. Great advances were achieved in dietetic prevention and management of non-communicable and/other chronic diseases. Pharmaceutical uses of certain vitamins, trace elements, other micronutrients and antioxidants were recognized. Interest in the science of genetics and molecular biology which was crowned by the decoding of the human genome is expanding and will be associated with great nutrition implications. Dietetic management of inborn errors of metabolism which started early during the twentieth century following Garrod's discovery of alkaptonurea in 1908 will witness great advances during the twenty first century. Enteral nutrition which dates back more 2300 years when ancient Egyptian physicians used enemas and rectal clysters to feed undernourished patients was revived in the latter half of the twentieth century. It became widely used during the last three decades following the introduction of successful procedures to deliver nutrients into high flow venous systems.

Great advances in agriculture were achieved since the green revolution in India. The introduction of genetically engineered food during the last decades of the twentieth century was followed by an ongoing international scientific debate. Parallel advances were achieved in animal nutrition and veterenary medicine, which increased animal food production. The relationship between mad cow disease and animal food as well as its relationship to Cruetzfeld Jacob disease in the humans is stimulating further research on animal nutrition, communicable disease and food safety. (7)

These and many other advances in nutritional sciences represent the ceaseless effort, genuine initiative and devotion of many pioneer scientists all over the world. Many pioneering studies were undertaken in the past century and stunning discoveries were made which revolutionized the field of medicine. To enumerate few studies of Burr on essential fatty acids, Goldberger and Spies on pellagra, McCollum and Moore on Vitamin A, Chick, Windaus and Hess on Vitamin D, Evans and Bishop on Vitamin E, King and Gyorgy on Vitamin C, Dam on Vitamin K, Mitchell, Snell and Williams on folic acid, Hodjkin on Vitamin $B_{12}$, McCance, Mac Kay, Widdowson, McLaren and Woodruff on iron deficiency, Ciceley Williams, Kerpel Fronuis, Gomez and Cravioto on protein calorie deficiency, Jelliffe on breast milk, Marriot and Jeans on infant feeding, Ylippo on feeding prematures (6) Pratt on food allergy, Guy and Kretchmer on lactose intolerance

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Lt Col Rajul K Gupta

# Body Composition and Energy

*"Tell me what you eat and I will tell you what you are. The destiny of a people depends on the nature of its diet."*

~Brillat Savarin (1)

From the nutritional point of view, mankind can be divided into four types:

(a) Primitive hunter gatherers
(b) Peasant agriculturalist
(c) Urban slum dwellers
(d) The affluent

India has the unique distinction of having all four types of communities. She is still predominantly a country of peasants but the rapidly growing towns have increasing number of poor slum dwellers and an ever increasing affluent society; even in the interiors of the country; few primitive hunter gathers still subsist in the jungles.(2)

These four groups have distinct and unique lifestyles, occupations, professions, emotions and mindset, so also, nutrition and diet. Across these four groups of people we, confront all the diseases known to mankind. Within these groups also, there are subgroups of infants, children, adults, elderly, the healthy, the pregnant, sick and infirm, vegetarians and non-vegetarians……. But, notwithstanding these variations, the basic principles of the science of nutrition remain the same whatever cultural or physiological group is being considered. The application through nutritional education is vastly different and has to be customized for the needs of a particular group. This chapter aims to put forth the basic principles of nutrition in brief.

At the very outset it is important to define the term nutrition. Nutrition is the branch of science that studies the process by which living organisms take in and use food for the maintenance of life, growth, reproduction, the function of organs and tissues and the production of energy. (3) Diet, on the other hand is what a person habitually eats and drinks.

## Composition of the body

### Chemical Composition

Normal chemical composition of a man weighing 65 kg is shown in Table - 1 (2). Most of the material listed in the table is part of the essential structures of the body, but a portion represents reserves or stores. Of the 9 kg of fat, not more than about 1 kg is essential, the remainder represents a store which can be drawn upon in times of need. In obese people this store may be very large and forms upto 70 percent of the body weight. Most of the protein is an essential component of the cell, but probably about 2 kg can be lost without serious consequences. By contrast, the body can be depleted at most by 200 g carbohydrate. During starvation the store of carbohydrate is continually replenished by synthesis from the large reserves of protein and fat. The body can lose upto10 percent of its total water and at least one third of the mineral content of the skeleton without serious risk to life.

Table - 1 :
Chemical composition of a man weighing 65 kg

| Constituent | Kg | Percent |
|---|---|---|
| Protein | 11 | 17.0 |
| Fat | 09 | 13.8 |
| Carbohydrate | 01 | 1.5 |
| Water | 40 | 61.6 |
| Minerals | 04 | 6.1 |

Various methods for estimating body composition are enumerated in Table - 2 (4, 5).

Table - 2 : Methods for body composition estimation

| Parameter | Method | Further application |
|---|---|---|
| **Anthropometry** | | |
| - Fat & Lean tissue derive fat mass | (BMI) | Quetlet's IndexTo and fat free mass |
| - % of body fat | Skinfold thickness, MUAC | |
| - Girth measurements | Arm, forearm, abdomen, waist, hip, thigh girths | |
| **Body fat** | Bioelectric-impedence analysis | To estimate LBM, body density & fat % |
| **Lean body mass** mass **(LBM)** | Bio-impedence analysis | To estimate fat |
| **Total body water** | Isotope dilution, Bio-impedence analysis | |
| **Total body** | Whole body | To estimate fat |

### Compartments of the body

At a meeting of the New York academy of science in 1963 the Professor of Surgery at Harvard, Dr Francis D Moore wrote on the blackboard:

Man = CM + EST + Fat

The body can be divided into three compartments, namely, cell mass(CM), extracellular supporting tissue (EST) and fat. Cell mass is the active tissue which carries out all the functions of the body. Extracellular supporting tissue supports the cells and can be divided into two parts - the extracellular fluid and minerals, and protein fibres in

**Newer techniques for body composition estimation**

While various methods are available, there is no 'gold standard' owing to wide variability in the human body compositions and 'assumptions' are made to account for them. Many newer techniques have therefore emerged. These are based on the following principles:

**(a) Near Infrared interactance**

A hand held instrument analyses near infrared light reflected from the skin on the biceps and analyses the spectrum of the reemitted light to indicate the fat and lean tissue. (5)

**(b) CAT Scan & MRI imaging**

Depict total tissue, fat and muscle areas. Can be used as a research tool. (6, 7)

**(c) DEXA (Dual-energy X-Ray absorptiometry**

A digital X-Ray image composed of individual pixels, produces rays of two defined energies. Beams are focused on the area of interest and energy spectrum of the emerging beams is analysed. This measures fat, LBM and bone mineral content. (8)

**(d) Neutron activation**

Neutron irradiation of the body results in production of short lived isotopes, analysis of which indicates the body composition. This requires expensive & costly equipment. (5)

**(e) Bio-Electrical impedence Analysis**

Analysis of a current passed through the body helps in

the skeleton and other supporting tissues. The extracellular fluid comprises the blood plasma and lymph. The living skeleton is a cellular organ in which minerals are laid down. Fat is the energy reserve held in adipose tissue beneath the skin and around the internal organs. In a healthy body the cell mass may contribute about 55 percent of total weight, the extracellular supporting tissue about 30 percent and the fat reserve about 15 percent. (2)

Food Constituents and Their Functions

Food is required for energy production, replacing the worn-out injured tissues and promoting tissue growth. In order to appreciate the influence of food on health and the factors which affect food requirements it is necessary to know the chemical composition of food and its metabolism in man. In order to appreciate these aspects of human nutrition, the biochemical and physiological qualities of food must first be considered. The constituents of food essential in human nutrition are the **'proximate principles'** which are the proteins, fats and carbohydrates. They yield energy and carry out tissue growth and repairs; **'the protective substances'** are the vitamins and minerals that are essential for normal tissue growth and function; and water which is an essential constituent of all tissues. These food constituents are described in detail in the subsequent chapters. The basics of 'energy' are briefly described hereunder.

**Energy**

Man gets energy from food in a chemical form, which is derived directly or indirectly from plants. This energy is bound in molecules of carbohydrate, fat, protein and alcohol. Whilst converting chemical energy into mechanical energy, man acts as an engine with measurable thermodynamic efficiency. Most of the energy is dissipated as heat. At best a man can convert 25% of the energy in his food into mechanical work. Energy is required for maintaining the body temperature and vital activity of organs, for mechanical work and for growth.

When an individual is at complete rest and no physical work is being carried out, energy is required for the activity of internal organs and to maintain the body temperature. This energy is required for maintaining the basal or resting metabolism. The basal metabolic rate (BMR) is determined experimentally when the subject is lying down at complete physical and mental rest, wearing light clothing in a thermo-neutral environment and at least 12 hours after the last meal. The BMR is more closely related to lean body mass (fat free body) than to the surface area but lean body mass is rarely used to estimate BMR. The reported value of BMR for Indians is 1 Kcal / kg/ hr.

**Units of Energy**

Calorie is the basic unit of energy. Kilo calorie is defined as the heat required to raise the temperature of 1 kg of water by 1°C from 14.5°C to 15.5°C. The joule (J) is now the accepted international unit of energy. It is defined as the energy expended when a mass of one kilogram is moved one meter by a force of one Newton (N). One Newton is the force needed to accelerate 1 kg mass by 1 meter per square second. Since joule is too small a unit to describe the energy value of diet, kilo joule (Kj) and mega joule (Mj) are of more practical use. One Kj is equal to 1000 J and one Mj is equal to 1000 Kj. However, the old unit of energy, namely, kilocalorie (Kcal) has been in use in nutrition for a long time and is still being used. (9, 10). The conversions of old and new units of energy are given below:

| | | |
|---|---|---|
| 1 cal | = | 4.184j |
| 1 Kcal | = | 4.184 Kj |
| 1000 Kcal | = | 4.184 Mj |
| 1 Kj | = | 0.239 Kcal |
| 1 Mj | = | 239 Kcal |
| 1 Kj | = | 1000 j |
| 1 Mj | = | 1000 Kj |

**Thermogenic Effect of Food**

Food intake itself increases heat production over the basal level even at rest due to its thermogenic effect. The intake of food raises the metabolic rate above the normal value (while fasting). This is known as the Specific Dynamic Action of food. The size of the effect is not closely related to the size of the meal. On normal diets, the overall effect amounts to no more than five to 10 % of the basal metabolism over 24 hours. (2).

Energy for basal functions, work metabolism and heat for

maintenance of body temperature is produced by the oxidation of carbohydrates, fats and proteins. Proteins are however, primarily needed for tissue growth, repair and maintenance. Fats serve as storehouse of energy, vehicle for fat soluble vitamins, as source of essential fatty acids and for maintenance of tissue structure. The intake of food is normally balanced by hunger which thus indirectly balances energy expenditure. Hunger may, however, not indicate this in various pathological states, notably in certain forms of malnutrition. Moreover, hunger can be modified not only by enough intake of food but also by doing less muscular work. Absence of hunger is not, therefore, necessarily an index of an adequate food intake.

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# The Proximate Principles

## Proteins

These are large molecules made up of nitrogen containing amino acids that are united together by peptide linkage. In adults approximately 16% of body weight is attributable to proteins. Next to water, protein is the major component of body tissues. Proteins are indispensable constituents of living protoplasm as they participate in all vital processes. Proteins are macromolecules consisting of amino acid chains. The human body has a limited capacity of converting one aminoacid into another (1,2). Of the 22 aminoacids now known to be physiologically important, the body is capable of synthesizing some under proper conditions provided the supply of nitrogen is adequate. These amino acids are known as nonessential amino acids. Others cannot be synthesized by the body and must therefore be supplied in diet. These are the eight essential amino acids viz. leucine, isoleucine, lysine, valine, methionine, threonine, tryptophan and phenylalanine. To these may be added histidine which appears to be essential for the growth of infants. (3)

### Sources of proteins

There are two main dietary sources of proteins: -

(a) Animal Sources: These include eggs, milk, meat and fish

(b) Vegetable Sources: Pulses, nuts, cereals, beans and oilseed cakes

### Digestion and Absorption of Proteins

After ingestion, dietary proteins are acted upon by proteolytic enzymes (pepsin, trypsin and chymotrypsin) in the gastro-intestinal tract and broken down into amino acids. These amino acids are absorbed from lower duodenum and jejunum and are used for tissue synthesis or the formation of enzymes, certain hormones and other proteins of special significance. The ultimate fate of amino acids is the removal of nitrogen for the formation of urea and the direct or indirect release of energy. Proteins are in a constant state of transition of synthesis and degradation (4).

### Functions of Proteins

Proteins are needed for various functions in the human body:

(a) Proteins are important for body building, growth, repair and maintenance of body tissues.

(b) Proteins are required for the synthesis of plasma proteins, haemoglobin, enzymes and hormones.

(c) Proteins like collagen, actin and myosin form the structural tissues - skin and muscles.

(d) Proteins act as transport carriers for many molecules like iron, haemoglobin, lipids, etc.

(e) Antibodies are also proteins. Proteins are involved in the acute phase of inflammation as well.

(f) Albumin, a protein, acts as a buffer in the maintenance of blood pH. (5)

### Quality of Proteins

The nutritive value of a protein depends upon its aminoacid composition. A biologically complete protein is one which contains all the essential amino acids in adequate amounts to meet human requirements. Proteins from foodstuffs of animal origin, such as milk, meat and eggs are biologically superior to proteins of vegetable origin as animal proteins have all the essential amino acids present in them. Most of the vegetable proteins lack one or more amino acid and are thus classified as biologically incomplete proteins. The essential amino acid that is in shortest supply in a given food item is known as the limiting amino acid. The quality of vegetable proteins in a vegetarian diet can be improved by providing a suitable mixture of vegetable proteins. A relative lack of a particular amino acid in one protein can be compensated by simultaneous consumption of another protein, which contains that limiting amino acid. This is known as supplementary action. For example, the limiting amino acid in wheat is lysine and in pulses it is methionine. A diet combining wheat products such as bread (chapati) with pulses (dal) will compensate for these deficiencies and provide all the essential amino acids. Other similar examples from Indian diet are Idli-Sambhar, Wada-Pav, Rice & Dal, Khichri etc.

### Recommended dietary allowance

Adults: 1g/kg body weight. An additional allowance of 15g/day is recommended for **pregnancy**. During **lactation** an extra allowance of 25g in the first 6 months and 18g in the subsequent 6 months is recommended. **Children** have a higher protein requirement (2).

### Deficiency

Deficiency can occur when the diet does not provide enough protein. Secondly, if energy intake is insufficient proteins will be diverted to produce energy and thus causing a deficiency of proteins. Protein energy malnutrition (PEM) is a major cause for concern for children in our country. Childhood infections (esp. measles) also play an important role in triggering and sustaining a long term protein deficiency.

**Recent developments : The lysine debate**

*"Are predominantly cereal based diets in the developing countries protein adequate?"* There is a great ongoing debate: Is the protein deficiency because of lysine deficiency? Even the latest 'stable isotope studies' have not been able to settle this debate. One recommendation has been to replace about 22% energy with soya in order to overcome the protein inadequacy. (6)

## Carbohydrates

Carbohydrates are polyhydroxy aldehydes or ketones, or substances that produce such compounds when hydrolyzed. They contain carbon, oxygen and hydrogen in proportion approximating that of a 'hydrate of carbon' ($CH_2O$), hence the term carbohydrate. (7)

From the nutrition point of view, the carbohydrates can be divided into two categories.

(a) The first category comprises of available carbohydrates, which can be digested in the upper gastrointestinal tract, absorbed and utilized. These are the polysaccharides such as starch, dextrin and glycogen; disaccharides such as lactose, sucrose and maltose; and monosaccharides such as glucose, fructose and galactose.

(b) The second category comprises of unavailable carbohydrates or dietary fibre, which are difficult to digest.

### Sources of Carbohydrates

In agricultural societies the major source of the dietary carbohydrates is starch from cereal grains, millets, legumes, roots and tubers. With increasing prosperity as in industrial societies, sugar replaces complex carbohydrates as the main source. The presence of monosaccharides (free glucose or fructose) is limited to fruits and vegetables, otherwise they are not abundant in natural foods. Fructose is found in honey, fruits and vegetables. Sucrose and Lactose are the commonest disaccharides. Sucrose is extracted from sugar cane. Table sugar is 99% sucrose. Sucrose gets hydrolysed into glucose and fructose. Lactose is found in milk. It is hydrolysed to glucose and galactose. Maltose is present in malted wheat and barley. Other sources are nuts and seeds.

### Digestion of Carbohydrates

The available carbohydrates i.e. polysaccharides and disaccharides, are hydrolyzed by the action of digestive enzymes into monosaccharides and absorbed from the small intestine. After absorption, these monosaccharides are transported to liver via portal circulation where galactose is converted into glucose. The absorbed glucose may be utilized directly for providing energy to tissues, temporarily stored in the form of glycogen in liver and muscles or converted into fat. They are essential for the oxidation of fats and for the synthesis of non-essential amino acids.

### Functions of Carbohydrates

Carbohydrates are the most significant and cheapest source of energy in the diet. Carbohydrates provide 60 to 85% of energy in our diet. Various kinds of sugars (glucose, fructose, sucrose, etc), most literally, impart the sweet taste to life! Fibre has the important function of increasing faecal bulk, stimulating peristalsis and blocking cholesterol synthesis in the liver.

### Requirement of Carbohydrates

In a prudent diet carbohydrates should contribute to 60 to 70% of total energy (2).

Table 1

**Sugar Substitutes**

Sugar substitutes can be classified into two groups :

**(a) Nutritive sweeteners**

Sugar alcohols (Sorbitol, Mannitol, Xylitol) used as sugar substitutes in candies, chewing gum and beverages. These provide 4 Kcal / g of energy.

**Advantages**

(i) Not absorbed as rapidly as sucrose, so can be used in those who cannot tolerate a high blood sugar level.

(ii) Low risk of dental caries, as these alcohols cannot be used by oral bacteria.

**(b) Non-nutritive sweeteners**

These do not supply any calories. Examples are aspartane, sucralose, alitame and saccharin. These are several time sweeter than sugar, so small quantity is sufficient to sweeten the food. They must be used with caution as they are known to have carcinogenic

### Dietary Fibre

Denis Burkitt (a surgeon) and Hugh Trowell (a physician), served for 30 years, after the World War II, in Makareree University, Kampala, Uganda, before returning to Britain. They were struck by the great difference in the pattern and nature of disease affecting the affluent west as opposed to more primitive communities. In Uganda much bulky vegetable material was consumed and constipation was unknown. Their attention was focused on the unabsorbable material of the diet which they recognized as Dietary fibre. They concluded that this was not only responsible for the faecal bulk but was also directly or indirectly related to the difference in the pattern of disease. A 'fibre hypothesis' was thus formulated which suggested that unrefined complex carbohydrates protected against the 'western ailments' : colonic cancer, diverticular disease, appendicitis, constipation, hemorrhoids, hiatus hernia, varicose veins, diabetes, heart disease, gall stones, obesity, etc.

Definition

Dietary fibres are the remnants of the plant cell resistant to hydrolysis by alimentary enzymes and do not provide significant nourishment. They remain in the ileum but are partially hydrolyzed by the colonic bacteria. The term 'dietary fibre' is a broad term which includes Non Starch Polysaccharide (NSP) and related material such as resistant starch, lignin and complex assemblies of plant tissue where polysaccharides occur in close association with other molecules. The NSPs are normally present in cell wall, cement, plant gums, mucilages and algal polysaccharides. (8)

Classification

Fibre can be classified according to solubility in water, as soluble or insoluble. Insoluble fibre consists mainly of

cellulose, hemicellulose and lignin. On the other hand the natural gel forming fibres like pectins, gums and mucilages are soluble.

Sources and Losses

Insoluble fibres: Peas, beans, rye, granary bread, bran flakes, brown rice, maize, lentils and pulses, whole meal cereals (dalia), brown bread, sprouted grains and dals, whole meal flour and fruits with edible seeds are good sources of insoluble fibres.

Soluble fibre: Fruits in general (e.g. apples, citrus fruits, pears, straw berries) are good sources of soluble fibre.

Lettuce, grapes, canned orange, jams, white rice biscuits, white bread and corn flakes are poor sources of fibre. Milling of grains and polishing of rice removes the outer "bran layer" and thus greatly reduces the fibre content.

Functions

Dietary fibre stimulates chewing, improves flow of gastric juice and provides a sense of satiety. Insoluble fibre binds to water in the colon and swells. Hence it forms substrate for colonic bacterial fermentation. This stimulates peristalsis which increases transit time in the colon thereby reducing the risk of constipation and possibly that of colon cancer. (9)

Dietary fibre in disease

*"People with low incidence of coronary disease, atherosclerosis, diabetes and hyperlipidaemia obtain 85% of their energy from complex carbohydrates"*

**~ Prof William Connor**

In general soluble fibre slows gastric emptying, provides fermentable material for colonic bacteria and binds bile acids and cholesterols. Insoluble fibres hold water, reduce elevated colonic intraluminal pressure and binds minerals like zinc.

**Cardiovascular disease**

Fibre helps in achieving prevention of cardiovascular disease through various mechanisms :

(a) Soluble fibre binds with bile acids and other lipids interfering with micelle formation in the proximal intestine. This alters the quantity of cholesterol or fatty acids absorbed. The size of lipoprotein particles formed by intestinal mucosa is also altered.

(b) The re-absorption of bile acids is slowed by soluble fibre to increase cholesterol losses in faeces.

(c) Intestinal bacteria reduce soluble fibre to short chain fatty acids which block cholesterol synthesis in the liver. These effects of fibre reduce blood cholesterol levels which in turn reduces the risk of coronary artery disease (10).

**Diabetes Mellitus**

Fibres help in the maintenance of weight and prevention of obesity. Soluble fibre blunts the response of blood glucose. This helps in the control of blood glucose. Soluble and viscous fibres (pectin and gums) have the greatest hypoglycemic effect (11).

**Colorectal Cancer**

Fibre is considered to be an important contributory factor to the prevention of colonic cancer. The following mechanisms could be at play

(a) Fibre reduces the transit time in bowel and thereby reduces the time of exposure to potential mutagens and carcinogens that may be present in the diet.

(b) Fibre dilutes the carcinogens in the colon and alters the production of carcinogens in the stools.

(c) It alters the nature of faecal bile acids by altering the colonic (faecal) flora.

(d) It reduces the colonic pH by increasing fermentation of short chain fatty acid production.

(e) Diets rich in fibre also contains Vitamin A and C, which are strong antioxidants and are associated with lowering of the risk of colonic cancers. (12)

**Other GIT Disorders**

Fibre increases faecal bulk and relieves constipation. This reduces the incidence of colonic cancers, diverticulitis and appendicitis. The alteration in cholesterol production and further metabolism reduces the formation of gallstones as most of them are of cholesterol origin.

**Obesity**

High fibre diet contributes to bulk in food and satiety. It also reduces 'more' food intake and thus limits energy intake. An altered cholesterol homeostasis as brought out earlier, also contributes to obesity prevention (13).

Recommended Dietary Allowance

The diet should contain 35-40 grams of dietary fibre per day (2). Fibre content of selected food stuffs are given in

Table - 2 : Dietary fibre content of common foods (g/100g)

| Food Stuff | Fibre Content (g per 100g food) |
|---|---|
| Rice, raw, milled | 0.2 |
| Wheat flour, whole | 1.9 |
| Bengal gram, whole | 3.9 |
| Red gram (Dal arhar) | 1.5 |
| Peas dry, Rajmah | 4.5 |
| Cabage, cauliflower | 1 - 1.2 |
| Spinach | 0.6 |
| French beans | 1.8 |
| Coconut dry | 6.6 |
| Guava | 5.5 |
| Mango, Papaya | 0.7 |
| Pomogranate | 5.1 |
| Peach, Pears, Apple | 1 - 1.2 |
| Whole wheat flour | 10-13 |
| | |

## Fats

Fats are organic compounds, which are insoluble in polar solvents (water) but soluble in organic solvents such as ether, chloroform and benzene. These are actual or potential esters of fatty acids. Fats are only distinguished from oils by their different melting points; fats are solid and oils liquid at room temperature. 'Fats' and 'oils' are the ones which the housewife buys and 'lipid' is the term used by biochemists. However, the general term fat is commonly used to refer to the whole group and is used interchangeably with lipids. (4) They can be roughly classified into neutral fats and amphiphilic fats. Neutral fats include the triglycerides, cholesterol and other sterols. Amphiphilic fats consist of phospholipids such as lecithin and sphingo-lipids (eg sphingomyelin). Dietary fats are mainly triglycerides (over 90%) composed of fatty acids.

### Fatty acids

As a class fatty acids are the simplest of lipids. They are composed of a straight hydrocarbon chain terminating with a carboxylic acid group, therefore creating within the molecule a polar hydroplillic end and a nonpolar hydrophobic end that is insoluble in water. The carbon chain contains 4 to 24 carbon atoms. Fatty acids are components of the more complex lipids. Hydrogen atoms are attached to the carbon chain; the number of hydrogen atoms determines the degree of saturation (with hydrogen atoms) of the fatty acid. A fatty acid with hydrogen atoms on every arm is said to be 'saturated'. Unsaturated fatty acids contain double carbon bonds where there is no hydrogen. If there is only one double bond the fatty acid is termed as monounsaturated and when more than one double bond is present the fatty acid will be polyunsaturated.

### Saturated Fatty acids (SFA)

They have a relatively high melting point and tend to be solid at room temperature. These are obtained from animal storage fats and their products, e.g. meat fat, lard, milk, butter, cheese and cream. Fats from plant origin tend to be unsaturated with the exception of coconut oil and palm oil. A high intake of SFA is associated with an increase in LDL and total cholesterol and thus increases the risk of atherogenesis and cardio¬vascular disease. Some examples of SFAs are Myristic acid, Palmitic acid and Stearic acid.

### Monounsaturated Fatty acids (MUFA)

MUFA contain only one double bond and are usually liquid (oil) at room temperature. Olive oil and rapeseed oil are good dietary sources of MUFA. MUFA are also present in meat fat and lard. Dietary MUFA does not raise plasma cholesterol. They lower LDL cholesterol without affecting the HDL. Oleic acid is an example of MUFA.

### Polyunsaturated Fatty acids (PUFA)

PUFA contain two or more double bonds and are liquid at room temperature. They are easily oxidized in food and in the body. PUFA are involved in the metabolism of cholesterol, are components of phospholipids in cell membranes, and are precursors of biologically active compounds such as prostaglandins, interleukins, and thromboxanes. Therefore they have vital role in immune response, blood clotting and inflammation. PUFA are derived from the essential fatty acids linoleic acid (n6 or ω6) and α-linoleic acid (n3 or ω3) and are therefore divided into omega-3 (ω3) or omega 6 (ω6) groups of PUFA.

Omega-3 (ω-3) Polyunsaturated Fatty acids (PUFA) are found in fish and fish oils. The health benefits of these include reducing the cardiovascular risk factors. Research also indicates their beneficial role in cognitive function of brain. Some common omega-3 fatty acids are α-linolenic acid (linseed, soyabean, rapeseed, leafy vegetables), eicosepentaenoic acid (marine algae, fish oils) and docosahexenoic acid (fish oils).

Trans fatty acids (t-FA)

Trans fatty acids have been associated with adverse effects on lipoprotein status by elevating LDL and depressing HDL. They rarely occur in nature. These are produced during the partial hydrogenation of PUFA. In Indian homes this process takes place commonly when oil is heated over and over again as it happens during the process of frying puri, pakori or samosa, esp when the same oil is used again and again.

Essential fatty acids (**E**FA)

If fats are entirely excluded from the diet, retarded growth, dermatitis, kidney lesions and an early death might result. Studies have shown that feeding of certain unsaturated fatty acids eg linoleic and linolenic acid is effective in curing the condition. It is therefore evident that certain unsaturated fatty acids cannot be synthesized in the body and must be acquired from diet. These are essential fatty acids. EFA are commonly found in plant and fish oils. Deficiency of linoleic acid has been demonstrated in children although a deficiency of α-linolenic acid is not seen commonly in healthy people (8). Fatty acid content of different fats is given in Table - 3 (14)

Sources of **f**ats

Dietary fats are derived from two main sources:

(a) Animal Sources

They are milk and milk products (ghee, butter), lard, egg and fish oils. Animal fats in general are poor sources of essential fatty acids with the exception of certain marine fish oils such as cod liver oil and sardine oil, but they are good sources of retinol and cholecalciferol.

(b) Vegetable Sources

They include various edible oils such as groundnut, gingely, mustard, cottonseed, safflower, rapeseed, palm and coconut oil. Vegetable oils with the exception of coconut oil are all rich sources of essential fatty acids, but they lack retinol and cholecalciferol except red palm oil which is rich in carotenoids.

### Digestion and Absorption of Fats

Fats have to be reduced to small particles before digestion and absorption are possible. Bile salts and small quantity of fatty acids and monoglycerides liberated by pancreatic lipase emulsify fat in the duodenum with the formation of droplets smaller than 0.5 mm. Pancreatic lipase splits triglycerides into fatty acids, diglycerides, monoglycerides and glycerol. Fatty acids and monoglycerides pass into the cells of mucous membrane as very small particles. Within the cells further hydrolysis

takes place under the influence of intracellular monoglyceride lipase, and then the long chain fatty acids are re-esterified into new triglycerides. After re-synthesis, the triglycerides enter the lacteals of the small intestine as small particles known as chylomicrons. These pass into lacteals and the mesenteric lymph vessels, enter the thoracic duct and then join systemic circulation into the right subclavian vein. The major part of the absorbed fat enters the circulation through the thoracic duct, except for most short and medium chain fatty acids, which pass to the liver via the portal vein. After absorption from the alimentary canal, fats are carried in the blood either to storage depots or to the muscles and other tissues as a source of energy. Glycerol is oxidized to triose phosphate, a compound in the intermediate metabolism of carbohydrates. Normally the fatty acids undergo beta-oxidation ending in carbon dioxide and water. The long carbon chains of the fatty acids are also broken down in the liver into ketoacids. It must be appreciated that the normal break down of fats also needs simultaneous carbohydrate catabolism. Therefore, in diabetes, starvation or with a diet containing too much of fats and too little carbohydrates, incomplete oxidation of fats leads to an accumulation of aceto-acetic acid and ketones in the body resulting in ketosis. Approximately 2% of total plasma lipids are free fatty acids. The remainder of lipids are carried in the blood as lipoproteins. These are a complex of lipids with proteins. The protein component consists of peptide chains known as apoproteins. Lipoproteins are identified by the apoliprotein that is present (apo A, apo B, apo C, apo D and apo E). There are five classes of lipoproteins which vary in density and functions. The important characteristics of four main classes of lipoproteins are shown in Table - 4.

### Chylomicrons

Chylomicrons mainly consist of triglycerides and transport dietary lipids. Chylomicrons leave the enterocytes and enter the lymphatic system before entering the blood vessels. The triglycerides are hydrolyzed by lipoprotein lipase to release fatty acids that are used up for energy or stored in adipose tissue. The chylomicrons are cleared from the blood by the liver in 15-20 minutes.

### Very low-density lipoproteins (VLDL)

VLDL are synthesized in the liver and are large particles that are rich in triglycerides. They deliver fatty acids to adipose tissue, muscles, and heart where lipoprotein lipase facilitates their release from triglycerides. The enzyme in the heart has a high affinity for triglyceride and when triglyceride concentrations are low, they are preferentially released into heart tissue.

### Low-density lipoproteins (LDL)

LDL contains mainly cholesterol and cholesterol ester as they are the end product of VLDL metabolism. They carry approximately 70% of plasma cholesterol and are taken up by the liver and other tissues by LDL receptors.

### High-density lipoproteins (HDL)

The liver and intestine synthesize and secrete HDL. HDL is

Table - 3 : Approximate fatty acid composition of common fats and oils (g/100g) (14)

| Oil/Fat | Saturated | MUFA | Linoleic acid | α-linolenic acid | Predominant FA |
|---|---|---|---|---|---|
| Coconut | 90 | 7 | 2 | <0.5 | SFA |
| Palm kernel | 82 | 15 | 2 | <0.5 | SFA |
| Ghee | 65 | 32 | 2 | < 1.0 | SFA |
| Vanaspati | 24 | 19 | 3 | <0.5 | SFA (t-FA) |
| Red palm oil | 50 | 40 | 9 | <0.5 | SFA + MUFA |
| Palm oil | 45 | 44 | 10 | <0.5 | SFA + MUFA |
| Olive | 13 | 76 | 10 | <0.5 | MUFA |
| Groundnut | 24 | 50 | 25 | <0.5 | MUFA |
| Rape/Mustard | 8 | 70 | 12 | 10 | MUFA |
| Sesame | 15 | 42 | 42 | 1.0 | MUFA + PUFA |
| Rice bran | 22 | 41 | 35 | 1.5 | MUFA + PUFA |
| Cotton seed | 22 | 25 | 52 | 1.0 | PUFA |
| Corn | 12 | 32 | 55 | 1.0 | PUFA |
| Sunflower | 13 | 27 | 60 | <0.5 | PUFA |
| Safflower | 13 | 17 | 70 | <0.5 | PUFA |
| Soyabean | 15 | 27 | 53 | 5.0 | PUFA |
| | | | | | |

Table - 4: Important characteristics of plasma lipoproteins (15)

| Lipoprotein | Density | Protein (%) | Triglycerol (%) | Cholesterol (%) | Phospholipids (%) |
|---|---|---|---|---|---|
| Chylomicron | <0.95 | 1.5-2.5 | 84-89 | 1-3 | 7-9 |
| VLDL | <1.006 | 5-10 | 50-65 | 5-10 | 15-20 |
| IDL | 1.006-1.009 | 15-20 | 22 | 8 | 22 |
| LDL | 1.020-1.063 | 20-25 | 7-10 | 7-10 | 15-20 |
| HDL | 1.064-1.210 | 40-55 | 3-5 | 3-4 | 20-35 |

involved in the reverse transport of cholesterol from tissues to the liver or transfers it to other lipoproteins.

Lipoprotein (a)

This is a complex of LDL with apolipoproteins (a).

Unfavourable levels of these lipoproteins have adverse effects on health. High levels of LDL are associated with atherosclerotic risk so LDL is colloquially known as 'bad cholesterol'. A high level of HDL has favourable effect on the cardiovascular system and is termed as 'good cholesterol'. (8)

**Functions of Fats**

(a) They are concentrated sources of energy providing about 37.7 kj/g (9 kcal /g).

(b) Fats serve as vehicle for fat soluble vitamins (A.D,E & K)

(c) Fats are structural components of cell and cell membrane

(d) They are the sources of essential fatty acids. Linoleic acid and arachidonic acid are precursors of prostaglandins which are required for a wide variety of metabolic functions.

(e) Apart from their nutritional significance, fats improve the palatability of diet, delay gastric emptying and raise the caloric density.

(f) Some fats can be converted to biologically active compounds such as steroid hormones, interleukins, thromboxanes, and prostaglandins and bile acids (from cholesterol).

**Recommended Dietary Allowance**

The RDA for adults is 20g of visible fat per day. For pregnant and lactating women it is 30 and 45 g respectively. (2)

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Lt Col Rajul K Gupta

# The Protective Foods

*"Milk and leaves occupy a unique position, as they correct the defects of cereals, tuber, roots and meats. Thus…they be distinguished by the term 'Protective foods'."*

**~EV McCollum(1)**

## Vitamins

They are organic compounds required in very small but definite quantities for normal growth and the maintenance of a healthy life. They are not produced in the body and have to be supplied in the diet. They do not furnish energy and play no part in the constitution of the structure of tissues, but are essential for the transformation of energy and regulation of tissue metabolism. They are necessary for the efficient functioning of the organism as a whole, each in a specific manner. Deficiency of vitamins causes profound changes in structural and functional wellbeing, the picture of each deficiency being, specific. A few can be synthesized by the micro-organisms of the bowel, this biosynthesis shows great variations in different people on the same diet with the result that only certain members of a group consuming diet deficient in one of these vitamins may develop symptoms of vitamin deficiency while the other members of the same group remain healthy. Certain types of commensal bacteria sometimes under anaerobic conditions destroy the vitamins, particularly thiamine, nicotinic acid and ascorbic acid but a balance is normally maintained between biosynthesis and destruction. A disturbed balance by reduced intake, alteration in the intestinal bacteria, presence of parasites and intestinal infections may precipitate the vitamin deficiencies. This occurs particularly under stressful conditions such as toxaemia, pyrexia or gastro-intestinal conditions when the vitamin demand increases.

Vitamins are widely distributed in diet. Fresh milk, meat, eggs, fresh vegetables and fruits are rich sources. Cereals (esp whole unrefined cereals) which form the bulk of our diets are also important sources. Storage, processing and cooking of food may cause considerable vitamin loss, so that the maintenance of an adequate intake is more difficult when fresh food is scarce. The pharmaceutical use of vitamins should be restricted to rectify or supplement the envisaged or existing deficiency in the diet or to meet the increased physiological demands (eg in pregnancy). No physiological benefit, however, can be expected from a large dose of vitamins under normal circumstances. Vitamins have long been classified into two groups; water soluble and fat soluble. The water-soluble group comprises of vitamins B and C; the fat-soluble vitamins are A, D, E and K. This division is still useful, since it helps to understand the distribution of vitamins in foods and their absorption and metabolism in the body. There is also an important distinction in the handling of the two classes by the body. An excess intake of water soluble vitamins is excreted in the urine. Thus, there is virtually no danger in giving an excess of these vitamins. On the other hand, the fat soluble vitamins cannot be excreted in this way. Any excess of these vitamins, beyond the immediate requirement is stored in the liver. The storage capacity of the human liver is large and it normally holds a reserve of vitamins sufficient for many months; this is a useful provision for times when the dietary supply may temporarily be cut off. However the amount that can be stored is not unlimited. (2,3)

## Water soluble vitamins

### Thiamin (Vitamin B1)

Thiamine hydrochloride is a crystalline substance which is readily soluble in water. It is rapidly destroyed by heat in neutral or alkaline solutions. In acid solutions however, it is resistant to heat upto 120°C. It is mainly excreted in urine. Thiamine is present in the body mostly as thiamine pyrophosphate (TPP) but about 10 percent as thiamine triphosphate. TPP is the active form of thiamine in the body.

Sources

The important stores are seeds of plants. The germ of cereals, nuts, pea, beans and other pulses and in addition yeast is a rich source. All green vegetables, roots, fruits, nuts, flesh foods and dairy produce contain significant amounts of the vitamin. Pork has a higher content of thiamine than beef or mutton. Highly processed foodstuffs like white bread, polished rice and refined sugar are deficient in thiamine. In cereal grains, thiamine is found in highest concentration in the germ or embryo, less in bran and least in endosperm.

Losses

Milling of cereals below an extraction rate of 75 percent reduces the content of thiamine to a great extent. As thiamine is readily soluble in water, considerable amounts may be lost when foodstuffs are cooked in an excess of water which is afterwards discarded. It is relatively stable to heat upto boiling point, provided that medium is slightly acid, as in baking with yeast. But if baking powder is used, or if soda is added in the cooking of foodstuffs, almost all the vitamin may be destroyed.

Functions

(a) It forms part of the coenzyme thiamine pyrophosphate (TPP). This is a coenzyme of carboxylase, concerned with the oxidative decarboxylation of pyruvic acid which is an intermediate stage in the oxidation of glucose. In thiamine deficiency, the carbohydrate metabolism is interfered with, and pyruvic acid accumulates in the tissues and body fluids, and toxic effects result. It is needed in the transketolase reaction in the hexose monophosphate pathway. (4)

(b) It is also a coenzyme in 2-oxoglutarate dehydrogenase in central energy yielding

metabolic pathways and the branched chain oxo-acid dehydrogenase in the catabolism of leucine, isoleucine and valine. (5)

(c) It is essential for the health of the nerve tissue, and for normal cardiac, and gastro-intestinal functions.

Requirement

Since thiamin plays an important role in carbohydrate metabolism, its dietary allowance is related to energy intake. It is 0.5 mg per 1000 Kcal. (6)

Deficiency

Thiamin deficiency causes beriberi and Wernicke-Korsakoff psychosis. Three forms of Beriberi are known: Wet Beriberi (cardiac), Dry Beriberi (neurological) and Infantile Beriberi. The early symptoms and signs are common in both dry and wet Beriberi. The onset is usually insidious, though sometimes precipitated by unwanted exertion or a minor febrile illness. (4)

(a) Wet beriberi is the acute form. It is characterized by high output cardiac failure, bounding pulse, warm extremities, peripheral oedema and cardiac dilatation.

(b) Dry beriberi is the chronic form of disease and is characterized by progressive peripheral neuropathy. The tendon jerks are sluggish and anaesthesia of the skin (especially over tibia) is common. The muscles become progressively wasted and weak and walking becomes increasingly difficult. The thin, even emaciated individual needs at first one stick, then two and may finally become bedridden.

(c) Infantile beriberi occurs in the first few months of life (of an infant), if the diet of mother is deficient in thiamin. The infant remains constipated and appears plump due to water retention. The heart is enlarged, heart sounds are muffled. The infant may die of a heart failure if untreated. (7)

(d) Wernicke-Korsakoff psychosis is seen in chronic alcoholics with poor diet. It is characterided by confusion, low levels of consciousness and poor coordination (encephalopathy). Memory loss often follows the encephalopathy.

**Recent Advances (Thiamin)**

- Brains of Thiamin deficient animals reveal presence of Alzheimer-like amyloid. Although such pathology has not been seen in humans with Wernicke-Korsakoff syndrome, this has led to trials of thiamin for treatment of Alzheimer's disease. (8)
- While the classical forms of Beriberi from a predominantly dietary deficiency is on the decline, an increasing relationship is being seen between central nervous system damage caused by its deficiency in narcotic abusers and HIV/AIDS patients. Results from postmortem examinations and brain imaging indicate that Wernicke encephalopathy is significantly underdiagonosed. (5)

## Riboflavin

It is a yellow green fluorescent compound, soluble in water but not in fats. Though stable in acid solution, in alkaline solution it is readily destroyed by heat. It is also destroyed by short visible and ultraviolet rays.

### Sources & Losses

The best sources of riboflavin are liver, milk, eggs and green vegetables. Ceraels and yeast extracts also contain the vitamin. Riboflavin differs from other compounds of vitamin B complex in that it occurs in good amounts in dairy produce. Cooking does not destroy the vitamin apart from losses that occur when the water in which green vegetables have been boiled is discarded. If food, especially milk, is left exposed to sunshine, large losses may occur.

### Functions

In plant and animal tissues riboflavin gets linked with phosphoric acid to form flavin mononucleotide (FMN). This, with adenosine monophosphate (AMP) forms flavin adenine dinucloeotide (FAD). These two coenzymes, FMN and FAD are the prosthetic groups of flavoprotein enzymes involved in oxidation-reduction reactions within the cells in many metabolic pathways. The important functions of riboflavin include:

(a) Promotion of normal growth

(b) Assisting synthesis of steroids, RBC and glycogen

(c) Maintenance of mucous membranes, eyes, and the nervous system

(d) Aiding iron absorption (4)

### Requirement

The requirement of this vitamin is also related to energy intake. It is about 0.6 mg per 1000 kCal. The daily safe requirement ranges from 0.7 to 2.2 mg/day. (6)

### Deficiency

(a) The signs suggestive of riboflavin deficiency are cheilosis, angular stomatitis, glossitis, magenta tongue, nasolabial seborrhoea and genital (scrotal or vulval) dermatosis. Corneal vascularisation is also seen but is not a specific sign of riboflavin deficiency.

(b) Severe deficiency is rarely seen. But the elderly, anorexia nervosa sufferers and chronic dieters are at a higher risk.

(c) Certain secondary nutrient deficiencies are seen in Riboflavin deficient people. Hypochromic anaemia results due to reduced iron absorption and increased gastrointestinal loss modulated by altered cell morphology and cytokinetics. Vitamin B6 deficiency may occur because pyridoxine oxidase is a flavoprotein sensitive to riboflavin depletion. Pallegra may be precipitated because of impaired tryptophan metabolism due to impairment of kynurenine hydroxylase and

**Recent Advances (Riboflavin)**

- Marginal riboflavin status may be a factor in hyper-homocysteinaemia. Riboflavin supplements may be beneficial in lowering plasma homocysteine.(9)
- It has been studied that riboflavin deficient people are relatively resistant to malaria and have a lower parasite burden as compared to well nourished people. (5)
- Certain secondary nutrient deficiencies resulting from Riboflavin deficiency are being studied. For example, secondary deficiencies of iron, functional deficiency of vitamin B6 and impaired niacin synthesis, leading to pellagra are known. (5)
- The structural analogues of Riboflavin like phenothiazines, tricyclic antidepressants, anti-malarials and adriamycin inhibit flavokinase, leading

reduced synthesis of NAD. (5)

## Niacin (Nicotinic acid & nicotinamide)

Niacin is the generic term for a group of compounds that prevent pellagra. It is a white crystalline substance readily soluble in water and is resistant to heat, in solution or in a dry state. Although related chemically to nicotine it possesses very different physiological properties. It occurs naturally in the body in the form of an amide - nicotinamide.

### Sources

Nicotinic acid is widely distributed in plant and animal foods. Meat (especially the organs), fish, chicken, eggs, milk, whole meal cereals, groundnuts and pulses are good sources. In some cereals, especially maize, the greater part of the vitamin may be in a bound unabsorbable form. The human body is not entirely dependent on dietary sources of nicotinic acid as it may also be synthesized from tryptophan. On an average about 60 mg of tryptophan is needed to form 1mg niacin. In the assessment of this vitamin in diet, both the dietary content and niacin obtained from conversion of tryptophan are considered. The total niacin content can be expressed in terms of niacin equivalents (mg), which is the sum of niacin in diet + 1/60$^{th}$ of tryptophan content, in diet. (6)

### Functions

Nicotinamide is incorporated into the pyridine nucleotide coenzyme nicotinamide adenine dinucleotide (NAD) and nicotinamide adenine dinucleotide phosphate (NADP). These coenzymes are involved in numerous oxidoreductase reactions including glycolysis, fatty acid metabolism, tissue respiration and detoxification.

### Requirement and intake

Since this vitamin takes part in many reactions of energy metabolism, its requirement is also related to energy requirement. Its safe level is estimated to be 6.6mg niacin equivalents per 1000 kcal. The daily requirement varies from 8-26 mg. (6)

### Deficiency

Pellagra results from the deficiency of niacin. This is characterized by the three 'D's (4)

(a) **Dermatitis:** (Pellagrous dermatosis) Skin exposed to sunlight gets inflamed, that progresses to pigmentation, cracking and peeling. The neck is frequently involved and the distinctive distribution of skin lesions is known as Casal's Collar.

(b) **Diarrhoea:** This is often accompanied by inflamed scarlet tongue.

(c) **Dementia:** It may present as mild confusion and disorientation to mania and psychosis.

**Recent Advances (Niacin)**

- Nicotinamide protects against the autoimmune destruction of pancreatic b islet cells. Nicotinamide thus, can delay the onset of Type 1 diabetes in susceptible individuals. The trials conducted so far have been promising. (10)
- Nicotinic acid is used in pharmacological doses to treat hyperlipidaemia. (5)

## Folic Acid (Folate or Pteroyl glutamic acid)

It is a yellow crystalline substance, sparingly soluble in water and a stable molecule. When heated in neutral or alkaline media it undergoes rapid destruction. About three quarters of folate in foods is in polyglutamyl form. These are normally hydrolyzed to free folate by a conjugate present in small intestinal epithelium. Free folate is actively absorbed from the upper small intestine. It is stored mainly in the liver. Small amount is excreted in urine and faeces. Free folic acid is converted in the liver into tetrahydrofolic acid (folonic acid) which is the functionally active form in the body.

### Sources and losses

It occurs in green leaves, pulse, cereals, liver, kidney, mushroom and yeast. Food preparation can cause serious losses of folic acid in canning, in prolonged heating, when cooking water is discarded, and from reheating. Reducing agents in food tend to protect folic acid.

### Functions

(a) Folinic acid plays important role in the synthesis of purines, pyramidines, glycine and methionine. It is essential for the synthesis of DNA.

(b) The folate derivative 5-methyl tetrahydrofolate requires vitamin B12 to enable the use of methionine synthase in the synthesis of methionine and tetrahydrofolate.

(c) It is a potent anti anaemia factor in the treatment of megaloblastic anaemias of malnutrition, pregnancy and malabsorption. It is also effective in treatment of pernicious anemia.

(d) Cell mediated immunity is impaired in children

suffering from megaloblastic anaemia due to folic acid and Vit B12 deficiency.

**Requirement and intake**

The requirement of folic acid ranges from 50 µg to 100 µg. In pregnancy it increases to 150-300 µg. (6)

**Measurement**

Recent intake can be assessed by serum folate. Cellular status is assessed by red cell folate levels.

**Deficiency**

Dietary folate deficiency is not uncommon. Deficiency results in megaloblastic anaemia. Deficiency may be accompanied by depression, insomnia, forgetness, irritability and dementia. Low folate levels are also associated with neural tube defects. Lack of folic acid is known to cause accumulation of homocysteine (hyper-homocysteinaemia), which is a potential risk factor for coronary artery disease. High folate levels overcome the hyper-homocysteinaemia. Low folate levels can cause an altered methylation of DNA, increasing the risk of cancer. (4,5)

## Vitamin $B_6$ (Pyridoxine and Related Compounds)

**Recent Advances (Folic acid)**

- Various epidemiological studies indicated in the 1990s that elevation of plasma homocysteine is an independent risk factor for CVD and supplements of folates lower plasma homocysteine. A lot of work is being done to understand mechanisms involved. (9)
- Recent studies indicate that low folate levels increase the risk of colorectal & other cancers. It is being investigated if aberrant methylation of DNA results in the de-differentiation of genes & development of

Three naturally occurring pyridines - pyridoxine, pyxidoxal and pyridoxamine are collectively known as Vitamin $B_6$.

**Sources**

Meat, pulses and wheat are known to be rich sources while other cereals are fair sources of the vitamins. Fruits and vegetables are relatively poor sources. The extent to which processing of foods and cooking practices destroy vitamin $B_6$ depends largely on the food. In meat and milk, considerable amounts are lost, while in food of vegetable origin there are hardly any losses.

**Functions**

The three vitamins can be converted to the coenzyme pyridoxal 5 phosphate which is involved in the amino acid metabolism. These reactions include:

(a) Transamination of aminoacids to produce keto acids and synthesis of (non-essential) amino acids.

(b) Decarboxylation to yield biologically active amines eg neurotransmitters (adrenaline, nor-adrenaline, serotonin and GABA) and histamine.

(c) Porphyrin synthesis, including haemoglobin.

(d) It is also believed to have a role in the production of antibodies

**Requirement and intake**

The exact requirement for Indians has not been worked out but it is safe to believe that an intake of 0.6 - 2.5mg/day would meet the requirement. (6)

**Deficiency**

Deficiency of Vitamin $B_6$ is rare. It may be seen in patients suffering from malabsorption, patients on dialysis, or alcoholics. Symptoms include lesions of lips, corners of mouth and inflammation of tongue. Peripheral neuropathy is also a sign of vitamin $B_6$ deficiency.

## Vitamin $B_{12}$ (Cyanocobalamin)

**Recent Advances (Pyridoxine and related compounds)**

- Hyper-homocysteinaemia is most significantly associated with low folates, but there is also a significant association with low pyridoxine. High doses of this vitamin are shown to lower homocysteinaemia. (12)
- Inadequate levels of this vitamin are also likely to be associated with a higher incidence of hormone

Cobalamin is a complex molecule containing 4-percent cobalt, besides phosphorous and nitrogen. Cyanocobalamin is the commercially available form. Vitamin $B_{12}$ is the 'extrinsic factor' originally postulated by Castle. It requires the 'intrinsic factor', secreted by the parietal cells of the stomach, to be absorbed. It is freely soluble in water and resistant to boiling in neutral solution though unstable in the presence of alkalis.

**Sources**

It is unique among vitamins in that it is not present in any vegetable foods. It is present in animal products - milk, milk products, meat and fish. It is synthesized by the microorganisms in the gut and assimilated in the food chain.

**Functions**

(a) It recycles the folate coenzyme.

(b) Vitamin $B_{12}$ plays important role in the synthesis of DNA.

(c) It helps in maintenance of myelin in the nervous system.

(d) It has an important role besides folic acid in the treatment of pernicious anemia.

(e) It also helps in conversion of homocysteine to methionine.

**Measurement**

Serum $B_{12}$ is assessed by radioligand binding or microbiological assay. Absorption is assessed by Schilling test. (4)

**Requirement and intake**

The daily losses of this vitamin range from 0.25 mg to nearly 1mg. An intake of 2 mg per day has been recommended by FAO/WHO. The ICMR has, however, suggested a daily intake of 1mg of the vitamin for Indian adults. (6)

**Deficiency**

Since the vitamin doesn't occur in vegetable foods, vegans and strict vegetarians are at a high risk of its deficiency. Malabsorption, gastric atrophy, and reduced production of 'intrinsic factor' are some other causes of deficiency. Pernicious anaemia results which is a megaloblastic anaemia due to deficiency of this vitamin. Neurological symptoms characterized by loss of sensation and motor power in the lower limbs (due to degeneration of myelin) may also be seen. Since it is also synthesized in the gut many cases of vitamin $B_{12}$ deficiency are not seen very frequently.

## Pantothenic Acid

It is a pale yellow oily liquid that has never been crystallized, but its calcium salt crystallizes rapidly and this is the form in which it is generally available. Though stable in neutral solution, it is easily destroyed by heat.

**Sources and losses**

The best sources are liver, kidney, yeast, egg yolk, wheat germ or bran, peanuts and green vegetables. In most cooking and baking procedures there is little loss of the vitamin, but temperatures above, boiling point may cause considerable loss.

**Functions**

(a) This vitamin is a constituent of coenzyme A (CoA) which participates in pyruvate and fatty acid oxidation.

(b) It is also involved in acetylation of choline.

(c) It is also part of the prosthetic group of acyl carrier protein, which is important in synthesis of fatty acid, cholesterol and steroids.

**Requirement and intake:**

The exact requirement of Pantothenic Acid has not been ascertained. The average intakes are about 5 to 27mg/day, which seem to be adequate. (6)

**Deficiency**

Cases of 'burning feet' (parasthesia) responding to Pantothenic acid were seen during the First World War Depression, fatigue and muscle weakness were also known. Spontaneous deficiency is not seen now. (3,4)

## Biotin

Of the eight isomers of biotin only d-Biotin is biologically active.

**Sources and losses**

Yeast and colonic bacteria of many species either make or retain biotin. Kidney, liver, milk and dairy products are good sources. Raw egg white contains a protein, avidin that binds avidin and prevents its absorption. The effect is prevented by heating the egg white.

**Functions**

(a) It forms part of several enzyme systems; notably one that fixes $CO_2$ derived from bicarbonate ions and then incorporates the $CO_2$ in to the pathway of fatty acid synthesis. It participates in the pyruvate-carboxylase system.

(b) It is also involved in metabolism of branched chain amino acid.

**Requirement and intake**

There is little information concerning biotin requirements. Average intakes range between 15-70µg/day. (6)

**Deficiency**

Deficiency is rare but seen in patients on total parenteral nutrition. It is associated with exfoliative scaly dermatitis, glossitis, hair loss, anorexia, depression and hypercholesterolaemia. It is possible to induce deficiency by consuming a large number of raw eggs. B cell defects are also associated with lowered levels of biotin. (3,4)

## Vitamin C (Ascorbic Acid)

It is a water soluble, crystalline, white substance. Crystals remain stable in air and daylight. Ascorbic acid is very sensitive to oxidation, which is accelerated by heat, alkaline solutions, light and traces of metals, especially copper. The biologically active forms are L-ascorbic acid and L-dehydroascorbic acid. It is rapidly absorbed from the intestine. It is present in all body tissues but is found in a high concentration in the adrenal glands, pituitary gland, and intestinal wall. The white blood cells contain a higher concentration of ascorbic acid than the plasma. Excretion of ascorbic acid in urine depends on the blood and tissue contents.

**Sources and losses**

Its rich sources are citrus fruits (oranges, lemons), guavas, papayas, pineapple, mangoes, gooseberry (amla), kiwi fruit and green leafy vegetables. Root vegetables also contain vitamin C, esp. sweet potato. It is also synthesized in germinating seeds, pulses and grains.

The vitamin C content of fruits and vegetables is reduced by storage and damage to plant cells by rough handling, bruising or cutting, which results in release of enzyme ascorbic acid oxidase which oxidizes ascorbic acid. Also cooking of vegetables destroys vitamin C through the enzyme action and heat and by its extraction into cooking water. High pressure steaming as well as rapid frying of green vegetables destroys the enzyme thereby causing a greater retention of vitamin C than boiling.

**Functions**

Ascorbic acid is a powerful reducing agent (antioxidant) and is essential for many oxidation-reduction reactions.

(a) Ascorbic acid is required for the formation of collagen and is therefore necessary for the formation and maintenance of the normal structure of the intercellular ground substance (connective tissue), bone, tendons, skin, teeth and capillaries.

(b) It is important for hydroxylation of dopamine to nor-adrenaline

(c) It is required for the production of carnitine.

(d) It enhances the absorption of iron, through the conversion of ferric ($Fe^{3+}$) to ferrous ions ($Fe^{2+}$).

(e) It has anti-oxidant property like vitamins A and E, which has an important role in free radical scavenging, as an anti-aging and anti-cancer factor.

(f) It influences the maturation of the red blood cells, synthesis of bile and metabolism of drugs and carcinogens by the liver. (4)

**Requirement**

The requirement of vitamin C is 40 mg/day for adults. For lactating women 80 mg/day is recommended. (6)

**Deficiency**

Vitamin C deficiency is not common now. It causes defective formation of intercellular ground substance whose characteristic gross lesions occur in gums, bones and capillaries. Reparative process especially involving connective tissues, as in wound healing, are interfered in vitamin C deficiency due to the lack of the formation of collagen. Deficiency leads to a condition called as scurvy. The signs and symptoms include spongy and bleeding gums, perifollicular haemorrhages in the skin, sub periosteal haematomas and poor wound healing. Fatigue and muscle weakness is also reported. (4)

## Fat soluble vitamins

Vitamin A, D, E and K are the fat soluble vitamins. A brief description of each is given here.

**Recent Advances (Ascorbic acid)**

Vitamin C has assumed great importance as a free radical trapping antioxidant. It reacts with superoxide free radical (and a proton) to yield hydrogen peroxide or with hydroxyl radical to yield water. By its strong reducing property it reduces α-tocopheroxyl radical formed in cell membrane and plasma lipoproteins during oxidation of vitamin E, so sparing vitamin E. (5)

## Vitamin A (Retinol)

Hopkins conducted an experiment in young rats (1906-1912). These were fed on casien, starch, sugar, lard and inorganic salts. These rats failed to grow and died. An addition of only 3ml milk enabled them to thrive! An 'Accessory food factor' was thus demonstrated. Mc Callum isolated it in 1913 and was named as Vitamin A. Wald was awarded Nobel Prize for description of 'dark vision' and its association with Vitamin A. (2,13)

Vitamin A is a term for the biologically active compound retinol and its provitamin (precursor) carotenoids. Retinol is a fat soluble pale yellow compound. It is stable to heat at ordinary cooking temperatures but liable to oxidation and destruction on rancidity of fat. Retinol, consists of a hydrocarbon chain with a β-ionone ring at one end and an alcohol group at the other.

However, carotenoids cannot wholly be converted into retinol in the body and man absorbs and utilizes these pigments less efficiently. 6 microgram of β-carotene has the biological activity of 1 microgram. Other Carotenoids have even lesser vitamin A activity. (4)

**Sources and losses**

Retinol is found in foods of animal origin. The important sources of Retinol are meat, liver, kidney, milk, fish and eggs. Retinol can also be formed in the intestinal mucosa from the pigments known as carotenoids which are widely distributed in plants. Carotenoids are found in coloured fruits and vegetables. Only 50 of the approximately 600 naturally occurring Carotenoids get converted into vitamin A. Carotenes are found chiefly in association with chlorophyll, so that the green outer leaves of vegetables (e.g. cabbage) are good sources of carotene. One of these, β-carotene is by far the most important source of retinol (provitamin A) and is found in abundance in yellow-orange vegetables and fruits (e.g. pumpkin, papaya, mango, apricots, yellow peaches and green leafy vegetables). α-Carotene another carotenoid, is found in carrots, lutein in dark green leafy vegetables and β-Cryptoxanthin in citrus fruits. The pigments with **no** vitamin A activity include lycopene in tomatoes and zeaxanthin in sweet corn. (4)

Vitamin E protects it from oxidation. It is destroyed by exposure to sunlight. Foods which are heated for long period of time lose an appreciable amount of vitamin A. Boiling, canning or freezing of foods does not cause loss but drying and dehydration causes considerable loss.

**Retinol Equivalents**

Vitamin A activity of a diet is usually expressed in retinol equivalents. As mentioned, the term vitamin A is applied to both retinol (preformed vitamin A) and pro-vitamin A (beta-carotene). One microgram retinol is considered as 1 retinol equivalent (1RE). It is also known that the biological activity of 6 µg beta Carotene has an activity of 1 µg retinol (or 1 µg beta Carotene = 0.167 µg RE). International unit or IU is an old unit and is sometimes used.1 IU is equal to 0.3 µg of Retinol.

**Physiology**

After absorption retinol is carried from the intestines as retinol palmitate in chylomicrons and is taken up by the liver and stored there. Animals can store retinol sufficient to meet their needs for several months. It is released from the liver as retinol and circulates in blood bound to a specific transport protein, retinol-binding protein (RBP), the transthyretin (previously known as pre albumin) which forms complex plasma prealbumin. This serves to maintain the vitamin in aqueous solution, protects it against oxidation and also delivers the vitamin to target tissues (eye tissues, various epithelia, etc) (5)

**Functions**

(a) It is vital for the formation of retinal pigment rhodopsin in rods of the retina. Exposure to light results in a series of changes in its configuration, which leads to the adaptation of vision in dark. Retinol deficiency leads to impairment of dark

adaptation or night blindness.

(b) Retinol is essential for integrity of cellular structure esp. epithelial tissue respiratory, gastrointestinal, genitourinary and skin.

(c) It has a role in the immune defence mechanism of the body.

(d) Vitamin A has an anti oxidant property of free radical scavenging. (For details refer to section on antioxidants)

**Requirements**

The recommended intake is 600 mg of retinol equivalent per day per adult including children above 6 years and pregnant women. Lactating mothers require 950 mg. In converting the carotene figures to retinol, a conversion factor of 0.25 has been suggested by ICMR. (6)

**Recommended Dietary Allowance**

For vitamin A the RDA is given in terms of retinol (vitamin A alcohol). If the diet contains vitamin A and carotene, its content can be expressed as retinol using the following formula:

Retinol content =µg retinol + µg of β-carotene X 0.25

**Deficiency**

Deficiency of Vitamin A leads to ocular and extra ocular manifestations. The ocular manifestations are more common. The ocular manifestations resulting from vitamin A deficiency are termed as Xerophthalmia. Deficiency is often seen to be associated with weaning, protein energy malnutrition and a diet poor in vegetables, fruits, milk and butter. Socio-economic factors like educational status, income, poverty; cultural beliefs like misconceptions on breast feeding, faulty weaning practices and poor environmental sanitation /hygienic practices, infections and infestations contribute to vitamin deficiency.

## Vitamin D (Calciferols)

The term Vitamin D refers to two molecules ergocalciferol (Vitamin $D_2$) and Cholecalciferol (Vitamin $D_3$). Cholecalciferol is the natural form of vitamin and is produced by the ultraviolet irradiation of 7-dehydrocholesterol widely distributed in animal fats such as the oily secretions in mammalian skin. Dietary ergocalciferol & cholecalciferol are biologically inactive and are activated to 25 hydroxy-cholecalciferol in liver. Further conversion in the kidney results in the production of the more active form 1,25-dihydroxy cholecalciferol (Calcitrol). (13)

**Food sources**

Cod liver oils oily fish, milk, margarine, eggs, liver

**Functions**

Vitamin D regulates the absorption and excretion of calcium from the small intestine and also plays an essential part in the mechanism for mineralizing bone. It is considered as a hormone rather than a vitamin. (4)

**Measurement**

### Recent Advances (Vitamin A)

**Genomic action of Vitamin A**

Vitamin A performs certain genomic actions through nuclear actions or modulating gene expression by activation of nuclear receptors. In the presence of all-trans or 9-cis-retinoic acid the receptor heterodimers are transcription activators. In the absence of retinoic acid the heterodimers still bind to the DNA, but act as repressor of gene activator. It is therefore now understood that both deficiency & excess of retinoic acid causes severe developmental abnormalities (5).

**Vitamin A in cancer prevention**

Vitamin A acts as antioxidants, trapping singlet oxygen generated by photo between chemical reactions or lipid peroxidation of membranes. Many studies have indicated a negative association between Vitamin A intake and cancer incidence (5).

Vitamin D status can be assessed by the measurement of plasma 25-hydroxy-cholecalciferol. In severe deficiency plasma calcium and phosphate fall and alkaline phosphatase is elevated.

**Requirement and intake**

The vitamin D requirement for a child is placed at 100-400IU/day. This requirement can be obtained from exposure of the body to sunlight. ICMR expert group therefore has not recommended any dietary intake. Whenever this requirement is not met, a therapeutic supplementation may be needed. (6)

**Deficiency**

People who stay indoors and are fully covered (purdah system amongst women) are at a higher risk of deficiency due to lack of exposure to UV radiation due to sunlight. Malabsorption also increases the risk of deficiency. Severe deficiency results in rickets in children, characterized by reduced calcification of bone epiphysis. It results in skeletal deformities, bone pain and muscle weakness. In adults deficiency results in osteomalacia.

## Vitamin E (Tocopherol)

Eight naturally occurring forms of vitamin E are synthesized in plants; four tocopherols (α, β, γ and δ tocopherols) and four tocotrienols (α, β, γ and δ tocotrienols). Alpha tocopherol which is synthesized commercially has the highest biological activity, and is used as the standard against which activity of other forms is measured. Being fat soluble, vitamin E is found in all cell membranes. (4)

**Sources**

Vitamin E is widely distributed in foods and the richest sources are vegetable oils like groundnut, sunflower, safflower, cotton seed, corn, wheat germ, rape seed, palm and other oils. Nuts (like almonds and peanuts) are also good sources. Eggs, butter, whole meal cereals are moderately good sources. Meat, fruits, vegetables contain small amounts. Foods rich in PUFA are also rich in Vitamin E.

**Functions**

(a) Like vitamin A and C, it has a strong antioxidant property and protects cell membranes and lipoproteins from damage from free radicals. It also prevents the non-enzymic destruction of polyunsaturated fatty acids by molecular oxygen.

(b) It maintains the cell membrane integrity.

(c) It has a role in the DNA and prostaglandin synthesis.

**Requirement & intake**

The human requirement of vitamin E is not known with certainity. (6) The US authorities have recommended an intake of 12mg/day.

**Deficiency**

Deficiency of vitamin E in animals interferes with normal reproduction and causes a form of muscular dystrophy, but the effects if any, on human being are being studied. However a genetically inherited disease Familial Isolated Vitamin E (FIVE) deficiency is known. Patients develop reduced tendon reflexes by age 3-4, loss of touch and pain sensation, unsteady gait, loss of coordination and impaired eye movement in adolescence. (4) Deficiencies have also been seen in people with severe fat malabsorption. (5)

## Vitamin K

It exists in nature in two forms. Vitamin $K_1$ (phylloquinine), originally isolated from lucerine, is the only form that occurs in plants. It is a yellow oil, soluble in fat solvents, but only slightly soluble in water. Vitamin $K_2$ (menaquinone) is produced by bacteria in the lumen of large intestine.

**Food sources**

Green leafy vegetables, vegetable oils esp. soya bean oil, eggs, meat and dairy products are good food sources of vitamin K.

**Function**

(a) Vitamin K promotes the synthesis of γcarboxy glutamic acid (Gla) in the liver which is an essential for Prothrombin (or factor II) and also factors VII, IX and X. It is well known that these factors participate, in the coagulation of blood.

(b) Some other proteins also contain Gla and require vitamin K for their synthesis e.g. osteocalcin, a bone protein made by osteoblasts. (4)

**Requirement & intake**

No recommendations are given by the ICMR. The US authorities recommend an intake of 120µg for males and 90µg for females.

**Measurement**

Coagulation assays are traditionally used for screening of vitamin K deficiency. Under-carboxylated vitamin K dependent proteins that are produced when vitamin K is in short-supply or is blocked by antagonists e.g. warfarin, can be assayed.

**Deficiency**

This is characterized by poor blood clotting and results in low prothrombin activity. Neonates are born with very low stores of vitamin K due to sterility of intestines (and absence of bacteria producing vitamin K). So neonates are given an injection of this vitamin at birth. Adults rarely manifest the deficiency, but can be seen in cases of obstructive jaundice as lack of bile leads to poor absorption of vitamin K. The anticoagulants warfarin and dicoumarol can cause a deficiency.

Vitamin contents of common food items are given in Table - 1 on next page.

Table - 1 : Vitamin content of selected food items (per 100g) (2)

| Food stuff | Carotene (µg) | Thiamine (mg) | Riboflavin (mg) | Niacin (mg) | Folic acid (µg) | Vitamin C (mg) |
|---|---|---|---|---|---|---|
| Wheat flour | 25 | 0.49 | 0.17 | 4.3 | 35.8 | 0 |
| Rice polished | 0 | 0.06 | 0.06 | 1.9 | 8 | 0 |
| Bajra | 132 | 0.33 | 0.25 | 2.3 | 45.5 | 0 |
| Maize dry | 90 | 0.42 | 0.1 | 1.8 | 20.0 | 0 |
| Bengal gram | 189 | 0.30 | 0.15 | 2.9 | 186 | 3 |
| Soya bean | 426 | 0.73 | 0.39 | 3.2 | 100 | - |
| Beans | 187 | 0.10 | 0.06 | 0.7 | 45.5 | 24 |
| Spinach | 5580 | 0.03 | 0.26 | 0.5 | 123 | 28 |
| Carrot | 1890 | 0.04 | 0.02 | 0.6 | 15 | 3 |
| Groundnut | 37 | 0.90 | 0.13 | 19.9 | 20 | 0 |
| Guava | 0 | 0.03 | 0.03 | 0.4 | - | 212 |
| Amla | 09 | 0.03 | 0.01 | 0.2 | 600 | |
| Egg | 420 | 0.1 | 0.40 | 0.1 | 78.3 | 0 |
| Liver sheep | 6690 | 0.36 | 1.7 | 17.6 | 188 | 20 |
| Milk cow | 53 | 0.05 | 0.19 | 0.1 | 8.5 | 2 |
| Fish (Hilsa) | - | - | - | 2.8 | - | 24 |
| | | | | | | |

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Lt Col Rajul K Gupta

# Minerals

Minerals are required in small quantities and constitute only a small portion of the body weight but enter into the metabolism to a much greater degree than their mere weight indicates. A large portion of the ash of the body is composed of calcium, magnesium, sodium, potassium, phosphorous, sulphur and chlorine. The main functions of the minerals include: providing rigidity and relative permanence to the bones and teeth; providing essential elements for the formation and activities of the muscular, glandular, neural, and epithelial tissues; forming components of enzyme systems; and providing dynamic characteristics to the intra and extra cellular fluids for regulation of pH, osmotic pressure and electro-neutrality and those of secretion and excretions. (1)

## Classification

Minerals can be classified into macrominerals and microminerals. Macrominerals also referred to as major minerals are distinguished from the microminerals by their occurrence in the body. Taking this as criterion, various definitions of macrominerals have evolved, such as “those which constitute atleast 0.01% of body weight (5g in a 60 kg man)” ; or a more quantifiable and unambiguous definition like “mineral whose requirement is more than 100mg per day”. Calcium, phosphorous, magnesium, sodium, potassium, chloride and sulphur are the macrominerals. (2)

A precise definition of microminerals or trace elements has not been established. Some define trace elements as those that comprise less than 0.01% of total body weight or more appropriately those which are needed in a concentration of less than 1ppm. (3) These were initially known as trace because their concentration in tissues could not be easily ascertained by early analytic methods. (4) Iron appears to be the mineral that divides the macrominerals from microminerals. Thus a trace element (or micromineral) can be defined as one that is required by the body in the concentration equal to or less than that of iron. (5)

An element is termed 'essential' if a dietary deficiency of that element consistently results in a suboptimal biological function that is preventable or reversible by physiological amounts of the element. (6) Microminerals include iron, zinc, iodine, copper, manganese, molybdenum, selenium chromium and flourine. Cobalt, nickel, tin, silicon vanadium, arsenic and boron can be classified as ultra-trace elements. (2)

## Calcium

Calcium is essential for the building of bones and teeth. It is the most abundant mineral in the human body, maximum is deposited as hydroxyapatite, in bones and teeth. Constant levels of calcium in the body/ plasma is maintained under the influence of parathyroid hormone and calcitonin. Factors promoting absorption of calcium are vitamin D, proteins and lactose.

### Sources and losses

Rich sources of calcium are milk and milk products, ragi, fish which is eaten whole, custard apple (Sitaphal), dried fruits such as raisins, apricots and dates, and betel leaves with lime, pulses and tofu.

Calcium in food is not uniformly available to the body e.g. calcium in vegetables and fruits is poorly absorbed due to the presence of oxalic acid in these foods which forms insoluble calcium oxalate. Spinach is one of the foods which is very rich in oxalic acid. Phytic acid in the pericarp of cereal grains unites with calcium to form phytin, which is not absorbed. However, many cereals such as rye and wheat contain an enzyme phytase, which splits phytic acid so that it no longer binds calcium and makes it available for absorption. Excess of fatty acids, particularly saturated fatty acids in the small intestine may form insoluble soaps with calcium and may carry significant amount of calcium into faeces. Calcium in milk and dairy foods is more readily absorbed. (7, 8)

### Functions

(a) Calcium is essential for providing the structural rigidity to bones and teeth.

(b) It is responsible for the maintenance of optimum excitability of the nervous and muscular tissues.

(c) It has an important role in the coagulation of blood as factor IV.

(d) It acts as a co-factor for a number of enzymes e.g. lipase. (9)

### Requirement and intake

The suggested levels for calcium intake for adult men and growing children are 400 to 600mg/day.In case of pregnant and lactating women it is 1000mg/day. (10)

### Deficiency

Plasma Calcium levels are tightly controlled and are not usually affected by dietary insufficiency in healthy adults. Reduction in the level of circulating ionised calcium produces a clinical condition known as tetany. This is characterized by twitching of muscles of face, hand and feet. Cardiac arrhythmias may also result. A long term calcium deficiency during the bone formative age can cause stunted skeletal growth and a low bone density. Vitamin D deficiency leads to rickets in children due to poor calcium absorption. (9)

## Phosphorus

Phosphorus is the most important macromineral next only to calcium. Calcium utilization is closely linked to phosphorus as calcium is deposited as calcium phosphate. An adult human body contains about 400-700 g of phosphorus as phosphate, most of this occurs in

bones and teeth. (10)

**Sources**

Phosphorus is widely distributed in food stuffs and therefore, its deficiency rarely occurs. Milk, milk products, cereals, meat, fish, nuts, fruits and vegetables are good sources. A large part of phosphorus present in vegetable foods occurs in combination with phytin (fibre) and is available to the body only to the extent of 40-60 percent.

**Functions**

(a) It is essential for the formation of bones and teeth along with calcium as hydroxyapatite.

(b) It also plays an important role in all metabolism for derivation of energy from the phosphate bonds in adenosine triphosphate (ATP).

(c) It is an important constituent of nucleic acids, phospholipids and membranes. (11)

**Requirements**

It is suggested that phosphorus intake should be about 1 g per day that is about twice as great as that of calcium. (10)

**Deficiency**

Phosphorus deficiency is unlikely to occur as it is widely available in foodstuff. However hypophosphataemia may occur in pathological conditions (sepsis, liver disease, alcoholism, diabetic ketoacidosis) patients on prolonged parenteral nutrition, hypophosphataemic rickets and excessive use of aluminium-containing antacids. (9)

## Sodium

An adult male has total body Sodium of about 92 g, almost equally divided into the extracellular fluid and bone. In the blood and interstitial fluid it is found to be largely combined with chloride & bicarbonate. Intracellular fluid contains about a third of the sodium content of the extracellular fluid (9).

**Sources**

Sodium chloride is the best and most common source of sodium; 3 g salt is roughly equivalent to 1.2 g of sodium. Indian diet is particularly rich in sodium (pickles, chutneys, etc.). It is also present in food additives like monosodium glutamate, mainly used in Chinese cuisine.

Absorption takes place from the stomach and the entire alimentary tract rapidly. Excretion takes place through urine and sweat. (10)

**Functions**

(a) Sodium is the main cation in the extracellular fluid of human body.

(b) It is important in the blood pressure regulation

(c) Sodium is an important cation in maintaining the transmembrane electrolyte gradient.

(d) Acid-base regulation is a function of sodium. It also maintains the osmotic pressure

(e) It is a vital component of the electrophysiological control of muscles and nerves.

(f) It takes part in the structure of cartilage and muscle cells. (9)

**Requirement**

The daily intake varies from 2 to 20 gm/day. The recommended daily intake of sodium chloride is about 5 g. (10)

**Deficiency**

Excessive sweating as in hot and humid climates and extreme exertion, diarrhoea and dehydration can lead to sodium deficiency.

## Potassium

The adult human body contains about 250 g of potassium. Potassium occurs widely in foodstuffs, so there is little likelihood of its deficiency. It is the principal intracellular cation.

**Sources**

Most foods contain useful amounts of potassium, particularly those of vegetable origin. Fruits like banana, apricots, fruit juices, vegetables including potatoes, pulses, meat and whole grain cereals are good sources. Chocolates and coffee are also good sources.

**Functions**

Along with sodium, potassium too is involved in acid-base regulation and the electrophysiology of nerves and muscles. These two ions are essential for the cellular uptake of molecules through the sodium-potassium pump. (9)

**Requirements**

The daily requirement of potassium has not been determined accurately. (10)

**Deficiency**

Dietary deficiency is not common. However deficiency could be caused by diarrhoea, vomiting, dehydration, purgatives, chronic acidosis or alkalosis, diuretics, etc. Potassium deficiency affects the electrophysiology of cell. It may cause cardiac arrhythmias and muscle weakness. (9)

## Magnesium

All human tissues contain small amounts of magnesium. The adult body contains about 25 g of the metal and greater part of this amount is present in bones in combination with phosphate and bicarbonate. About one fifth of the total magnesium in the body is present in the soft tissues, where it is mainly bound to protein. Inside the cells, the metal is concentrated within the mitochondria.

**Sources**

Most foods contain useful amounts of magnesium, particularly those of vegetable origin. Green vegetables, pulses, meat, nuts and whole grain cereals are good sources. Hard drinking water may make a significant contribution to magnesium intake.

**Functions**

(a) Magnesium Is an integral part of bones and teeth.

(b) Within the mitochondria it is a co-factor for co-carboxylase and co-enzyme A and is concerned

with Intracellular energy metabolism.

(c) It is important in the replication of DNA, synthesis of proteins and RNA.

(d) It is essential for muscle and nerve cell function.

**Requirements**

Requirements are estimated to be about 350 mg/day for adults. (10)

**Deficiency**

It is unlikely that magnesium deficiency would arise in man from simple lack of food. Vitamin D appears to increase magnesium absorption from the intestine. Excessive losses of magnesium in the faeces or urine occur in many diseases e.g. renal or adrenal disease, malabsorption, use of some drugs (e.g. diuretics) and in re-feeding syndrome. Magnesium deficiency leads to apathy and muscular weakness and sometimes to tetany, convulsions, cardiac arrhythmias and cardiac arrest. (9)

## Iron

It is one of the most important micronutrients and is of fundamental importance to life. The body of an adult human contains about 4 g of iron, of which more than two thirds (about 2.4g) is present in haemoglobin. The rest of the iron in the body is present as a reserve store in liver and to a lesser extent in the kidney, spleen and other organs.

**Sources, Transport & Losses**

The sources of iron can be divided into two main groups:

(a) Haem iron sources

These are essentially the non-vegetarian sources of iron eg meat, fish and eggs. Milk is considered a poor source of iron but breast milk is an efficient source for the infant, as iron is absorbed well from it.

(b) Non-haem iron sources

These are the vegetarian sources, namely cereals, dark green leafy vegetables, pulses, nuts and dry fruits. Absorption of iron from these foods is only 10 to 20 percent.

Non-haem iron is poorly absorbed (1 - 20%) and is influenced by dietary constituents. Certain compounds like Phytic acid (in cereals, fibre), polyphenols (in plants), tannins (in tea), phosphates (in milk and eggs) present in foods of vegetable origin inhibit the absorption of iron. There are also factors in the diet that increase non-haem iron absorption, such as red meat, fish, chicken and liver. Ascorbic acid and low pH also enhance the absorption of non-haem iron. Haem-iron is absorbed directly into the mucosal cells where iron is released by haem oxidase and then bound to transferrin.

Maximum absorption of iron takes place in duodenum and upper part of small intestine. The amount of iron absorbed from a given meal depends to a large extent on the iron status of the individual. Iron absorption increases during growth and pregnancy.

When the body needs iron it passes directly through the mucosal cells and is transported by transferrin to the bone marrow. If iron is not required it is stored in the mucosal cells as transferrin. It will be lost in faeces when the mucosal cells are exfoliated. Excess iron is stored as ferritin or haemosiderin in the liver, spleen, or bone marrow. It can be mobilized from these stores when demand is increased.

It is lost mainly during menstruation and from the gastrointestinal tract. Physiological losses from all other routes (exfoliation from alimentary, urinary and respiratory tract and by dermal and hair losses and losses in the sweat) also occur. Excretion of iron is very low (about 1 mg/day in men).

**Functions (9, 11)**

(a) Iron is a component of haemoglobin and myoglobin.

(b) It is also a constituent of important enzymes like cytochromes, catalase, peroxidase, etc. As a part of these haemocomplexes and metallo-enzymes, it serves important functions in oxygen transport and cellular respiration.

(c) It is also involved in cellular immune response for appropriate functioning of phagocytic cells.

(d) Iron is known to play a part in imparting an optimum cognitive functioning of the brain.

**Requirements**

The requirement of iron is quite small, in the vicinity of 1 to 3 mg/day, depending on the age, sex and the physiological status. But since the absorption of iron is rather poor, diet should contain 10 to 25 fold iron. Hence the RDA of iron is about 28 mg for males and 30 mg for females (38mg for pregnant females). (10)

**Deficiency**

Iron deficiency anaemia is the most common nutritional deficiency in the world. It is estimated that up to half of all women and two-thirds of all pregnant women have anaemia esp. in developing countries. The common physical signs include: pallor, fatigue, breathlessness on exertion, insomnia, giddiness, anorexia and tachycardia and in severe cases oedema. (9)

## Iodine

*"Iodine-deficiency is a colossal public health problem in*

**Recent Advances (Iron)**

**Pro-oxidant activity of Iron**

There is no doubt in the fact that iron is an important mineral involved in various vital metabolic functions. But lately, a pro-oxidant role of iron is being studied. Excess iron promotes lipid per-oxidation and tissue damage in vitro. There is a possibility that, via these pro-oxidant effects, disturbances in iron metabolism play a pathogenic role in many diseases. Therefore iron may be potentially harmful in some situations, especially during preexisting inflammation and disease. (12) For more details section on 'Antioxidants' (Applied

*India. Survey upon survey has shown that out of the 26 million children born each year, as many as 13 million are at risk of suffering from iodine deficiency disorders."*

**- Union Health Minister Shri Anbumani Ramadoss (2005)**

It is an essential trace element because it is an integral component of the thyroid hormones: thyroxine and triiodothyroxine, both of which have important metabolic roles. Iodine deficiency is endemic in the mountainous areas with poor soil content such as the sub-Himalayan regions. This is due to iodine being washed from the soil. Its deficiency causes the widely prevalent preventable iodine deficiency disorders that affect all ages: abortions, still births, cretinism, mental retardation, deaf-mutism, dwarfism and goiter.

### Sources and losses

The presence of iodine in the food is a function of the iodine content of local soil. Among the natural foods the best sources of iodine are seafoods and vegetables grown on iodine-rich soils. Dairy products, eggs, cereal grains, legumes and green leaves (spinach) are also reasonable sources of iodine. Water contains traces of iodine which contributes to as much as 10% of our total iodine intake.

Certain vegetables of *Brassica* group such as cabbage, cauliflower and radish contain goitrogens such as thiocyanates and cynoglycosides. Consumption of large quantities of these foods may lead to the development of goiter by making the iodine present in food unavailable to the body. Goitrogens are inactivated by heating. Dietary iodine absorbed from the small intestine follows two main pathways within the body. Approximately 30 percent is used up by the thyroid gland for the synthesis of thyroxine hormone; the remainder is excreted in the urine. (9)

### Functions

(a) Iodine is a component of the thyroid hormones thyroxine ($T_4$) and triiodothyronine ($T_3$).

(b) Thyroid hormones maintain the body's metabolic rate by controlling energy production and oxygen consumption in cells.

(c) They are required for normal growth and development.

(d) In the fetus and neonate normal protein metabolism in the brain and CNS requires iodine.

### Requirement

The daily requirement of iodine is 150µg for an adult. (10)

### Deficiency

Endemic goiter of varying degree is found in a large proportion of the population in India, where the soil and thus food materials are deficient in iodine. Iodine deficiency of varying degree is found in almost all districts in India.

(a) **Adults:** Iodine deficiency disorder (IDD) in adults results in hypothyroidism and raised levels of TSH, which cause hyperplasia of thyroid tissues resulting in goitre. Hypothyroidism is characterized by lethargy, poor cold tolerance, bradycardia, and myxoedema.

(b) **Fetus & infants:** In the fetus, IDD results in cretinism. This is characterized by mental retardation, hearing, speech defects, squint, disorders of gait, and growth retardation.

(c) IDD is also linked to an increase in the rates of still birth, miscarriage, and infertility.

Fortification of salt with iodine is carried out to reduce IDD. The PFA act has specified an iodine concentration of 30 and 15 PPM in salt at source and consumer ends respectively thereby providing 150 mg of iodine in 10 gm of salt.

## Fluorine

It is normally present in the bones and teeth and is essential for the normal mineralisation of bones and formation of dental enamel.

**Recent Advances (Iodine)**

**Detection of iodine in salt**

It must be appreciated that mere iodination of salt does not ensure availability of iodine to the consumer. Iodine has a property to 'sublimate' and is thus constantly lost from its 'iodized vehicle (salt)' on keeping. It is therefore recommended to consume the iodized salt within a period of 6 months of iodization. There is a simple inexpensive rapid test (UNICEF) available to detect the level of iodine in salt. Test kits can be obtained by directing requests to MBI, 85 GN Chetty Road, III Floor, T

### Sources

Fluorine is widely but unevenly distributed in nature. It is found in many foods, but seafoods, cheese and tea are rich sources. However, the main source of fluorine to man is drinking water. The fluoride content of drinking water in India is about 0.5 mg/l but in fluorosis endemic areas, the natural waters have been found to contain as much as 3 to 12 mg of fluoride/l. A concentration of 0.5 to 0.8 mg/l in water is considered a safe limit in India. In temperate climate where the intake of water, is low, the optimum level of fluorine in drinking water is accepted as 1 mg/l. (14)

### Deficiency

Deficiency of fluoride in water below 0.5 mg/1 is usually associated with dental caries.

### Excess

Ingestion of large amounts of fluorine (>2-3ppm in water) is associated with dental and skeletal fluorosis. Skeletal fluorosis has been reported to be health problem in rural districts of Andhra Pradesh, Haryana, Karnataka, Kerala, Punjab, Rajasthan and Tamil Nadu. Scientists working at the National Institute of Nutrition Hyderabad found new form of fluorosis characterized by *genu valgum* and osteoporosis of the lower limbs in some districts of Andhra Pradesh and Tamilnadu.

## Zinc

Zinc is present in small amounts in all tissues of the body.

Total content of the body is over 2.0 g.

**Sources**

Zinc is widely distributed in food stuffs of both animal and vegetable origin. Good sources of zinc are meat, whole grains and legumes. Its bioavailability in vegetable foods is poor due to presence of phytate which impairs its absorption.

**Requirement**

The daily requirement of Zinc is about 15 mg in men and 12 mg in women. (15)

**Functions**

(a) It is part of over 100 enzymes including carbonic anhydrase, alcohol dehydrogenase, alkaline phosphatase, super oxide dismutase, collagenase, leucine aminopeptidase, aldolase, RNA polymerase and pancreatic carboxypeptidase; and is thus of importance in protein and carbohydrate metabolism, bone metabolism, and oxygen transport.

(b) Zinc is a powerful antioxidant.

(c) Zinc is important in the immune response and gene expression.

(c) Zinc stabilizes the structure of DNA, RNA, and ribosomes. (9)

**Deficiency**

A clinical syndrome characterized by small stature, hypogonadism, mild anaemia and low plasma zinc occurs in older children and adolescents in poor peasant communities in Iran and elsewhere in Middle East, where the staple diet is unleavened bread. The zinc intake is low and its absorption is impaired by phytate in the unleavened bread. However the common deficiency symptoms are:

(a) Severe deficiency results in growth retardation, failure to thrive, delayed sexual maturation esp in children.

(b) Deficiency of zinc impairs cellular immune mechanism while excess of it may depress neutrophils.

(c) Zinc deficiency may present as a tetrad of symptoms comprising of neuro psychiatric changes, dermal lesions, diarrhoea and alopecia (Acro - dermatitis Enteropathica). Zinc supplementation has been found useful in these conditions. (9,15)

## Copper

It is an essential trace element as it is a component of many metallo-enzyme systems and iron metabolism is closely dependent on it. The amount of copper in the adult body is estimated to be 80 -100mg. Copper is widely distributed in nature and therefore primary copper deficiency in adults has never been reported in adult man. Even poor diets provide enough copper for human needs.

**Sources**

Meat, nuts, cereals, fruits

**Functions**

Many metalloenzymes contain Copper. These enzymes have the following important functions: (9)

Caeruloplasmin (Ferrioxidase 1)- Iron oxidation & transport

| | |
|---|---|
| Superoxide dismutase | - Antioxidant |
| Cytochrome-c oxidase | - Electron transport |
| Dopamine hydroxylase | - Hydroxylation of Dopa in brain |
| Tyrosinase | - Formation of melanin |
| Clotting factors V and VIII | - Thrombogenesis |

**Requirement**

Suggested daily intake is 1-2 mg. (10)

**Deficiency**

Copper deficiency is rare. Hypocupraemia occurs in patients with nephrosis, Wilson's disease and sometimes in protein energy malnutrition. Neutropaenia is the commonest documented abnormality of copper deficiency. Infants, especially those who are premature, may develop copper deficiency which usually presents as chronic diarrhoea. Neutropaenia and later anaemia develop and they do not respond to iron. Menke's disease, a rare hereditary defect of copper absorption is invariably fatal. Copper deficiency may be a risk factor for coronary heart disease as it has been associated with raised plasma cholesterol levels and heart-related abnormalities.(9)

## Chromium

There is some evidence that chromium is an essential nutrient for man. Investigations of the relationship of the element to carbohydrate metabolism are suggestive of its possible role in human nutrition. Chromium is believed to be part of an organic complex known as the 'glucose tolerance factor' (GTF), which potentiates the action of insulin. The evidence for essentiality of chromium comes from observations of patients receiving total parenteral nutrition who develop diabetic symptoms. The symptoms respond to chromium treatment but not insulin. Studies on the use of chromium in the management of type 2 diabetes are not conclusive. Chromium may participate in lipoprotein metabolism.

**Sources**

The richest sources of chromium in the diet are meat, whole grains, legumes, and nuts. It is also present in significant amounts in drinking water.

**Requirement**

There are no RDAs for chromium. The average daily intake of chromium for adults is estimated as 0.1 mg. (10)

**Deficiency**

Chromium deficiency in man is evidenced by impairment of glucose tolerance, low tissue concentrations and low concentrations of glucose in urine and raised plasma cholesterol and triglyceride levels, weight loss, neuropathy, depressed respiratory quotient and abnormal nitrogen metabolism. Deficiency in humans has only been observed in patients receiving long-term total

parenteral nutrition. (9)

## Selenium

There is a resurgence of interest in the mineral selenium due to its antioxidant properties. It is an essential component of glutathione peroxidase, an important enzyme.

### Sources

Meat, fish, nuts and eggs are good sources. Lacto-ova vegetarians and vegans may be at risk of deficiency.

### Functions

Selenium is an integral part of over 30 selenoproteins; the most important of which are glutathione peroxidases and iodothyronine deiodinases. Glutathione peroxidase has an important role in the detoxification of peroxides and free radicals. Iodothyronine deiodinases are involved in the production of triiodothyronine from thyroxine. It also contributes to antibody responses, the production of eicosanoids as well as cytotoxicity of natural killer cells. (9)

### Requirements

Recommended daily intake is 70 µg. (11)

### Deficiency

Its deficiency has a wide range of symptoms, not all attributable to glutathione peroxidase. Its deficiency is associated with increased coronary artery disease. Keshan disease (endemic cardiomyopathy) in China and Kashin Beck syndrome, an osteo-arthropathy in children of 05-13 years age is seen in selenium deficient areas. (9,10)

## Molybdenum

**Recent Advances (Selenium)**

**Selenium and cancer prevention**

Epidemiological studies reveal an inverse relationship between serum selenium and cancers at several sites including prostate, colon, lung and non-melanoma skin cancers. (16)

Evidence that Molybdenum is an essential trace element is based on the fact that it is part of the molecular structure of the three enzymes; xanthine oxidase, sulphite oxidase and aldehyde dehydrogenase.

### Sources

Meat, nuts, cereals, bread, green vegetables are good sources. The amount of Molybdenum present in plants varies greatly depending on the soil, being relatively high in those grown on neutral or alkaline soil with a high content of organic matter and low in those grown on acid sandy soil. Consequently, dietary intakes vary but are usually within 0.5 to 2.0 mg/day.

### Function

Molybdenum functions as co-factor in xanthine oxidase, suiphite oxidase, and aldehyde oxidase and is involved in the metabolism of purines, pyrimidines, quinolines, and sulphites.

### Requirement

There are no recommended intakes but safe intakes are believed to be between 0.15 to 0.5 mg. (10)

### Deficiency

Primary deficiency is unknown in humans, but an inborn error of metabolism results in abnormal coenzyme production. It is characterized by abnormal urinary metabolites, neurological and ocular problems, and failure to thrive. The condition in the most severe cases can be fatal. Association between deficiency of Molybdenum and cancer of mouth and oesophagus has been recently reported.

## Cobalt

It is a constituent of vitamin $B_{12}$, an essential nutrient for man for methionine biosynthesis and propionate metabolism. It has been suggested that cobalt may be necessary for the first stage of thyroxine production i.e. capture of the iodine by thyroid. Cobalt is present in many foods, in cooking utensils, and even in atmosphere (at least in industrial cities). It is readily absorbed in the intestinal tract, but most of the absorbed element is excreted in urine.

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Lt Col Rajul K Gupta

# Nutritive Values of Commonly used Food Items

Our food comprises of many foodstuffs. The major foodstuffs are cereals, pulses, nuts, oilseeds, sugar, jaggery, fruits, vegetables, roots, tubers, milk, eggs and flesh foods. A brief description of the basic food items used is given here.

## Cereals

These form the staple food for human diet as they are cheap and have a high energy value. In an agricultural country like ours, rice, maize, wheat, and millets form the bulk of the diet. Thus the nutritive quality of the staple cereals is of great importance in India. Cereals are rich sources of carbohydrates and moderate sources of proteins. A predominantly cereal diet should invariably contain supplementary sources of protein; for vegetarians, pulses are very valuable in this respect.

Cereals contain no vitamin C and little carotene. Whole (unrefined) cereals are relatively good sources of the vitamin B complex, whereas refined cereals such as white flour and highly milled rice lose much of their vitamin content in processing. This is because the vitamins are concentrated in the outer layer of the whole grains, which are removed by machine milling. (1)

Machine milling and refining cause a considerable deterioration of nutritive value of staple human foods and of public health. For example, beriberi is endemic in countries where polished rice is habitually eaten. On the other hand, the absorption of nutrients decreases with an increase in the extraction rate. As a result the whole meal flour has lower energy value than white flour. Nevertheless, the lower digestibility of the protein of whole meal flour is compensated by higher contents and biological value of its proteins. (2)

Much of the phosphorus is present in the form of phytic acid in the fibrous part of the grain which forms insoluble phytates with calcium and iron, thus preventing absorption of these minerals. Atta produced for the Armed Forces is of 85 percent extraction, and not more than 5 percent bran is permitted to be removed during milling.

Parboiled rice is the only cereal which does not suffer appreciably when machine milled. The parboiling process consists of steaming the paddy after preliminary soaking so that the outer husk splits and becomes easier to remove. This also causes the B group vitamins in the outer layers to diffuse in to the interior of the grain. Rice supplied in Armed Forces rations is either undermilled or parboiled.

## Pulses

These comprise dried peas, beans, dals and grams. Dals are arhar, moong, urd massor or channa. They have high protein content, although with biological values inferior to foods of animal origin like meat, fish eggs and milk. They are, nevertheless very suitable for supplementing the vegetarian diet. Pulses are cheap and a valuable source of calcium, iron and vitamin B. Bengal gram (dal channa) and to a lesser extent green gram (dal moong) contain a small amount of ascorbic acid in the dry state. Soya bean is a pulse which has a high protein and fat content. The nutritive value of soya bean proteins is equivalent to milk proteins even though the protein quality is inferior. The consumption of unprocessed soya bean as dal is however, not acceptable to many. (1)

The ascorbic acid content of all unsplit pulses can be increased by germinating or sprouting. Whole unsplit dal or gram is first soaked in water for 12 to 24 hours and then spread on a damp blanket in a thin layer to allow access of air and covered with another blanket kept damp by sprinkling water. In a few hours small sprouts appear; when these are 10 to 20 mm long the process is complete. The vitamin C content is maximal after about 30 hours of germination. Boiling for 10 min causes a loss of vitamin C by 15 to 30%. Germination causes an important increase in vitamin B also. (3)

## Meat

It is a rich source of high quality protein and a good source of most B vitamins esp. nicotinic acid. It contains principles necessary for the prevention of nutritional anaemia and promotes haemopoiesis and thus has special blood forming properties. The protein of meat is qualitatively as good as that of fish, egg, milk, cheese and other dairy produce. Meat is rich in phosphorous but poor in calcium. Liver has first rate source of protein, vitamin A and the whole of the vitamin B complex. Meat extracts are of use in hospital dietetics on account of their mild stimulant action on the secretion of gastric juice. Meat extracts must also be regarded as a reasonably good source of vitamins of the B complex. The forms of preserved meat that may be issued in the Armed Forces rations are meat curried (mince and chunk), solid meat pack, dehydrated meat and accelerated freeze dried (AFD) meat.

## Milk

This being the sole food for growing young animals, it is as nearly complete a food as exists in nature. All the important nutrients are well represented in milk except iron, nicotinic acid and ascorbic acid. On the average, one liter of cow's and buffalo's milk respectively yield 32 g and 43 g of protein, 41 g and 88 g of fat, 44 g and 50 g of lactose, 520 mg and 480 mg of retinol, 670 and 1170 Kcal (2.8 to 5.02 Mj) of energy and 1200 mg and 2100 mg of calcium. (1)

Milk proteins are caseinogen (85%), lactalbumin (12%) and lactglobulin (3%). These proteins are of high biological value. Milk fat is an emulsion of extremely fine particles of

the glycerides of butyric, palmitic and oleic acid rendering it easily digestible and this is especially so in cow's milk. Newly drawn milk contains 2 mg of vitamin C per 100 ml but this readily disappears on storage, heating or processing in any other way.

### Curd

When lactose in milk is broken down to lactic acid by bacterial (lactobacilli) action, the proteins are coagulated by the acid and the curd is formed. Curd and whole butter milk have the same nutritive values as that of the original milk from which they are prepared and are easily digestible. Whole milk, curd and butter milk, are all very good sources of protein, calcium, vitamin A and riboflavin. They are indispensable for the feeding of children and adolescents up to young adult age, pregnant women, lactating mothers, patients and convalescing persons. Skimmed milk and butter milk made from it have less fat content than the whole milk due to extraction of butter.

### Cream, butter and ghee

Cream, butter and ghee are gradations of fat extracted from milk. Cream has nutritive value in between whole milk and butter. Good butter should not contain more than 16 percent of water and not less than 80 percent of fat. 100gm butter yields about 730 Kcal (3.05 Mj) and 960 mg of retinol. 100 g of ghee yields 900 Kcal (3.76 Mj) and 270 mg of retinol, which is, however, destroyed if ghee is used as a frying medium.

### Ration issue of milk

The milk issued in the ration is either a mixture of buffalo's and cow's skimmed milk, designated as standard milk, or a mixture of buffalo's whole milk and powder skimmed milk, designated as blended milk. The fat content of both these types of milk should be 3.7%, solids not-fat (SNF) 8.5 to 9.0%, and total solids not less than 12.5%. (4)

When fresh milk cannot be made available whole powdered or tinned milk is supplied. Tinned milk may be condensed, evaporated or homogenized; condensed milk may be sweetened or unsweetened. Condensed milk contains 50 percent cane sugar, which is a good preservative. Dried or powered milk is reconstituted by adding 7 volumes of boiled water just before consumption. Tinned milk should be reconstituted as per instructions given on each tin. Tinned or powered milk after reconstitution conforms to the specifications laid down for fresh standard or blended milk except that it is deficient in vitamin C.

### Eggs

Eggs contain all the nutrients required for the embryo. They have a high nutritive value. The proteins are of a high biological value. The NPU of egg protein is 100 and is taken as the standard protein, to compare other proteins with. The fat is present in the yolk. It is finely emulsified and hence easily assimilated. The minerals and vitamins exist in the yolk, which is also a valuable source of calcium, phosphorus, iron and vitamins A and D. The white of the egg is one of the best sources of riboflavin.

Eggs in rations are issued by number. For average estimations, the minimum weight laid down is not more than 25 eggs to a Kg, and not less than 35g per egg. Eggs are issued in hospital dietary and high altitude rations as well. In other rations they are issued in lieu of meat. Egg powder may be issued if fresh eggs are not obtainable.

### Vegetables

Vegetables esp. green leafy vegetables are rich in carotene, ascorbic acid, calcium, iron and riboflavin. The carotinoids and vitamin C possess antioxidant properties. The carotene of green vegetables like drumstick, amaranth and methi is better utilized than of yellow vegetables. A progressive loss of vitamin C occurs when vegetables are stored, bruised and cut. Cooking of green leafy vegetables in small quantity of oil increases the retention rate of carotenes to between 41 to 100%.

Gourds are generally of poor nutritive value; but the bitter gourd is relatively rich in ascorbic acid, and the yellow pumpkin is a fairly good source of carotene. Root and tuber vegetables are of variable nutritive value. Most of them contain moderate amounts of ascorbic acid. The carrot is outstandingly rich in carotene. Potatoes and sweet potatoes having high carbohydrate content have a good fuel value and contain moderate quantities of ascorbic acid. The tomato has good ascorbic acid and riboflavin contents. Onion has no outstanding nutritive properties, but is virtually irreplaceable because of its value as a flavouring agent and appetizer.

Canned vegetables have nutritive values almost equal to that of fresh, well cooked vegetables, except that 50% vitamin C is destroyed during processing. Dehydrated vegetables lose some ascorbic acid and vitamin A in processing and the remaining vitamin C is unstable. Vegetables processed through accelerated freeze dying process however retains most of the nutrients to a very high degree. (1)

### Fruits

Fruits are classified into citrus, non-citrus and dried varieties. They are inexpensive sources of antioxidants. Citrus fruits are rich in vitamin C. Guavas are a very rich source of vitamin C. Papaya and mango are rich in carotene and moderately rich in vitamin C. Banana and plantain have energy value but are not particularly good source of vitamins. Bottled lime juice supplied to hospitals and canteens are usually synthetic and completely devoid of vitamin C. The loss of vitamin C in cooking of fruits and in the process of canning and bottling is less than vegetables owing to the acids in fruit juices. Dried fruits contain neither thiamine nor vitamin C. Dried apricots, prunes and yellow peaches are a good source of carotene. (1)

### Nuts

Nuts have a high fat and protein content and hence a high energy value. Groundnuts are a good source of vitamin B complex. The protein of groundnuts is of low biological value. Multipurpose food (MPF) is flour made from a mixture of 75 percent groundnuts from which fats have been extracted and 25 percent roasted red gram. It is rich in protein and is fortified with vitamins and minerals.

## Fats and Oils

Vegetable oils such as mustard, groundnut, gingelly, coconut and safflower oils are widely used for cooking purposes. Vegetable fats (except red palm oil) are free of any vitamin A activity and contain predominantly unsaturated fatty acids. Coconut and palm oils are rich in saturated fatty acids. More details have been given in the section on lipids.

## Sugar

It is pure sucrose and is used for its sweetening effect and energy value. Excessive consumption of such purified food at the expense of energy provided in protective food lowers the vitamin, mineral and protein intake. On the other hand troops do benefit from a fairly liberal sugar ration: hot sweet tea is a traditional reviving agent for fatigued troops. Jaggery contains an appreciable amount of carotene and iron. Jams have the nutritive value of sugar & increase the palatability of diets. (5)

## Condiments, Pickles and Chutney

Most people use spices to flavour food and improve its palatability. They are essential to the culinary art and by stimulating the appetite improve health. They have little nutritional value as they are used in very small quantities. Green or dry chillies have a high carotene and vitamin C content. Pickles and chutney are appetisers. Tamarind has preservative effect on vitamin C if cooked along with vegetables. Turmeric, cloves and red chillies have been shown to have antioxidant properties.

## Beverages

By themselves tea, coffee or other non-alcoholic beverages have no special nutritive properties except for the sugar and milk added; but due to caffeine which is a stimulant for the higher centers of the brain, they help to relieve fatigue. If used in excess they may cause insomnia and tachycardia in some individuals. Recent studies show that they contain substantial amounts of antioxidants, which have distinct health benefits. Alcoholic beverages have an energy value of 6 to 8 Kcal (25.1 to 33.4 Kj) per ml. Authorization in ration scales is, however, not guided by its energy value but is considered from the point of view of its immediate psychological effects.

## Vitamin Concentrates

Vitamin concentrates are normally available through ASC sources for supplementing dietary deficiency to prevent diseases and preserve health; and through medical stores for therapeutic purposes to treat ailments. The multivitamin tablets available through ASC contain vitamin A 5000 IU, vitamin D 500IU, thiamine 2 mg. Riboflavin 3 mg. Nicotinic acid 20 mg and ascorbic acid 75 mg and other vitamins of B group, Zinc, Selenium etc. They should not be issued unless there are clear indications that the rations are deficient in vitamins. With special ration scales, when the tablets form a component part of the rations the tablets are incorporated in the pack or scales themselves and the issue is automatic.

When an outbreak of vitamin deficiency disease is anticipated through continued absence or severe shortage of supplies of fresh fruits and vegetables or of meat and milk and their substitutes, authority to recommend vitamin tablets is vested in the DDMS Command. The issue is done on the orders of the Army Commander. The scale of issue for prevention of disease is one tablet per man per day. The multivitamin tablets issued through medical stores are much costlier than the ration compound tablets issued through ASC sources and contain therapeutic doses of all vitamins, including 10 components of vitamin B group, and 8 important minerals. Therefore, the tablets obtained through medical stores should not be issued in lieu of the ration multivitamin tablets issued by ASC.

## Effects of Processing Foods

Processing of foods involves cooking, tinning, dehydration, freeze drying (pre-cooked or uncooked), pickling, bottling, smoking, or making jams. Variable quantities of nutrients are lost during processing. Processed foods, however, do not normally form the actual constituents of dietaries in the Armed Forces to any appreciable degree under normal conditions. Dried or tinned food stuffs have to be issued under adverse tactical or operational conditions or to tide over the temporary administrative /logistic breakdown.

### Cooking

Effects of cooking vary greatly according to the method of preparation, cooking and serving. The losses occur mainly due to destruction by heat and / or extraction into washing or cooking water which is not consumed. The latter is the more important of the two. The losses affect the vitamins and minerals. To minimize vitamin C destruction in green vegetables they should be used when fresh, stored in cool damp places; crushing and bruising should be avoided; the cooking time should be reduced to a minimum and cooking water be used up while cooking or added to other items being cooked at the time. Food should be served as soon as possible after it is cooked. It is better to allow it to cool and reheat when necessary rather than keep it hot; this conserves more vitamin C. Rapid frying before boiling leads to conservation of vitamin C by hydrolysis of oxidase enzyme. (1)

### Tinning

Generally speaking, tinned foods have the same nutritional values as cooked fresh foods and are good substitutes for fresh items. On the other hand, a diet based on fresh items offers a much greater variety than a tinned diet. For this and administrative and financial reasons a military ration composed of fresh foods is preferable to tinned rations.

### Dehydration, Drying and Freeze Drying

Dehydrated and dried foods are those from which

moisture has been extracted by evaporation. 'Dehydration' is a term used when the evaporation has been carefully regulated as part of the factory process under controlled temperature and moisture conditions, with the intention that the essential characteristics of the food should not be altered and perfect reconstitution should take place when moisture is replaced. 'Dried' food is generally prepared by exposure to sun, which doesn't reconstitute exactly to the original quality. Freeze-drying is carried out by subjecting the foodstuffs to freezing and

Table 1: Nutritive value of common foods* (per 100g) (1)

| Food stuff | Proteins (g) | Fat (g) | Fibre (g) | Carbohydrates (g) | Energy (Kcal) | Iron (mg) |
|---|---|---|---|---|---|---|
| Wheat flour | 12.1 | 1.7 | 1.9 | 69.4 | 341 | 4.9 |
| Rice polished | 6.8 | 0.5 | 0.2 | 78.2 | 345 | 0.7 |
| Rice parboiled | 6.4 | 0.4 | 0.2 | 79 | 346 | 1 |
| Bajra | 11.6 | 5 | 1.2 | 67.5 | 361 | 8 |
| Maize dry | 11.1 | 3.6 | 2.7 | 66.2 | 342 | 2.3 |
| Bengal gram | 17.1 | 3 | 3.9 | 60.9 | 360 | 4.6 |
| Soya bean | 43.2 | 19.5 | 3.7 | 20.9 | 432 | 10.4 |
| Rajmah | 22.9 | 1.3 | 4.8 | 60.6 | 346 | 5.1 |
| Redgram | 22.3 | 1.7 | 1.5 | 57.6 | 335 | 2.7 |
| Beans | 1.7 | 0.1 | 1.8 | 4.5 | 26 | 0.61 |
| Spinach | 2 | 0.7 | 0.6 | 2.9 | 26 | 1.14 |
| Tomato | 0.9 | 0.2 | 0.8 | 3.6 | 20 | 0.64 |
| Carrot | 0.9 | 0.2 | 1.2 | 10.6 | 48 | 1.03 |
| Onion | 1.2 | 0.1 | 0.6 | 11.1 | 50 | 0.6 |
| Potato | 1.6 | 0.1 | 0.4 | 22.6 | 97 | 0.48 |
| Groundnut | 25.3 | 40.1 | 3.1 | 26.1 | 567 | 2.5 |
| Guava | 0.9 | 0.3 | 5.2 | 11.2 | 51 | 0.27 |
| Amla | 0.5 | 0.1 | 3.4 | 13.7 | 58 | 1.2 |
| Mango | 0.6 | 0.4 | 0.7 | 16.9 | 74 | 1.3 |
| Orange | 0.7 | 0.2 | 0.3 | 10.9 | 48 | 0.32 |
| Banana | 1.2 | 0.3 | 0.4 | 27.2 | 116 | 0.36 |
| Lime | 1.5 | 1 | 1.3 | 10.9 | 59 | 0.3 |
| Grape green | 0.5 | 0.3 | 2.9 | 16.5 | 71 | 0.52 |
| Grape blue | 0.6 | 0.4 | 2.8 | 13.1 | 58 | 0.5 |
| Papaya | 0.6 | 0.1 | 0.8 | 7.2 | 32 | 0.5 |
| Egg | 13.3 | 13.3 | - | - | 173 | 2.1 |
| Fish (Hilsa) | 21.8 | 19.4 | - | 2.9 | 273 | 2.1 |
| Chicken | 25.9 | 0.6 | - | - | 109 | - |
| Milk, cow | 3.2 | 4.1 | - | 4.4 | 67 | 0.2 |
| Milk, buffalo | 4.3 | 6.5 | - | 5 | 117 | 0.2 |
| Ghee | - | 100 | - | - | 900 | - |
| Butter | - | 81 | - | - | 729 | - |
| Veg oils | - | 100 | - | - | 900 | - |
| Cheese | 24.1 | 25.1 | - | 6.3 | 348 | 2.1 |
| Curd | 3.1 | 4 | - | 3 | 60 | 0.2 |
| Jaggery | 0.4 | 0.1 | - | 95 | 383 | 2.64 |
| | | | | | | |
| | | | | | | |

*Vitamin content of common foods is given in table 1 in the chapter on Vitamins

Table - 2: Calorie content of selected food items (per serving) (6)

| Food item | kcal | Food item | kcal |
|---|---|---|---|
| Samosa (1no.) | 256 | Dalia (1 plate) | 80 |
| Masala dosa (1no.) | 360 | Khichri (1 plate) | 160 |
| Kachori (2 no.) | 500 | Biscuits (4 no.) | 150 |
| Omlette (1egg) | 236 | Poha (1 plate) | 120 |
| Puri (4 no x 25g each) | 320 | Bread (2 slices) | 125 |
| Chapati with ghee (4 no.) | 360 | Chapati (2no x 35g each) | 160 |
| Cake (1small piece) | 250 | Kheer (1 katori) | 120 |
| Butter chicken (1 katori) | 400 | Cornflakes (1bowl) | 190 |
| Chiken biryani (200g) | 400 | Veg salad | 50 |
| Malai paneer (1katori) | 270 | Butter milk (1 glass) | 90 |
| Paratha (2no x 50g each) | 360 | Jam (2tsp) | 40 |
| Ice cream (100ml) | 250 | Dhokla (2 pcs) | 100 |
| Pastry (1 no.) | 290 | Green leafy veg (1katori) | 130 |
| Milk cake (1 piece) | 300 | Idli (2no x 55g each) | 155 |
| Butter (2tsp) | 180 | Dosa (2no x 45g each) | 250 |
| Fried Cashew (50g) | 375 | Tinned cheese (2tbsp) | 105 |
| | | | |

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Lt Col Rajul K Gupta

# Healthy and Unhealthy Diet

Not far back did we say "Eat drink and be merry!" Now the trend is changing, one tends to eat with caution. The notorious Roman banqueter was as uncomfortable as is the food over-indulgent of today. That, this truth was revealed to many is attested by the number of proverbs in various languages which instruct us the wisdom of moderation, for example :

'Eat only when hungry and drink only when thirsty, and never to leave the table with a feeling of satiety'

All this ancient wisdom prompts us to limit our food, then why does man eat or overindulge in eating? Why do we eat at all? The answer could be personal, philosophical, religious or merely a one liner 'because we feel hungry!'

## Why do we eat food: Functions of food

We eat to satisfy hunger, for satiety, to get energy for our day to day functioning. Food serves many functions in the body:

### (a) Food builds body tissues

The structural materials of food, proteins, minerals, vitamins and water are needed for growth and development. The food is also needed for the maintenance of the cells and tissues.

### (b) Food regulates body processes

Many a body processes are regulated by the 'fuel' supplied through food e.g. temperature control of the body, control of osmotic pressure, maintenance of hydrogen ion concentration of tissues, innumerable metabolic processes.

### (c) Food supplies energy

The macronutrients (carbohydrates, proteins and fats) supply energy. These provide constant source of fuel to the body. It is measured in terms of a kilo calorie or kcal, (the amount of energy required to raise the temp of 1kg water by 1°C).

### (d) Food gives us enjoyment

We want to enjoy food and entertain our guests with tasty food.

These requirements may be met by various combinations of the three major food constituents: carbohydrates proteins and fats, taken in different proportions. Although the actual distribution of each one of these nutrients in our daily diet is vital for good health, one hardly considers their proportion, as long as he enjoys the food. It must be appreciated that our lifestyle governs all facets of our life including our eating habits.

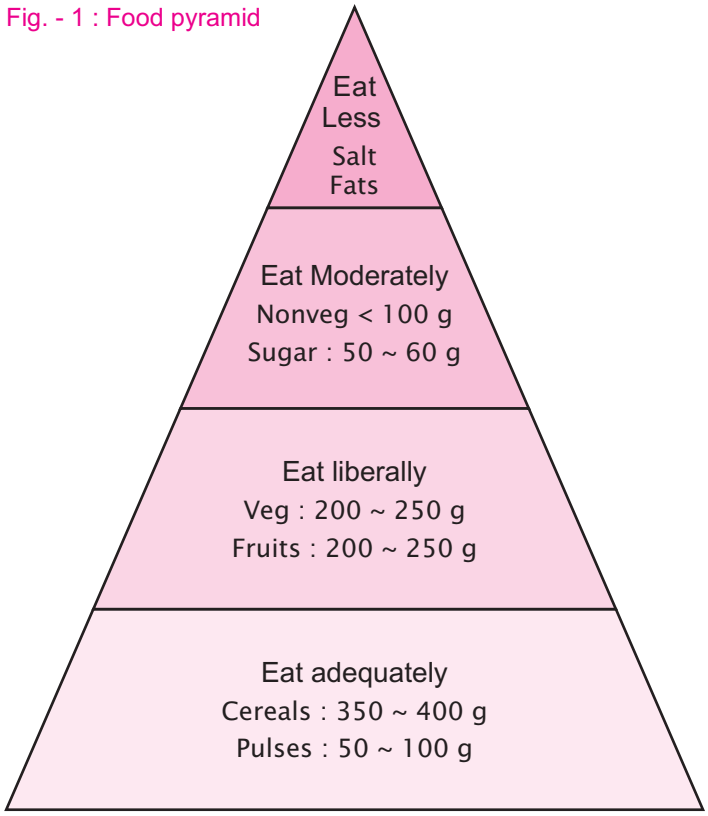
It is important to apply the knowledge of basic nutrition to real life situations to draw maximum benefits from it. We face some major nutritional problems in our daily life, both in the relatively healthy and those suffering from disease. Such situations arise mainly from the consumption of an unhealthy diet. Let us learn the basic principles of a healthy diet.

## Principles of a healthy diet

### Food Pyramid

The principles of a healthy diet for an average adult (2500 to 2800 kcal per day) can be summarized pictorially, through a food pyramid (Fig -1) (1). Foods depicted at the bottom of the pyramid (cereals, pulses, vegetables and fruits) are to be consumed in plenty. Foods in the middle of the pyramid, meat products and refined sugars, are consumed in moderation and the foods at the top (salt and oils) are sparingly consumed.

Fig. - 1 : Food pyramid




In other words, foods which give low calories (and low refined sugars), enough proteins, low fats and salts but lots of antioxidants, vitamins and natural fibre constitute a healthy diet. Such a diet is contributed to by whole grains, cereals, pulses, white meat, milk, low fat foods and plenty of fresh fruits and vegetables.

Besides fulfilling the biological requirement of

**Keeping bulk large and calories low ! An example...**

One liter of tomato soup and plain rice/dal will give the same satiety as one kg of butter chicken, but the former will give only 500 kcal while latter 4000 kcal. Therefore food items which are thin, watery, or made of grain, legumes & pulses give lesser calories than even much lesser quantities of fats and starchy foods. It is recommended to eat "low energy dense" items like fresh fruits, vegetables, raw salad or meals cooked with little amount of oil.

energy, food caters to the important psychological cue of satiety. So, one eats not only to meet the nutritional requirements, but also because one needs to be psychologically satiated each and every time he sits to dine. Such satiety depends on the "bulk" of food rather than the count of calories. Therefore the quantity of food, besides of course the quality also decides, as to which food is healthy or otherwise. Therefore one may aim to keep the bulk large and the calories low.

**How much oils and fat is healthy? (2,3)**

Let us recapitulate the basic principles with respect to consumption of fats and oils. It is recommended that:

(a) Not more than 20 to 30% of all calories should be obtained from fats.

(b) Out of this not more than 7% (of the total energy) should be from saturated fatty acids.

(c) The trans-fatty acids intake should be negligible (less than 1%) of daily energy intake.

(d) Adequate intake of PUFAs: 6-10% of daily energy intake, with an optimal balance of n-6 PUFA (at 5-8%) and n-3 PUFA (1-2%) levels of daily energy intake, respectively.

(e) Intake of MUFA should make up rest of the daily energy intake.

(f) Daily cholesterol consumption should be restricted to less than 300mg/day, mainly through restriction of dairy fats and red meat.

(g) Restrict intake of fats from dairy and red meat sources, avoiding use of hydrogenated oils and fats in cooking.

These dietary goals (with respect to fats) are translated into actual dietary intakes. Details of these are given in a subsequent section.

**Low Sugars**

Consumption of refined sugars must be restricted to less than 50-60 g of sugar per adult per day.

**Low Salt**

About 5 g of daily intake of salt is recommended for each individual. Low intake of sodium is helpful in the prevention of hypertension and other cardiovascular diseases.

**Plenty of fruits & vegetables**

A daily intake of 400 grams of a variety of fresh, seasonal fruits and vegetables (other than potatoes) is recommended for an adult. (2)

**High fibre in diet**

A daily intake of 35-40 g of fibre in diet is recommended. The fibre must be a combination of soluble fibre (pectin, gums, mucilages) and non soluble fibre (cellulose, lignin and hemicellulose). Unprocessed grains (cereals), seeds (legumes), green leafy vegetables, fruits and nuts contain plenty of fibre. (4)

**Avoid red meat**

Red meat contains high amounts of fat. High intake of preserved and red meat is also associated with high incidence of colorectal carcinoma. Heterocyclic amines, created by cooking, haeme-iron and specific fatty acids could be responsible. Therefore non vegetarians should prefer lean meat (fish or chicken) rather than mutton, pork and beef. (5)

**Low calorie foods**

As a general rule, food that is low in calories, but which can fulfill the daily requirements of energy in a balanced manner is considered as healthy. To keep the calories low in the diet the upper limit of calories intake must be limited to the recommended values for sex and activity level. Fats and oils are the most concentrated source of energy so intake of fats and oils must be restricted, as mentioned earlier. Similarly excessive intake of carbohydrates (cereals and starchy foods like potatoes) must also be discouraged. Some low calorie foods are given in Table - 1 (6).

Table - 1: Calories provided by one typical serving of some low calorie foods

| S. no. | Food item | Approximate quantity per serving | Calories per serving |
|---|---|---|---|
| 1 | Dalia | 1 plate | 80 |
| 2 | Khichri | 1 plate | 160 |
| 3 | Dhokla | 2 pieces | 100 |
| 4 | Poha | 1 plate | 120 |
| 5 | Biscuits | 4 numbers | 150 |
| 6 | Kheer | 1 katori | 120 |
| 7 | Bread | 2 slices | 125 |

## Unhealthy diet as a contributory factor to life style diseases

The changes in dietary patterns, as part of altered lifestyle in both developed and developing countries, have led to a markedly rising trend in chronic non-communicable diseases : obesity, diabetes mellitus, cardiovascular diseases, hypertension, stroke and various forms of carcinomas (e.g. oral cancer, lung cancer, breast cancer, colonic cancer, etc)

These are significant causes of disability and premature death. Most importantly, these can be almost completely prevented if correct diet is consumed.

**What is unhealthy diet?**

To put it in very few words: food high in calories, fats and salt and low in fibre is unhealthy food. What qualifies for such a food choice?

High calorie fatty foods

High calories are provided by food rich in oils and fats. These foods could be any 'oil dripping' preparations or fried foods like the deep fried puris, kachories, samosas, pakoras, parathas, matar paneer, malai kofta, cheese

balls, meat preparations (mutton curry, butter-chicken) or simply lot of ghee on the roti/dal, sweets, cakes and pastries, etc. Table - 2 gives calories provided by one typical serving of these 'unhealthy fatty foods' (6). The high calories present in these foods increase weight and cause obesity. These foods are high in fats, esp saturated fatty acids and cholesterol, which are strong risk factors for cardiovascular diseases (hypertension, ischaemic heart disease, stroke) and some cancers. Repeated cooking/frying of these fats (saturated or unsaturated), turns them into a dangerous variety of fats called as the trans fatty acids (t-fatty acids). The trans fatty acids are considered as extremely dangerous for the cardiovascular system, as they reduce the HDL-c and increase LDL-c, thereby further augmenting the risk (2).

Table - 2: Calories provided by one typical serving of some fatty foods

| Food item | Approximate quantity per serving | Calories per serving |
|---|---|---|
| Samosa | 1 number | 256 |
| Masala Dosa | 1 number | 360 |
| Kachori | 2 numbers | 500 |
| Mathri | 1 plate | 500 |
| Puri | 4 numbers | 250 |
| Ghee roti | 4 numbers | 360 |
| Cake | 1small piece | 250 |

### Sugary foods

Such foods contain excessive refined sugar. Chocolates, cakes, candies, halwa, laddoos, ice creams, soft drinks, etc are some examples of such foods. These foods are also considered unhealthy. These foods have high glycaemic index and their consumption causes sudden spurt in blood glucose levels, which may be deleterious for health. They also contain high calories (e.g. 1 small piece of cake provides 250 Cal), which leads to an increase in body weight causing obesity and other diseases. In addition to these calorie related drawbacks, since most of these foods are commercial products, they contain chemicals, artificial colours, flavours and preservatives, which are generally unnatural and harmful, many of them being carcinogenic. Moreover, excessively sugary foods are also liable to cause dental caries.

### Junk foods

Fast foods are served quickly and conveniently at a relatively low cost and so are very popular especially amongst young people. These include burgers, pizzas, chips, French fries, wafers, colas, etc.

Junk food is generally a fast food that is devoid of nutritional value. For example burger and cola are nutritionally only refined carbohydrates and sugar. It contains empty calories and hardly any vitamins, minerals or proteins. Some common problems with these foods are:

(a) Most such menus lack vitamin A, folate, biotin, pantothenic acid and other vitamins.

(b) They are deficient in iron, calcium and copper and other trace elements.

(c) The calorie content of one such meal could be about 900 to 1800 calories, which is 33 to 66% of the RDA. Excessive consumption of these is liable to increase weight and cause obesity.

(d) Their sodium content is very high and potassium content low.

(e) Contain chemicals, artificial colours, flavours and preservatives

(f) The fat content of some of these meals may be as high as 50% of the total daily calories consumed.

(g) The ratio of saturated to unsaturated fatty acids may be unfavourable.

(h) The method of cooking may not be acceptable (deep frying / grilling). Also, the temperature at which food is fried, and if the cooking fat is reused, affects fat quality.

(j) Very costly and less beneficial.

Regular and consistent 'addiction' to fast foods may therefore be deleterious to health. (7)

### Low fiber foods

The processed products of refined cereals such as refined flour and maida e.g. noodles, pasta, cake, white-bread, pizza, macaroni, etc are low in roughage and fibre. Their consumption may cause constipation as compared to a diet that is high in fibre. Such foods are also poor in vitamins and minerals as these important micronutrients are lost with the husk of the grains during processing and refining. Regular intake of low fibre food poses a risk of certain cancers, e.g. cancer colon.

### High salt foods

Some dishes contain very high amounts of salt, for example pickles, sauce, salted fish, chutneys, etc. High salt content in the diet is known to be an important contributory factor to hypertension and heart disease. Consumption of such food articles is therefore not recommended.

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Lt Col Rajul K Gupta

# Diet & Lifestyle Diseases

Lifestyle is the way we live or the way we would naturally live our lives, if not coerced by outside influences i.e. circumstances or persons. It is an outcome of genetic influences, early childhood developmental influences and certain acquired traits and attitudes as a result of our interaction with the society.

Over the past decade or so our lifestyle has witnessed a sea change. What has changed is the way we live, the way we work. Our habits, our physical activity, levels of stress, reaction to situations, attitude to time and our very behaviour has changed. These are the changes in our lifestyle.

Rapid changes in diet and lifestyle have resulted from industrialization, urbanization, economic development and globalization of the market. This has had a significant impact on the health of populations esp. in the developing countries undergoing rapid socio-economic transition. Standards of living have improved, there have been significant negative consequences in terms of inappropriate dietary patterns and reduced physical activity and a corresponding increase in diet related chronic disease.

With changing lifestyle, probably diet has suffered the most. People resort to fast foods, snacks, high calories - low nutrient foods, colas and burgers, all of which are basically unhealthy foods. This 'changed diet' coupled with an altered lifestyle is deleterious to health.

## Diet related behaviour and lifestyle disease

There are a variety of diet related behaviours and other host issues that have a potential effect on a population's level of lifestyle disease. Timely and suitable modification of these can go a long way in prevention of these diseases.

### Snacking

Taking frequent snacks (snacking) is a part of our culture. One tends to snack at home, on social functions, at the office, in the college canteen or simply while watching television. These snacks are always over and above the normal 3 meals. Therefore we do not account for the calories provided by them, and they are often ignored.

### Implications of one samosa a day

One samosa and a cup of tea adds up to 300 calories. Taken over a month would add up to about 9000 calories, which is good enough to add 1 kg weight in a month, i.e. 12 kg of extra weight in an year!

It is not only the calories or the weight gain that matters, samosa provides the unhealthy trans (t) fatty acids as well. t-fatty acids would increase the triglycerides and LDL-c, and reduce the HDL-c, thereby increasing the risk of heart disease.

To negate the weight gain, it is recommended that one must walk. Walking 1km burns 75 calories. To reduce the 1 kg weight gained one must walk for 4 km every day and to reduce the 12 kg gained over an year, one has to walk or 1500 Km in a year, that is the distance between Pune to

The two issues in snacking are the content and frequency of consumption of snacks. The occasions of snacking increase the density of energy and its contribution to total energy. Snacks contribute to 20-25% of all energy in the food in the USA and UK and the same trend is catching up in urban India. The truth with Indian snacks is that most of them are rich in fats and calories eg samosa, kachori and pakori.

The solution is to avoid high fat snacks like samosas and replace these with low calorie snacks like salads, vegetable dips, fruit based snacks, salt biscuits, poha, dhokla, etc.

Similarly soft drinks which are an inevitable accompaniment with snacks esp for the young generation, are also unhealthy. They contain excessive refined sugar, high calories, artificial flavours and colours and are devoid of micronutrients. These can be easily replaced with fruit juices or other natural drinks like lemon-water, coconut water, etc.

### Eating out

In modern societies, the frequency of eating food prepared outside the home is increasing. This rising trend of eating out has coincided with the increasing prevalence of obesity. These foods prepared outside, are richer in energy, fat, esp. saturated fat, cholesterol and sodium but are poor in minerals and fibre. So these foods are nutritionally poorer than home made food. A change in this practice might be an important positive lifestyle change.

The portion size in prepackaged, ready to eat and restaurant foods is also important. Large portion size builds on the consumers' desire of value for money. "Super-sized' portions potentially lead to increased energy intake and could therefore be significant contributor to obesity and other lifestyle disease.

### Restrained eating, dieting and binge eating patterns

Many selective and restrained eaters are at a risk of dieting-overeating cycles. A rigid restraint eating pattern is associated with a greater risk of weight gain. Binge eating disorder and night eating syndrome are examples of this pattern. Such a pattern needs to be discouraged.

## Potential etiological factors in relation to lifestyle diseases in population

An undesirable lifestyle may be responsible for contributing to the three major lifestyle diseases namely cancers, CVD and diabetes. (1,2,3)

### Cancers

Obesity is convincingly related to risk of carcinoma of breast, colorectum, oesophagus, endometrium, kidney, etc. Also, the excess risk of these cancers increases continuously with greater adiposity. Similarly alcohol also convincingly increases the risk of carcinoma of oral cavity, larynx, liver, breast and colorectum. High intake of salted fish (e.g. Chinese style salted fish) also increases the risk

of various cancers.

**CVD**

Due to lifestyle changes not only the incidence of cardiovascular diseases is increasing but is affecting more and more younger people. This is an alarming trend. Coronary artery disease, hypertension, stroke, etc are rising. 'Poor' diet with excessive saturated fat intake and low fibre is an important contributory factor along with sedentary and stressful lifestyle.

Diabetes mellitus

Diabetes mellitus has reached epidemic proportions in developing countries in the past few decades, and the incidence is rising. The lowest rates of this disease are seen in rural communities where people retain their traditional lifestyle. Dramatic changes have occurred in communities where there have been massive changes in the type of diet, from traditional to typical western. Such changes are associated not only with diet but also with other lifestyle factors e.g. physical activity.

## Dietary modifications for lifestyle disease risk reduction

Many studies indicate that a change in lifestyle can reduce the risk of obesity, diabetes mellitus, CVD and carcinoma. A weight loss achieved by dietary changes and increased physical activity can go a long way to achieve risk reduction. Lifestyle modification, as far as dietary modifications are concerned would concentrate on reduction in total and saturated fats, increased dietary fibre, low calories and plenty of fruits and vegetables. The practical modifications that should be made in our day to day diet to reduce risk of lifestyle diseases are discussed in the subsequent paragraphs:

### Recommendations on fats: The preventive prescription

Dietary intake of fats, esp the qualitative composition of fats in diet, strongly influences the risk of lifestyle diseases, through effects on blood lipids, thrombosis, blood pressure, endothelial function, arrhythmogenesis and inflammation.

The dietary goals with respect to various kinds of fats can be achieved by limiting the intake of fat from dairy and meat sources, avoiding the use of hydrogenated oils and fats and substituting saturated fats with unsaturated plant oils.

**The calculations**

Calculating a scale of 25% of energy to be obtained from fats, for a daily requirement of 2400 Kcal a sedentary man needs to obtain 600 Kcal from fats. Half of these come from invisible fats (which are mostly unsaturated variety) and the other half need to be provided through apparent dietary sources (300 Kcal/day or above 33g of oil / fat per day). So in a month, one would need to purchase (33g x 30 days = 990g) about 1 kg oil/fat. Saturated fats (butter, ghee) should account for not more than 7 % or 1/10$^{th}$ of total daily requirement. This works out to about 240g of butter or ghee per month. The rest 760g should be obtained from some unsaturated sources. It must be appreciated that an Army soldier is not really a sedentary worker, but a moderate or heavy worker, requiring atleast 2800 - 3000 Kcal per day. On recalculating, the fat requirement for him we find that he requires 42g oil/fat per day, or about 1260g per month. Saturated fats ( butter / Ghee) should not exceed 300g per month.

Different vegetable oils available in the market have varied saturated and unsaturated (PUFA, MUFA) compositions. One must therefore use different oils like mustard, soyabean, groundnut, safflower, sunflower, rice bran, cottonseed, sesame etc in rotation, to obtain all types of unsaturated fatty acids.

**The preventive prescription on fats for lifestyle diseases**

- One must cater for 1 Kg of vegetable oil and not more than 168g of butter/ghee per adult in the family per month.
- For a family of 4 adults it works out to 4 Kg of vegetable oil and about 670g of butter/ghee per month.
- Out of these 4 kgs of oil to be procured in a month, one may purchase different varieties of oils (or rotate the oils over few months) to get an all round benefit.
- Regular intake of fish (1-2 times per week) provides PUFA and MUFA, rich in omega 3 fatty acids, beneficial for heart.
- Non-frying methods must be resorted to, rather than deep frying and baking with lots of butter/fats.
- Puris, parathas rich in oils should be substituted by plain rotis.
- Sweets with plenty of ghee and oils must be shunned.
- Snacks (kachoris, pakoris, cheese-balls, namkeens, etc) which are rich in oils must be avoided.

### Recommendations on carbohydrates

Cereals

A maximum of 60% of total energy intake ie, about 1700-1800 Calories should be obtained from carbohydrates for a sedentary male. About 450g carbohydrates per day would provide these calories. Carbohydrates in excess of this amount would result in accumulation of surplus calories, eventually leading to obesity. Excess intake of starchy food (potato as vegetables, chips, wafers, french fries, etc) also provides plenty of 'easy' calories, liable to cause obesity. It is also recommended that different cereals must be consumed in one form or the other. One cereal could be the staple cereal say wheat, but it is advisable to consume one other cereal say rice as the second parallel cereal. In addition to this other cereals eg corn, millet (bajra, ragi), etc should be used as snacks.

Fibre

Intake of whole grain cereals must be encouraged. Excessive milling of cereals leads to loss of the outer layer of bran and fibre. Thus consumption of whole grains provide adequate fibre. These can be obtained from brown rice, flour with higher level of bran ie coarse atta,

dalia and porridge. To ensure maximum intake of fibre, the flour (atta) should not be strained with a thin strainer, so that bran is incorporated in the flour. The bran should not thus be discarded. Pulses, beans and other legumes also provide valuable fibre, so they must be consumed aplenty. The fruits and vegetables contain abundant amount of fibres and must be consumed regularly.

**Recommendations on salt**

Sodium

Many studies have proved that the amount of sodium in diet is a definite risk factor for hypertension and heart disease. Sodium is present in common salt which is generally consumed without a second thought. The use of sodium should be limited to reduce the risk of lifestyle disease. An upper limit of 5g of salt is recommended so its use should be restricted to less than this amount (5g/day).

Potassium

Dietary intake of potassium lowers blood pressure and is protective against stroke and cardiac arrhythmias. Potassium intake should be at the level which will keep the sodium potassium ratio close to 1, i.e. at the level of about 5g/day. This could be achieved by adequate daily consumption of fruits and vegetables, in the amounts given above. Potassium enriched low sodium salt substitutes can also help achieve this balance.

**The preventive prescription on salt**

At a rate of 5g/day, for a family of four, salt consumption works out to about (5gX4) 20 g per day; or about 600g per month. The following recommendations are made:

- For a family of four adults, buy a 1 kg pack of salt and about 1/3rd should be left at the month end, which should either be discarded or included for in the next months 'quota' of 600g.
- Avoid foods containing excessive salt like pickles, sauce, tinned and preserved food, processed cheese, etc.
- Consumption of fast foods like burgers, pizza, French fries, chat, bhel-puri which contain high amount of salt must be discouraged.
- Never add any salt to the food on the dining table.
- Remove saltcellars from dining table, to discourage sprinkling of salt on ready to eat food.
- Avoid sprinkling of salt on fresh salads.

The other sources of sodium consumption should also

**Recommendations for fruits and vegetables**

Fruits and vegetables are clearly an important part of a good diet. "Eat your fruits and vegetables" is one of the tried and true recommendations for a healthy diet. Eating plenty of fruits and vegetables can help ward off lifestyle diseases: coronary artery disease, stroke, hypertension, Alzheimer's disease, cataract, macular degeneration, etc and prevent many cancers.

Fruits and vegetables contribute to health through a variety of phytochemicals, antioxidants, flavanoids, potassium and fibre. A variety of seasonal fruits and vegetables should be consumed. Adequate intake of fruits and vegetables (400-500g) every day is recommended to reduce the risk of lifestyle disease. A family of 4 must consume 1.5 - 2 Kg fruits & vegetables in a day or about 10 - 15 kg in a week.

Variety is as important as quantity. No single fruit or vegetable provides all the micronutrients needed to be healthy. The key lies in the variety of different fruits that one eats.

Quantity

An average Indian takes a maximum of just three servings of fruits / vegetables a day. The earlier dietary guidelines called for about 100g of fruits to be taken per day. However the guidelines have been changing with the stronger emerging inverse relationship between lifestyle diseases and fruits. Now the American authorities recommend as many as five to thirteen servings of fruits and vegetables a day, depending on one's caloric intake. For a person who needs 2,000 calories a day this translates to nine servings, or about 5 cups/portions per day. And this doesn't count potatoes (as potatoes are mostly starch). A typical portion can be defined as :

| | |
|---|---|
| (a) Melon, Pineapple | Large slice |
| (b) Fresh corn on the cob | 1 whole cob |
| (c) Apple, banana, orange | 1 fruit |
| (d) Small tomatoes | 6 tomatoes |
| (e) Grapes, cherries or berries | 1 cupful |
| (f) Fresh fruit salad | 2-3 heaped tsbp |
| (g) Dried fruit - raisins, apricots, dates, figs | 1/2-1 heaped tbsp |
| (h) Fruit juice | 1 glass (150ml) |
| (j) Vegetables, raw, cooked, frozen or canned | 2 heaped tbsp |
| (k) Salad | 1 dessert bowlful |

Variety

Since different fruits and vegetables have different nutritional benefits a wide variety must be chosen. A rough public health guideline could be to choose fruits of different colours. Moreover, seasonal fruits are recommended, as they are not only cheap but also available fresh.

How to meet this requirement

This requirement can be met by simply including some fruit and a couple of servings of vegetables at each meal i.e. lunch and dinner. For example: a glass of orange juice (freshly squeezed or from concentrate) at breakfast, together with a banana is equal to two portions. Similarly, a piece of fruit or some salad with lunch is equal to one portion. Vegetables included in the dinner, together with a fruity pudding are equal to at least two portions.

Role of frozen, dried or canned fruits

Fruit and vegetable intake can be augmented by including fresh, frozen, canned, dried or juiced fruit as well. The main aim is just to eat more of them! Although cooking reduces the level of some nutrients, there will still be useful amounts left. Dried fruits generally have less vitamin C and, although a concentrated source of sugar, they are usually high in fibre and other vitamins and minerals. Frozen vegetables are often frozen quickly after harvesting so they retain a good level of their vitamin content.

**Other Recommendations**

Sugar

Excessive intake of refined sugar is deleterious to health. Therefore its use must also be limited by all in general and by patients of diabetes, hypertension and heart disease in particular. The following recommendations are made:

(a) The recommended sugar intake is about 60-75g per adult per day.

(b) For a family of 4 the maximum sugar consumption works out to about (60gX4) 250g per day.

(c) Thus, for such a family composition, maximum sugar purchase should not be more than 7 kg per month.

Fish

Regular fish consumption is protective against CVD, stroke, etc. Fish is therefore recommended to be taken once or twice a week.

Alcohol

While regular low or moderate consumption of alcohol is protective against CVD, concerns about other cardiovascular and health risks associated with alcohol (stroke, hypertension and carcinoma) do not favour a general recommendation for its use. Moreover, alcohol is an energy dense nutrient (7kcal/gm) and because of its place at the top of oxidative hierarchy, its potential for sparing fat oxidation and promoting fat storage is significant. Generally, the snacks consumed with alcohol are also energy dense, which add to the calorie consumption. If consumed one should not exceed 2 units of alcohol per day. Complete cessation of cigarette smoking is a must.

Meat & eggs

Meat contains high amounts of fat so their use must also be limited quantitatively and qualitatively. The following recommendations are made:

(a) Non-vegetarians should restrict the consumption of red meat (beef, pork, mutton).

(b) Preserved meat (ham, bacon, salami, sausages) must also be limited.

(c) Prefer lean meat (chicken and fish) to red meat.

(d) Prefer marinated / baked / grilled dishes to oil dripping fried ones.

(e) Discourage high fat meat / cooked in thick gravies.

(f) Let meat be a part of meal, not the full meal.

(g) Egg yolk too contains high cholesterol so its use should also be restricted.

Hot foods

Consumption of very hot drinks and foods typically consumed in some cultures probably increase the risk of carcinoma of oral cavity, pharynx and oesophagus. It is recommended not consume foods/drinks when they are very hot (scalding hot).

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Lt Col Rajul K Gupta

# Antioxidants, Minerals and Diseases

## History

*Jules Verne*, the famous French author and visionary, author of the famous book '*Twenty thousand leagues under the sea*' wrote in 1865, in another of his novels *"From the earth to the moon"*, that "Oxygen... this gas without a smell, eminently vital, can cause the most serious disorders in the organism." No one believed him then, or even dreamt of the fact that oxygen could "cause the most serious disorders in the organism".

Oxygen toxicity in laboratory animals was however, first described in 1878 and was established in 1899. The first experiments investigating a free radical reaction were reported in 1894 by Fenton. But the attributability of retrolental fibroplasia among premature newborns to oxygen, had to wait till as late as the 1950s. And it was not until the 1960-70s when bronchopulmonary dysplasia in the new-born and the adult respiratory distress syndrome were appreciated by the medical community. It was thus only towards the later part of the last century that the free radicals and the role of antioxidants was scientifically well understood with the discovery of superoxide dismutase in 1969 (1).

The issue on which the present research is concentrated, the world over, is the role of micronutrients in lifestyle diseases. Even though a final word on the issue has not yet been said, there are epidemiological indications that the antioxidants and trace elements have a major role to play in the causation, modification and prevention of these diseases.

## Role of micronutrients

In context of the lifestyle diseases, the micronutrients can be grouped into two: the antioxidants and metals including the trace elements. Micronutrients are the key to optimal macronutrient metabolism because of their essential role in metabolism. Invariably, metabolic steps require the concomitant involvement of one or more vitamins and minerals. Chronic degenerative disease etiology and rate of pathogenesis are intimately associated with micronutrient imbalances. Although precise mechanisms remain to be identified, antioxidant status is critical in the pathogenesis of such diseases (2).

### Mechanism of oxidant injury

Reactive species like those of oxygen (reactive oxygen species), nitrogen (reactive nitrogen species) and chlorine (reactive chlorine species) are produced during normal metabolism: a certain amount of production of these reactive species is, in fact, necessary for proper health: for example, it helps the body's immune system to kill microorganisms. Reactive oxygen species are mainly produced in mitochondria and are formed in much larger amounts during activity than during rest (3,4). These species are oxidants - i.e., molecules or atoms which can oxidize a substrate and are reduced in this reaction. They are able to damage several key cellular components like membrane lipids, nucleic acids, carbohydrates and proteins, thereby severely disturbing major cellular and organic physiologic functions. This type of damage occurs when the host defenses against oxidants (for this reason called antioxidants) are quantitatively and/or qualitatively unable to counteract the production and effects of oxidants themselves. This state is referred to as oxidative stress and is known to be associated with a number of disease states in humans (5,6). To date, compelling evidence supports the important role played by oxidative stress in the pathophysiology of lifestyle diseases and the aging process.

### Antioxidant defence system

The antioxidant defence system provides protection against oxidative reactions and is organized at three levels namely prevention, interception and repair (7).

The interplay of all these processes and compounds in the network provides optimal protection to the organism. In oxidative stress related disease states and during aging the antioxidant micronutrients are consumed and their levels may fall below normal range (8,9,10).

Several components of the antioxidant defence system are micronutrients (e.g. vitamins C and E) or are dependent upon dietary micronutrients (e.g. copper, zinc and manganese, superoxide dismutase, etc). The antioxidant defences act as a coordinated system where deficiencies in one component may affect the efficiency of the others. Oxidative stress may be an important factor as much in infection as it is in chronic disease, if micronutrients are deficient (11).

### Sources of micronutrients

A wide range of natural sources have been shown to contain antioxidants. These include fruits, vegetables, nuts, plant extracts, herbs and spices. As is well known, antioxidants range from various vitamins including tocopherols, carotenoids, ascorbates, etc, whose sources are well established (fruits, vegetables and cereals) to various trace elements, eg Selenium. (12, 13)

Work is now being concentrated on other specific plant products namely polyphenols, which have significant antioxidant properties. Evidence for their role in the prevention of degenerative diseases such as cancer and cardiovascular diseases is emerging. A summary of polyphenols in food is given in Table - 1 (13).

### Implications to lifestyle diseases

Free oxygen radicals may be involved in several pathologic conditions. Oxidation of LDL-c is thought to play an important role in the development of atherosclerosis. Free oxygen radicals are apparently involved at different stages of cancer development. Free radicals may contribute to the autoimmune destruction of ß cells, leading to diabetes and may impair insulin action. Reactive oxygen species have also been proposed as mediators of inflammatory damage in asthma and in joints in rheumatoid arthritis. Furthermore, it has been suggested that the oxidation of lens proteins by free radicals play an important role in the process leading to cataract. (14)

Table - 1 : Polyphenols in foods (13)

| Polyphenol | Source |
|---|---|
| Protocatechuic acid | Raspberry |
| p-Hydroxybenzoic acid | Strawberry |
| Chlorogenic acid | Cherry |
| Coumaric acid | Plum |
| Sinapic acid | Apple, Pear, Coffee, Flour, Potato, Corn |
| Delphinidin | Black grape |
| Malvidin | Cherry, Strawberry, Red wine, Plum , Broccoli, Tea, Apricot, Apple, Beans, Black grape |
| Flavanones | Orange juice |
| Naringenin | Lemon juice |
| Isoflavones | Soy flour |
| Daidzein | Soybeans, boiled |
| Monomeric flavanols | Chocolate |
| Catechin | Beans |
| Epicatechin | Apricot, Cherry, Grape, Peach, Apple, Tea, Red wine |

## Antioxidants and cardiovascular diseases

### Atherogenesis

Several lines of evidence support a role for oxidative stress in atherogenesis. Epidemiological studies suggest that low levels of antioxidants are associated with increased risk for CVD,(15) while high vitamin E plasma levels have been shown to be associated with the absence of atherosclerosis in the elderly (16). The oxidation of LDL by the oxygen free radicals result in the unregulated uptake of modified LDL by macrophages in arterial walls, accelerating the atherosclerotic process. α-tocopherols, β-carotene and ascorbic acid can directly scavenge free radicals and help prevent the condition. These mechanism suggest that increased dietary intake of these nutrients would be protective against atherosclerotic vascular diseases. This was supported by the evidence from observational studies on vitamin E and β-carotene but the results of clinical trials have been variable. (17)

### Coronary Heart Disease

Antioxidant micronutrients have been postulated to exert protective effects against coronary heart disease (CHD). A meta-analysis has indicated that the relative risk reduction of ischaemic heart disease in high consumers of fruit and vegetables may be in the order of 15% (18).

#### Vitamin E

Vitamin E is thought to prevent atherosclerotic disease not only by its antioxidant effects, but also through its inhibitory effects upon smooth muscle proliferation and platelet adhesion. In supplementation studies in humans, á-tocopherol decreases lipid peroxidation, platelet aggregation and adhesion and is anti-inflammatory in nature. (19)

#### Flavonoids

Flavonoids are polyphenolic antioxidants, which occur in a variety of foods of vegetable origin, such as tea, onions and apples. Data from several prospective studies indicate an inverse association of dietary flavonoids and CHD (20). Benefit on stroke risk has also been reported(21).

#### Isoflavones

A composite analysis of 38 clinical trials found that an average consumption of 47 g of soy protein per day led to a 9% decline in total cholesterol and a 13% decline in LDL-c, in subjects free of CHD. Cholesterol lowering of this magnitude could potentially lower the risk of CAD by 20-40%(22). This effect of soy proteins was attributed to isoflavones, compounds that are structurally and functionally similar to estrogen. Several animal studies too suggest that intake of these compounds may provide protection against CVD(23). Besides their estrogenic activity, other suggested modalities of action are their thyroxine like activity, antioxidant activity and their effect on arterial compliance(24).

#### Folates

Homocysteine has been incriminated as an independent risk factor for CHD and probably stroke(25). There is also evidence which suggests that homocysteinaemia results in endothelial dysfunction, an effect that is reversed by oral folate supplementation(26). Folic acid is required for the methylation of homocysteine to methionine. Reduced plasma folate has been strongly associated with elevated plasma homocysteine levels and folate supplementation has been demonstrated to decrease those levels(27).

#### Sodium

High blood pressure is a major risk factor for CHD and stroke (both ischaemic and haemorrhagic)(28). Of the many risk factors associated with high BP, the dietary exposure most investigated has been daily sodium consumption. Sodium (salt) intake has been directly correlated with mean blood pressure and prevalence of hypertension in many populations. Comprehensive epidemiological evidence was provided by the INTERSALT study (29). The results of low sodium DASH trial further strengthen the conclusion that reduction of daily sodium intake, through salt restricted diets lowers BP effectively and is additive to the benefits conferred by the DASH diet (30).

Based on the observational and trial data so far available it would be justified to recommend a daily salt intake of less that 5g/d. Such a recommendation holds good even in tropical countries as sodium homeostasis regulates sodium excretion in sweat and urine (30).

#### Potassium

Cardioprotective effects of dietary potassium have been hypothesized as the basis for low CVD rates in populations consuming traditional diets and in vegetarians in the industrialized countries. The INTERSALT study provided evidence of an inverse association between urinary potassium excretion and BP

levels, across diverse populations (31).

**Cardiovascular Accidents (CVA)**

After a stroke (ischaemic or haemorrhagic) or trauma, the production of reactive oxygen species may increase, sometimes drastically, leading to tissue damage via several different cellular molecular pathways. It was shown that the plasma levels of vitamin C - but not of vitamin E, were inversely correlated with the size of the brain lesion. Also the plasma levels of vitamin C and of lutein were shown to be associated with functional outcome in patients with stroke of recent onset. In these individuals, lipid peroxidation was shown to be significantly higher compared to controls. It was also shown that short-term and long-term vitamin C supplementation increases the resistance of plasma to lipid peroxidation (7).

**Diabetes mellitus**

Diabetes mellitus represents a state of increased oxidative stress, which is based on evidence of increased peroxidation, glycoxidation and reduced antioxidant reserve (32).

It has been shown that oxidative stress has an adverse effect on glucose metabolism. Development of the disabling chronic complications of diabetes mellitus has also been attributed to oxidative stress (33). Recent research suggests that reactive oxygen species (including free radicals) may also be involved in the initiation and development of vascular complications in diabetics. Free radicals meet many of the criteria required for a role in the pathogenesis of diabetic vascular disease: they are present in tissues affected by the diabetic process, they have a direct toxic effect on tissues, under certain condition glucose molecules can induce free radicals production(32).

Vitamin E

Two cohort studies conducted in Finland reported that a low plasma level of vitamin E is associated with a 3.9 fold elevated risk of developing the disease. A nested case control study carried out within a cohort study reported that subjects with a high serum vitamin E level had a 39% lower risk of Diabetes compared to those with a low level of vitamin E. While the relationship between vitamin E and the risk of diabetes should be further investigated, there is insufficient evidence that an increased intake of this nutrient will prevent the disease (34).

Magnesium

Three large American cohort studies have reported a strong negative association between intake of magnesium and risk of type-2 diabetes. In the absence of any evidence regarding the mechanisms of action, it seems inappropriate to offer recommendations regarding intake (34).

Chromium

The relationship between chromium and glucose metabolism is being studied since the late 1950s. Anderson et al reported that subjects with mildly impaired glucose tolerance showed an improvement in glucose tolerance and a lower level of blood insulin after receiving chromium supplement (35). Another study in patients with type-2 diabetes showed improved glycaemic control with chromium supplements, compared with placebo (36).

Flavonoids

Recent research focussed on flavonoids shows a trend toward a reduction in risk of type-2 diabetes with higher intakes of flavonoids (fquercetin and myricetin) (29).

Although there is scarcity of data from controlled studies, anecdotal reports indicate that the use of these antioxidant vitamin and mineral supplements may be beneficial as an adjunct therapy in the management of diabetes and its complications. In particular, it has been reported that high doses of single micronutrient antioxidant supplements, such as vitamin E, may be beneficial to patients suffering from this disease (33).

**Cancers**

Even though it has been reiterated many times that fruits and vegetables probably reduce the risk for cancers of the oral cavity, oesophagus, stomach and colo-rectum, but role of specific micronutrients in the prevention of various cancers is still under study. Some of the probable mechanisms relating micronutrients to cancer are enlisted below:

Prevention of cancer by micronutrients: Mechanism

(a) Several phytochemicals like flavanoids, isothiocyanates and allyl sulphides derived from fruits and vegetables are potent modulators of the enzyme systems responsible for metabolizing carcinogens, which can decrease the incidence of cancer (37).

(b) Antioxidants such as vitamin C, vitamin E, phytic acid and polyphenols inhibit formation of N-nitroso compounds, which are potential carcinogens (38).

(c) Lignins and phytoestrogens in soy have weak estrogenic activity and have been shown to lower the risk of hormone dependent cancers (39).

(d) Some plant starches e.g. oligosaccharides have growth promoting effects on bifidobacteria that are important for the health of colon, decreasing the risk of colonic carcinoma (40).

(e) Phytochemicals in the whole grains and legumes have the ability to block initial DNA damage and suppress post initiation, which halts the carcinogenic process(41).

There is evidence that the consumption of cereals, fruits, dairy products, and added lipids (especially olive oil) are found to be associated inversely with the risk of oral carcinoma(42).

**Alzheimer's disease and other age related diseases**

Neuro-degenerative diseases including Alzheimer's Disease, Parkinson's disease, Huntington's disease and amyotrophic lateral sclerosis share, in common, both aging as a major risk factor and oxidative stress as an

important pathophysiological mechanism. Collectively, there is enough evidence to suggest that oxidative damage plays an important role in brain dysfunction seen in dementias, especially in Alzheimer's disease. Antioxidants appear to be specifically associated to particular biomolecular damage. This is, for instance, the case of lutein, lycopene, ß-carotene, whose plasma levels have been found to be inversely related in Alzheimer's disease patients(7).

### Human immuno deficiency virus

Low plasma or serum levels of vitamins A, E, $B_6$, $B_{12}$ and C, carotenoids, Se and Zn are common in many HIV infected populations. Micronutrient deficiencies may contribute to the rapid progressive pathogenesis of HIV infection through increased oxidative stress and compromised immunity. Low levels or intakes of these micronutrients have been associated with adverse clinical outcomes during HIV infection, and new studies are emerging which suggest that micronutrient supplementation may help reduce morbidity and mortality during HIV infection (43).

### Conclusion

A large body of scientific evidence doubtlessly indicates that an association exists between inadequate antioxidant status and increased risk for or poor outcome of several lifestyle diseases, including CAD, stroke, cancers, diabetes, Alzheimer's disease degenerative diseases of the eye, and even injuries. Antioxidant micronutrients do also show beneficial effects in the prevention of several of these diseases. This effect, however, is much stronger and consistent for antioxidant-rich fruits and vegetables than for single vitamin supplements. In addition, fruits and vegetables contain other polyphenolic phytochemicals, which help in detoxifying many kinds of carcinogens

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# Obesity and Diet

Obesity is a condition of excess body fat accumulation to an extent that increases the risk of causing or complicating diseases. It is generally defined as a body mass index of more than 30kg/m$^2$ (1, 2). Industrialization and urbanization have played a vital role in determining the nutritional status of the population. Those living in cities are more prone to the problems of overweight and obesity. Overweight and obesity contribute to the development of diabetes, heart disease, hypertension and many other illnesses. Obesity is largely preventable through changes in lifestyle.

Over the past two decades there has been a dramatic rise in the prevalence of obesity throughout the world. It is estimated by the WHO that globally, over 1 billion (16%) adults are overweight and 300 million (5%) are obese. The highest rise in the number of obese is noted in the countries with fast growing economies esp of South East Asia. 250 million people in the third world countries suffer from obesity. In India alone there are more than a 100 million obese individuals. We are truly in the midst of an obesity epidemic, which has serious health ramifications (3).

## Causes of obesity

Obesity results from an excess of dietary energy intake over energy expenditure and thus both an increase in intake and a decrease in expenditure will lead to excess calories being stored as fat and, ultimately to obesity (3).

### Increased energy intake

An increased energy intake due to lifestyle changes and affluence as seen in urban areas seems to be fuelling the obesity epidemic.

### Decreased energy expenditure

There is a rapid decline in manual labour resulting from car ownership, availability of labour-saving devices, shunning outdoor sports and watching television and computer use for long hours. These factors contribute to obesity.

### Metabolic factors

In some individuals endocrine disorders such as Cushing's syndrome and hypothyroidism, Prader-Willi syndrome etc are the causes of obesity.

### Genetic factors

Obesity tends to run in families. Obesogenic genes are under study, which alter the metabolism or alter the response to obesity limiting hormones like Leptins, etc.

### Obesogenic environment

The shared environmental factors like lifestyle, meals, home environment, family traditions of eating and exercise, level of activity, affluence, etc substantially contribute to obesity than mere genetic factors.

### Fetal programming

The Barker hypothesis proposes that undernutrition during pregnancy may increase the susceptibility of that individual to obesity in adulthood.

## Implications of urban life on obesity

Till recently, obesity was understood in fairly simple terms and was believed that excess body weight results from eating too much and exercising too little! But today it is understood that obesity results from a complex interaction of the factors discussed above: genetic, metabolic, psychological and environmental, causing an imbalance between energy intake and expenditure.

The varied lifestyle and dietary habits of people play an important role in the causation of obesity. In India one important factor, which has ignited the obesity epidemic, is the '*nova-rich*' culture. This is marked by a sudden increase in income, having more disposable income at hand, higher purchasing power and being able to spend more on food. Stress, time crunch, sedentary lifestyle and excessive television viewing add fuel to fire. Non-traditional foods and snacks are considered as more and more mainstream. Easy availability of fast foods, falling prey to food fads, pub and junk food culture and aping the west make the problem more complex. Aggressive advertising, marketing and universal accessibility of chips, wafers and colas have made them not only a household item but a must for any outing or birthday party! These are some of the reasons of urban obesity. Subconsciously we are imparting the same 'unhealthy' eating-behaviour to our children, ensuring that the next generation too falls in the same vicious cycle of no return.

## Quantifying obesity

### Body Mass Index (BMI)

Overweight is usually determined by the Body Mass Index (BMI), which compares the person's weight to his height. BMI is computed by taking the body weight in kilograms and dividing it by the square of the height in meters.

BMI does not measure the body fat but relates well with the

$$\text{BMI} = \frac{\text{Weight in kilograms}}{\text{Height}^2 \text{ (in meters)}}$$

degree of obesity. The categories of obesity as pronounced by the WHO are depicted in Table - 1.

Table - 1: Grades of obesity based on BMI (4)

| BMI | Classification | Risk of comorbidities |
|---|---|---|
| < 18.5 | Underweight | Low |
| 18.5-24.9 | Healthy/normal weight | Average |
| 25 - 29.9 | Pre-obese (Overweight) | Mildly increased |
| 30 - 34.9 | Obesity Class I | Moderate |
| 35 - 39.9 | Obesity Class II | Severe |
| > 40 | Obesity Class III | Very severe |

The guidelines have been revised lately for Asians, considering the fact that Asians (esp South East Asians including Indians) are more susceptible to metabolic syndrome. These are summarized in Table - 2.

Table - 2: Grades of obesity for Asians (1)

| BMI | Classification | Risk of co-morbidities |
|---|---|---|
| < 18.5 | Underweight | Low |
| 18.5 - 23 | Normal weight | Increasing but acceptable |
| 23 - 27.5 | Pre-obese | Increased |
| >27.5 | Obese | High |

**Waist circumference**

Measurement of the waist circumference is a practical method to assess obesity, esp. the degree of abdominal adiposity and the cardiovascular disease risk. Waist is measured at mid point of lower border of rib cage and iliac crest (a more practical method is to measure it at the level of lower edge of umbilicus). A measure of less than or equal to 90 cm for men and 80 cm for women is considered normal.

**Waist-Hip Ratio**

It is another measure of abdominal adiposity and the cardiovascular disease risk of the individual. A ratio of <0.9 for men and <0.8 for women is considered normal.

## Critical periods for weight gain

Weight gained during certain critical periods, usually lead to an increased number of fat cells and makes obesity difficult to treat (5). These periods include:

(a) Age range of 12 to 18 months
(b) Age range of 12 to 16 years
(c) Gain of 60% (or more) of his ideal weight by an adult
(d) Weigh gain during pregnancy

It is important to be on guard during these critical periods, with an aim of preventing almost irreversible weight gain.

## Clinical consequences of obesity

Obesity is associated with a higher risk of mortality and morbidity. The life expectancy of a morbidly obese individual is about a decade lower than one with normal BMI. Most overweight and obese individuals exhibit certain symptoms like difficulty in walking, heavy breathing while walking, joint pains, snoring, morning headaches and shortness of breath. Some specific clinical consequences are listed below:

**Metabolic**

Diabetes type 2 (50 to 100 times more common in obese), hyperlipidaemia, hypertension (5 to 6 times commoner), stroke (2.5 to 6 times commoner), gall stones, breast and colon cancer, infertility (men and women) and polycystic ovary syndrome are seen more often in the obese.

**Physical**

Osteoarthritis, chronic back pain, respiratory problems, limited mobility, higher accidents, sleep apnoea and skin problems.

**Psychological**

Depression, low self-esteem, social isolation, poor employment status, impaired relationships.

## How to reduce weight?

The aim should be to maintain a BMI of 18.5 to 25 kg/m2 and avoid weight gain in adulthood. Details are discussed in subsequent sections. It is important to follow the height weight chart so that one could follow his BMI.

**Preventing / treating obesity in the conventional manner : Role of dieting**

Being overweight, a high BMI or an overt obesity is probably the first indication of the fact that our diet is off - course and needs correction. If ignored at this stage other more sinister lifestyle diseases might soon follow. The origin of obesity could however be multifactorial. Many modalities for treatment/prevention of obesity are available. The dietary therapy (commonly known as 'dieting') remains the most practical and effective measure. Other measures are:

(a) Behaviour therapy
(b) Drug therapy
(c) Surgical intervention
(d) Genetic approach

In the present chapter we shall concentrate only on the dietary therapy.

**Reducing weight through dietary therapy (dieting)**

The first step to adopt a healthy lifestyle is to get educated on nutritional and health aspects. Understanding the nutritive values of Indian foods is perhaps a good beginning. One must learn about calorie content of different foods, food composition (fats, carbohydrates and proteins), nutrition labels, types of foods to buy and details on cooking procedures. Correct dieting technique involves instructions on how to make safe, sensible and gradual change in eating patterns. Moderate reduction in calorie intake is essential to achieve a slow but steady weight loss. This strategy also helps in maintaining this weight loss.

People should be encouraged to increase the intake of complex carbohydrates (unrefined cereals and sugars, fibre rich foods) and to decrease the intake of fats and simple carbohydrates (refined sugars, excessively milled cereals e.g. white bread, etc). Intake of low calorie and low fat foods must be emphasized. Fruits and vegetables must be made an integral part of the diet.

There are four areas to be considered in the use of dieting and nutritional education in treating obesity. These are

(a) Ascertain the activity status: sedentary, moderate or hard worker. Assess the present BMI and the desired BMI (20 to 25 kg/$m^2$). This would indicate the weight (in Kg) to be reduced.
(b) Set a practical time frame for weight reduction. It has to been achieved at a rate of around 1 - 1.5 kg per month.

(c) Assess the daily calorie intake from fats, proteins and carbohydrates. The weight to be reduced is then translated to the calorie restriction. These calories are distributed between carbohydrates, protein and fat so as to cut down calories preferably from fats and carbohydrates (in that order). This also helps balance all nutrients.

(d) Suitable substitutions should be made. The frequency with which the foods are to be eaten and the situation in which the food is ingested is also to be looked into.

**Reducing weight: An example**

Let us take a 1.66 m tall, sedentary male, weighing 80 kg.

**Step 1:** His present BMI works out to 29 kg/m$^2$. Let us presume that his desired target BMI is 25 kg/m$^2$. To achieve this BMI his weight must be about 69 kg i.e. he must reduce 11kg.

**Step 2:** It is recommended that he reduces 1.5 kg weight per month, i.e. he would be able to reduce 11 kg in about 7 months.

**Step 3:** Assess his total daily calorie intake. As a rule, generally, a daily reduction of about 500 kcal brings about a weight loss of about 500g per week. Conservatively, let us assume that a reduction of say, 1.5 kg per month can be achieved. 500 kcal per day can be reduced by cutting down 16 g oil (150 kcal), and about 85 g carbohydrates per day. Suitable modifications must also be made to other lifestyle factors like alcohol, junk foods, parties, snacks, physical activity, etc.

**Step 4:** Make suitable substitutions as applicable (see next para). For example, replace saturated fats with PUFA/MUFA, replace whole milk with skimmed milk, and refined flour with whole-wheat flour. More fruits and

### Food substitutions that help in weight-loss

It is well known that one must try to eat a variety of foods, especially whole-grains and lots of fruits and vegetables. These foods can be filling and satisfying and are lower in calories than foods full of oils or fats. Some times it is not only scientific but easy and more palatable too, to substitute one (set of) food item with other, which is less fattening or healthier. While cooking, try to replace undesirable ingredients with healthier alternatives. Some such examples are given here. This list is, by no means comprehensive. Many more such substitutions can be worked out provided they are nutritionally correct and acceptable to the individual (6).

Complex carbohydrates take longer time to digest, so they contribute to prolonged satiety. Foods that are rich in complex carbohydrates, low in fat and high in fibre are very beneficial for an individual's health and well-being. In addition, these foods help to maintain a low body weight. Therefore, refined carbohydrates (milled rice, white bread, biscuits) must be replaced with preparations of complex carbohydrates e.g. brown rice, whole-wheat atta and whole-wheat bread, etc

Potatoes, rice, beans and some vegetables (like yam, sweet potato, turnips, beet-root and carrots) are rich in complex carbohydrates. But one must consume even these with caution as their starch content is fattening. It is advisable to choose starchy foods that are high in fibre, like whole grains.

Nuts are good source of proteins, fibre, unsaturated fatty acids and certain antioxidant polyphenols. In small amounts they can be part of a healthy weight loss programme, however if consumed in large quantities their calorie content may add on to the weight. Use of fried nuts must be avoided to inhibit intake of undesirable oil.

Low fat and non-fat dairy products are as nutritious as whole milk dairy products, but they are lower in fats and calories, so it is advisable to substitute whole milk with skimmed milk.

Similar substitutions can be worked out for meats. Mutton and beef must be substituted with lean meat (e.g. chicken & fish). Prefer non-fried meats (e.g. stews, soups, etc) to 'tasty' oil dripping meat preparations.

One must cut down on sugar and fried / baked food, especially fast foods like chips, wafers, burgers, samosa cutlets and cakes! Such foods may have plenty of harmful 'unseen' fat. These can be replaced with some light biscuits, nuts, plain toast, fruits, salad and fruit juices.

Choose fats and oils wisely. Shun saturated fats like ghee and trans-fatty acids found in fried and baked foods. Replace these with oils having higher contents of PUFA and MUFA e.g. vegetable oils sunflower, safflower, groundnut, linseed or cotton seed oils. But one cannot consume these in an unlimited quantity. The total intake of fat has to be restricted to not more than 30% of total energy intake, (ideally at about 20%). Fish and fish oils are also healthy additions to the diet.

### Some more tips on dieting

(a) To reduce weight many people skip meals with an aim of reducing calories in their diet. But this is not the correct practice, because during the course of the day one is likely to make up for those 'missed' calories by snacking or eating more during the next meal. Do not eat food left over after the meals.

(b) A healthier way to lose weight is to eat many small but measured meals or to eat a minimum of three meals, which include a variety of nutritious, low-fat and low calorie foods. So the best way to lose weight is to cut back on the number of calories on a sustained basis and be more physically active.

(c) Try not to snack while doing mundane things like watching television, playing video games or using the computer. If you want to snack while watching TV, then keep small and fixed amounts of food with you.

(d) One should not shop when hungry because impulse buying of 'junk food' is likely to occur

which is fattening in the long run.

(e) Stress must be reduced. Find relaxation methods that work for you to limit excessive eating triggered by stress. Meditation is an excellent relaxation method. Develop an attitude of positive thinking and be cheerful. One must exercise regularly. It helps burn the body fat, strengthens the muscles and reduces stress.

(f) Slow and steady weight loss of about 0.5 to 1kg per week is the safest way to lose weight. Very rapid weight loss in a short while means you may be losing water rather than fat, so such a weight loss would not last long. On the other hand a very rapid weight loss for a relatively sustained period can cause you to lose muscles rather than fat, which again is harmful.

Other cautions

(a) There are certain other factors that should not be lost sight of. For example some food labels may claim 'low-fat' or 'no-fat'. But these foods may still have a lot of calories. Food labels claiming 'zero cholesterol' may not mean 'zero oil'. They may not have 'cholesterol' in the technical sense, but may still have oil, excessive consumption of which may not always be healthy. Often these foods have extra sugar, flour or starch thickeners to improve their taste and appearance. These ingredients add calories, which in turn can lead to weight gain.

(b) It is also important to drink enough water each day. One needs to drink a minimum of 8-10 glasses of water daily. Alcohol has high calorie content and apart from endangering health, it may act as a causative factor for obesity. The snacks taken along with drinks are often not counted by the individual as part of their daily diet. These in fact could be full of fats and calories, since, more often than not; these are fried foods, e.g. nuts, wafers, kebabs or cheese balls.

(c) Fruits and vegetables are the main sources of nutrients in vegetarian diets. Most fruits and vegetables have negligible fats and calories. Fruits and vegetables offer the additional but vital advantage of being the important source of antioxidants.

(d) There are certain nutrients (like iron, calcium, vitamin D, B12 and zinc) that are more commonly found in animal products rather than in vegetarian diets. Here are some vegetarian foods that contain useful nutrients (6,7)

(i) **Iron** : Whole grain cereals, pulses especially soybeans, chickpea, Dark green leafy vegetables, jaggery, dried fruits especially figs, raisins, apricots, certain seeds like pumpkin seeds and sunflower seeds, etc

(ii) **Calcium** - Dairy products, custard apple, ragi, broccoli.

(iii) **Zinc** - Whole grains (especially the germ and bran of the grain), dairy products, nuts, leafy vegetables and root vegetables (onions, potatoes, carrots, radish).

(iv) **Vitamin $B_{12}$** Cereals, dairy products.

(v) **Vitamin D** Milk, soyamilk and exposure to sunlight.

### Fad diets and their role in weight reduction

Fad diets stress either the absence or presence of particular foods or combination of foods. These are commonly aimed at weight reduction. A fad diet is a set of menus advocated generally by people who have little or no knowledge of nutrition or on the basis of inadequate evidence by nutritionist as well. Such diets have short lives and persons addicted to dietary fads shift from one such diet to other rapidly. These diets exist because of ignorance and gullibility. People clutch to almost any straw to lose weight or regain health.

The secret of the short-lived success of such diets is that, weight is rapidly lost, but is regained little later, once the former eating habits are resumed (8).

### Commercial 'Weight reducing' diets

Either the sheer number of obese and weight conscious people is so high or there is such a glamorization of good physique that today dieting is not only 'commercialized' but dieting and 'slimming centres' have attained industrial proportions. Visiting a well-known slimming centre is considered a prestige symbol for the affluent.

Popular diets have become increasingly prevalent and controversial. More than 1000 diet books are now available, with many popular ones departing substantially from mainstream medical advice. Public interest is being fuelled by cover stories of popular magazines and televised debates.

Out of the thousands of structured commercial diets, probably the more popular ones are the **Atkins diet, Ornish diet, Weight watchers diet and the Zone diet.** These are based on different 'principles' to reduce weight. For example, Atkins diet, the most popular of the lot, restricts intake of carbohydrates to less than 30 g a day and permits ad-libitum, the consumption of fats (fatty meat, butter, and other high-fat dairy products). The Ornish diet restricts fat, Weight watcher's diet restricts portion size and calories, Zone diet modulates macronutrient balance and glycemic load (9).

Since all these diets are not natural, they have their own associated disadvantages, risks and controversies.

Atkins diet : A critical analysis

One such diet warrants a more detailed discussion and a critically analysis. Let us take the most popular of these, the Atkins diet (10).

The Atkins diet books have sold more than 45 million copies over 40 years all over the world. In the present obesity epidemic, this diet and accompanying Atkins food products are popular. The diet claims to be effective at producing weight loss despite ad-libitum consumption of fatty meat, butter, and other high-fat dairy products, restricting only the intake of carbohydrates to under 30 g

a day.

It eliminates carbohydrates from food without restricting protein and fat intake. Deprived of carbohydrates, the body uses fat for fuel. A small part of metabolized fat is eliminated in the urine as ketone bodies, and this is why such diets are called "ketogenic".

Caloric loss due to ketonuria does not exceed 100 Cal/day in the non-diabetic. It is maximal during total fasting and cannot be increased further by a ketogenic diet. In the short run, such diets produce rapid weight loss due to polyuria. The apparent paradox that ad-libitum intake of high-fat foods produces weight loss might be due to

(a) Severe restriction of carbohydrate depleting glycogen stores.

(b) This leads to excretion of bound water causing weight loss

(c) The ketogenic nature of the diet being appetite suppressing

(d) The high protein-content being highly satiating

(e) High fat / protein diet reduces spontaneous food intake

(f) In the absence of carbohydrates the food choices are limited, leading to decreased energy intake

On the other hand in the long run, re-feeding carbohydrates causes water retention and weight gain. The diet decreases appetite: patients eat less without feeling severe hunger and without measuring their food intake. Orthostatic hypotension, fatigue and nausea are

**Some benefits of weight loss**

**Losing 10 kg is associated with :**

- A reduction in total mortality by 20%
- A reduction in systolic blood pressure by10 mmHg
- A reduction in diastolic blood pressure
- A reduction in fasting glucose
- A reduction in total cholesterol by10%
- A beneficial rise of 8% in HDL cholesterols
- An improved self-esteem

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# Major Non-communicable Diseases and Diet

After having swept the Western world, cardiovascular diseases have now assumed epidemic proportion in South East Asian countries, including India. It is extremely important to modify the lifestyle to prevent these dangerous diseases. Diet is an important aspect of the lifestyle which can be easily modified to prevent CVD. The details of CVD, its risk factors and prevention are described in another section on Non-Communicable diseases.

## Dietary recommendations for a healthy heart

### Fats

Quality of fats

Fats affect the risk of cardiovascular disease by virtue of both their quantity and quality. Various types of fats came under disrepute at different points of time. *Desi ghee* was once considered ideal food for health. It came under disrepute in the 1970s when the 'cholesterol theory' took shape and cholesterol was declared the biggest 'villian'. So *Dalda,* a hydrogenated fat replaced ghee in our diet. In a decade or so it was realized that *Dalda* too was 'not' healthy as it contained saturated fats. It was then thought that unhydrogenated vegetable oils were healthy. This was followed by the emergence of the 'omega 3 fatty acids' and the 'linolenic acids'. The scientific data apart, even the history tells us that the 'quality' of fat has a lot to do with the risk factors of CVD.

Quantity of fats

It must be realized that ad-libitum consumption of even the so called 'good' fats is not acceptable. The total quantity of fat consumption has to be kept in check and excessive consumption is certainly deleterious to the heart. It is well understood that both quantity and quality of fat strongly influence the risk of CVDs like the Coronary Heart Disease (CHD) and stroke, through effects on blood lipids, thrombosis, blood pressure, endothelial function, arrhythmogenesis and inflammation. For promoting cardiovascular health diets must provide the following: (1,2)

Total fat intake

The total fat intake should be less than 30% of total energy intake. (Note : 1g fat provides 9 Kcal)

Type of fat

Restrict intake of fats from dairy and red meat sources, avoiding use of hydrogenated oils and fats in cooking. Prefer plant oils (e.g. groundnut, sunflower, soyabean, ricebran, etc.). It is best to use these different oils in rotation to have the benefits of each.

Saturated fatty acids

These should not contribute to more than 7% (of the total energy).

Trans-fatty acids

The trans-fatty acids intake should be negligible (less than 1%) of daily energy intake.

PUFA

Intake of PUFAs should be adequate, ie. 6-10% of total daily energy should be from PUFA. There should be an optimal balance of n-6 PUFA (at 5-8%) and n-3 PUFA (1-2%) levels of daily energy intake, respectively.

MUFA

Intake of MUFA should make up rest of the daily energy intake from fats, i.e. about 10% of daily energy.

Cholesterol

Daily cholesterol consumption should be restricted to less than 300mg/day, mainly through restriction of dairy fats, red meat and eggs.

### Fruits & vegetables

Fruits & vegetables contribute to cardiovascular health through a variety of phytochemicals, antioxidants, potassium and fibre. A daily intake of 400-500 grams of a variety of fresh, seasonal fruits and vegetables (other than potatoes) is recommended for an adult.

### Sodium

Current evidence suggests that an intake of 70mmol or 1.7g of sodium per day, is beneficial in reducing blood pressure. This is equivalent to about 5 g of daily intake of salt. Low intake of sodium is helpful in the prevention of hypertension and other cardiovascular diseases. Other forms of sodium (food additives or preservatives, such as monososium glutamate and sodium benzoate, etc should also be guarded against (1).

### Potassium

Dietary intake of potassium lowers the blood pressure and is protective against stroke and cardiac arrhythmias. Potassium intake should keep the sodium to potassium ratio close to 1.This may be achieved through adequate daily intake of potassium, in the form of fruits and vegetables (1).

### High fibre in diet (Non starch polysaccharides)

A daily intake of 35-40 g of fibre in diet is recommended. The fibre is protective against CHD. Unprocessed grains (cereals), seeds (legumes), green leafy vegetables, fruits and nuts contain plenty of fibre (2).

### Fish

Regular fish consumption (once or twice a week) is protective against CHD and stroke. As brought out earlier fish is a rich source of omega-3 fatty acids (4).

### Alcohol

While low to moderate consumption of alcohol is protective against CHD, concerns about the other cardiovascular and health risks associated with alcohol consumption (like stroke, hypertension and cancers) do not favour a general recommendation for its use.

### Low calorie foods

As a general rule, food that is low in calories, but which

Reduce fat in your diet : Facts on fats & how to ensure right quantity and quality (3)

- **Fats are necessary but excess is dangerous.**
  ~Moderate total fat intake. Limit visible fat and cut down invisible fat from animal foods.
- **Saturated fats present in animal foods increase blood cholesterol and worsen blood clotting.**
  ~Select low fat milk, limit/avoid cheese, meat, butter, ghee and hydrogenated oils.
- **Trans fatty acids increase blood cholesterol.** ~Limit/avoid hydrogenated oils and repeated frying.
- **Vegetable oils and plant foods do not have cholesterol. MUFA and PUFA decrease blood cholesterol and suppress clot formation in blood.**
  ~ Prefer plant foods and vegetable oils.
- **The ratio of saturated to polyunsaturated fats should be roughly 0.8 to 1.0.**
  ~This can be achieved by a judicious combination of cereals, pulses, vegetables, milk & vegetable oils.
- **A good balance of linoleic (n-6) and alpha-linolenic (n-3) acids is essential.**
  ~Use of mustard oil or soyabean oil along with other oil(s) will help to achieve this.
  ~ Also eat plant foods that are good sources of alpha-linolenic acid (Table 1).
- **Long chain n-3 PUFA found in fish lower blood cholesterol, triglycerides and prevent clot formation. They also lower blood pressure and have several other beneficial effects.**
  ~Those who like fish should take 100-200g twice a week.
- **Carbohydrates esp. refined sugars, increase triglycerides.**
  ~Prefer natural food; reduce refined sugars (sucrose, sweets, candies etc.) in diet.

Rich sources of α-linolenic acid (2)

| | |
|---|---|
| Cereals and Millets | Wheat, *Bajra* |
| Pulses and Legumes | Blackgram, cowpea (*lobia*), *rajmah*, soya bean |
| Vegetables | Green leafy vegetables |
| Spices | Fenugreek (*methi*), mustard (*rai*) |
| Oils | Mustard, soyabean |
| Animal foods | Fish (Rich in n-3 PUFA) |

can fulfill the daily requirements of energy in a balanced manner is considered as healthy. To keep the calories low in the diet the upper limit of calories intake must be limited to the recommended values for sex and activity level. Fats and oils are the most concentrated source of energy so intake of fats and oils must be restricted, as mentioned earlier. Similarly excessive intake of carbohydrates (cereals and starchy foods like potatoes) must also be discouraged.

## Diabetes mellitus and diet

Diabetes is a metabolic disorder characterized by chronic hyperglycaemia with disturbances of carbohydrate, fat and protein metabolism resulting from defects in insulin secretion, insulin action, or both (5). The details of the disease, its risk factors and prevention are discussed in the section on Non Communicable diseases.

We will concentrate on the dietary management of diabetes in this chapter.

### Objectives of dietary management (5,6,7)

(a) To remain healthy using appropriate foods.
(b) To achieve and maintain optimal metabolic outcomes:
(c) Reduce blood sugar
(d) Maintain ideal body weight
(e) Reduce serum lipids
(f) To avoid any complications
(g) Avoid acute complications – hypoglycaemia, ketoacidosis, etc.
(h) Prevent vascular complications

### Diet in Diabetes

Dietary advice should be placed within a comprehensive context of care which includes supporting patients to manage their diabetes and make decisions; it should also complement other treatment including drugs, physical activity, etc. Dietary advice must take account of the individual's personal preferences, cultural background, and lifestyle.

The diet should not be a complete deviation from his existing diet. People with diabetes do not need to follow a 'special diet' or comply with narrow restrictions or measured portions of food, as thought earlier. However, eating well is important for good diabetes control and can contribute to improved well-being. The optimum healthy choice of food for people with diabetes is the same as for the general population and ideally should be low in fat, sugar, and salt, include plenty of fruits and vegetables and base meals on carbohydrate foods such as bread, potatoes, and rice. In fact a typical Indian diet is very close to such a diet! Patients with newly diagnosed diabetes should be referred for individual advice to a dietitian and

afterwards receive an annual dietetic review (6,7)

Calories

It is recommended that the patient should take that many calories which help him to maintain his body weight to 10% lower than the ideal body weight. A rough measure of the ideal body weight can be obtained by subtracting 100 from his height; or else height-weight charts can be used.

**Recommended Calorie Intake**

Recommended Calorie Intake is based on the current body weight of the patient and is given in Table - 1. (7,8)

The distribution of calories in the diet for a diabetic is given in Table - 2

Table - 1 : Recommended Calorie Intake for Diabetics

| Body weight | Recommended calories |
|---|---|
| Ideal | 30 kcal/kg/day |
| Overweight (> 20% of ideal weight) | 20 kcal/kg/day |
| Underweight (< 20% of ideal weight) | 40 kcal/kg/day |

The composition of optimum diet above must be translated into practical advice through the following tips on major foods / nutrients :

Table - 2 : Distribution of calories in the diet

| Nutrient | Percent of total calories |
|---|---|
| Carbohydrate | 60-65% |
| Protein | 15-20% |
| Fat | 15-20% |

Carbohydrates

Eat regular meals based on starchy carbohydrate foods such as bread, potatoes, rice, and chapattis. Choose wholegrain foods where possible, e.g. wholemeal bread and whole grain cereals.

Sugars

Reduce refined sugars and sugary foods. However, following a very strict sugar-free diet is not necessary. Some sugar can be used as an ingredient in foods e.g. in many wholegrain breakfast cereals (dalia, cornflakes). Sugary drinks should be replaced by sugar-free or diet alternatives.

Fats

Reduce intake of fat, especially animal fat. Eat less butter, cheese and red meat. Prefer low fat dairy foods like skimmed milk. Replace fried foods with steamed or oven baked items. Prefer small quantities of PUFA (plant oils) to saturated fats (butter/ghee).

Proteins

A liberal intake of proteins is recommended (except in associated kidney disease). Intake of 1 to 1.5g protein /kg body weight is recommended.

Vitamins & minerals

Eat more fruit and vegetables to get optimum vitamins and minerals. Five portions per day would suffice.

Salt

Cut down on salt. Spices, lemons, etc can be used as an alternative.

Alcohol

Avoid alcohol. Limit alcohol to not more than two units per day.

Fenugreek seeds

A lot of work has been done on fenugreek seeds (Maithi), which is used as a condiment in Indian diet. They suppress the urinary excretion of sugar and relieves symptoms of diabetes. Fenugreek leaves do not show such effects.

Fibre

A liberal intake of dietary fibre is helpful in the contol of diabetes.

Weight

Weight is a good indicator of diet and diabetic control. Lose weight if overweight by trying to reduce at a rate of 0.5-1.0 kg/ week, as discussed in the chapter on obesity.

**Glycaemic index**

Every carbohydrate when consumed increases the blood sugar. Those carbohydrates that get absorbed quickly raise the blood sugar fast. Such foods are deleterious to health esp for diabetics as they induce an abrupt insulin response. This immediate effect of foods and carbohydrates on the blood glucose levels is measured in terms of glycaemic index. Foods with a high glycaemic index are readily absorbed and raised blood glucose quickly. Low glycaemic index foods are digested and absorbed slowly and raise blood glucose levels slowly. The glycemic index of Glucose is taken as 100. The glycemic index of various common Indian

Table - 3 : Glycaemic Index of Common Foods (7)

| Item | Glycaemic Index | Item | Glycaemic Index |
|---|---|---|---|
| Bread | 70 | Apple | 39 |
| Millets | 71 | Banana | 69 |
| Rice (White) | 72 | Potato | 70 |
| Wheat (Paratha) | 70 | Potato chips | 51 |
| Soya beans | 43 | Idli | 80 |
| Dals | 48 | Groundnuts | 13 |
| Glucose | 100 | Milk | 33 |
| Sucrose | 59 | Fructose | 20 |

In general, all foods can be classified into the following three categories for diabetics: (7)

**(a) Foods that can be used freely**

(i) Vegetables ( including green leafy vegetables) and low sugar fruits (banana, mango, dates are high sugar content fruits)

(ii) Spices

(iii) High-fibre foods

(b) Foods to be used in moderate amounts

(i) Fats

(ii) Cereals/Roots/Tubers

(iii) Pulses

(iv) Nuts

(v) Milk products

(vi) Eggs & Meat products

(vii) Artificial sweeteners

(c) Foods to be avoided

(i) Sugar / Sweets /Honey

(ii) Jam and jellies

(iii) Cakes and pastries

(iv) Sweetened juices and soft drinks

(v) Fried fruits, *ghee*, butter

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# Common Nutritional Deficiency Disorders

There are serious deficiencies in the diets of our population particularly among the poor. As a consequence of this dietary deficiency, several nutritional deficiencies with clinical manifestations and disabilities are encountered in our country. Most important of them being:

(a) Vitamin A deficiency
(b) Iron deficiency anaemia
(c) Iodine deficiency disorders (IDD)
(d) Protein energy malnutrition (PEM)

These four are often referred to as *'Nutritional giants'* and have been the concern of health authorities in the country. PEM and vitamin A deficiency occur mostly among preschool children. Goitre due to iodine deficiency results in thyroid insufficiency, impaired metabolism and mental retardation. Anaemia is prevalent in all groups. Fortunately our troops and families are in receipt of good nutrition and so, except for anaemia, the other three nutritional deficiencies are not commonly come across. Hence they are dealt with in brief (1).

## Vitamin A deficiency

Vitamin A deficiency is a major nutritional problem affecting young children and leading to blindness.

### Magnitude of the problem

It is one of the major nutritional public health problems in India and other developing countries. Millions of children (esp preschool children) are at risk of xerophthalmia. About 36 countries in South East Asia, Western Pacific & Africa are most affected. World-over 256 million people suffer from preclinical xerophthalmia and 2.7 million from xerophthalmia. 7,00,000 patients develop corneal lesions and 3,50,000 become blind of xerophthalmia.

In India it is commonest amongst preschool children esp from rice eating states (Andhra Pradesh, Tamilnadu, Karnataka, West Bengal and Bihar). The prevalence of Bitot Spots in the 1to 5yrs age group is about 1-5%. Very few studies report corneal lesions in India (0.05-0.1 per 100 preschool children in South India) (2)

### Xerophthalmia

Xerophthalmia is the manifestation of vitamin A deficiency in various clinical forms. Xerophthalmia assumes extreme importance because it is seriousness, may lead to blindness and is preventable. Public health problem of Xerophthalmia can be ascertained by the levels of prevalence of various conditions amongst the preschool children in the community (Table - 1)(3).

### Clinical Features (4)

Night Blindness

It is classically associated with vitamin A deficiency. Seen more commonly in the pre-schoolchildren, mother of the child typically complains that in the evening child strikes against a stone while playing and falls down frequently, he can't see the contents of his food plate and gropes for food especially at dusk time and he is unable to see what's written on the black-board. Night blindness usually responds rapidly to vitamin A tablets/oil or injections.

Table - 1 : Xerophthalmia as a public health problem

| WHO Classi-fication | Clinical condition of xerophthalmia | Prevalence among preschool children |
|---|---|---|
| XN | Night blindness | >1% |
| X1A | Conjunctival xerosis | |
| X1B | Bitot's spots | >0.5% |
| X2 | Corneal xerosis | |
| X3A | Corneal ulceration/keratomalacia (involving <1/3 of cornea) | >0.01% |
| X3B | Corneal ulceration/keratomalacia (involving >1/3 of cornea) | >0.01% |
| XS | Corneal scar | >0.05% |
| XF | Xerophthalmic fundus | - |
| Biochemical | Plasma retinol <0.35 mmol/l | >5% |
| | | |

Conjunctival Xerosis

It is one of the earliest detectable signs of vitamin A deficiency. It manifests as thick, wrinkled (vertically folded) conjunctiva with a tendency to dryness. It is resticted to 'exposed' bulbar conjunctiva. The dryness looks like “Waxy Paint” as there is loss of transparency and no shine in the affected conjunctiva. It is unwettable, classically referred to as a “Receeding tide” of the tear drop. The unwettability is because of reduced goblet cells/mucin secretion from the lachrymal glands, due to affected epithelium. The 'break-up time of tears' is also reduced

Bitot's spots

These are white triangular patches present on the conjunctiva. They resemble flakes of foam or plaster on the surface of the conjunctivae, due to hyperkeratinizing metaplasia of the epithelium and accumulation of seborrhoeic excretions.

**Site :** Bulbar Conjunctiva, on either side of cornea, generally temporal and bilateral

**Shape :** Classically triangular (but not always)

**Color** : Pearly white/creamy-yellowish/cheese

**Texture**: Foamy, soapy

**Symmetry**: May be bilateral

**Characteristic feature** : Unwettable

**Importance:** Usually indicates Vitamin A deficiency, esp in children.

Corneal xerosis

If not treated at an early stage, the cornea too, becomes pale, lusterless and looses its sheen, corneal xerosis. This may progress to a state of **corneal ulceration** and subsequently **keratomalacia** may ensue. There may be an eventual perforation through which the contents of the eye may extrude out and the patient looses his sight.

Extra-ocular manifestations

Follicular hyperkeratosis, growth retardation and anorexia are some of the extra-ocular manifestations of vitamin A deficiency.

**Treatment of xerophthalmia (2)**

(a) 2,00,000 IU (110mg) of Retinol Palmitate (oil miscible vitamin A) is administered orally for 2 days. In cases of persistent vomiting/diarrhea, water miscible vitamin A 1,00.000 IU is administered IM Injection, followed by 2,00,000 IU 1-4 wks later

(b) For infants less than 1year old or less than 8 kg weight, use half the dose

(c) Refer case to Eye specialist, if active corneal lesions are there

(d) Monitor severe cases of Acute Respiratory Infections, diarrhoea, measles and protein energy malnutrition carefully, as vitamin A deficiency is likely to be precipitated in them.

(e) Avoid large doses in pregnant women

**Prevention**

It is one of the simplest preventable nutritional disorders. The following actions must be taken.

Dietary modifications

Dietary modifications to promote production & consumption of Vit A & beta-carotene rich foods. Include rich sources of vitamin A, like dark green leafy vegetables, Deep yellow/ orange coloured fruits, eggs, milk, meat in the diet.

Nutrition education

Educate the troops on the importance of vitamin rich diet, its regular intake and the harmful effects of its deficiency. Importance of home gardening, consumption of fresh fruits and vegetables, food preservation techniques must also be emphasized. *Sainik sammelans*, family welfare meets and mass media can be used to the fullest to disseminate this message.

Periodic massive dosage (2)

(a) Vitamin A administration is now integrated with immunization program

(b) 1st dose 100,000 IU is given at 9 months of age along with measles vaccines

(c) Thereafter the second and subsequent doses of 200,000 IU are given at 6 monthly intervals till 3 yrs of age

(d) Fortification of ghee and butter are being done as a government policy to augment the vitamin A status of people.

Long term action

Constant nutritional education emphasizing good diet (including fruits & vegetables), importance of immunization, environmental sanitation, breast feeding, early treatment of infections and good maternal and child health care would go a long way in the prevention of this condition.

## Anaemia

Anaemia is another important nutritional problem affecting all segments of the population in general and children, women and pregnant women in particular.

Anaemia is defined as a condition in which the haemoglobin content is lower than normal as a result of deficiency of essential nutrients, regardless of the cause of such deficiency. As per the WHO, normal haemoglobin levels are (5)

| | |
|---|---|
| Males | 13g/dl |
| Females | 12g/dl |
| Pregnant female | 11g/dl |
| Children | |
| 6m-6yrs | 11g/dl |
| 6yrs-14yrs | 12g/dl |

Any levels below those specified above are considered as anaemia.

In pregnant women prevalence of anaemia may be as high as 60-70%. Anaemia in our country is essentially due to iron deficiency although in children and pregnant women, folate deficiency also plays a part. Although our diets contain fairly good amount of Iron, its absorption is very poor (2-3%). Anaemia can be aggravated by environmental factors which lead to blood loss e.g. poor sanitation, hookworm infestation, etc.

**Prevention**

Anaemia can be prevented by increasing iron intake in the population. Two approaches are used to achieve this.

One is by improving the diet by incorporating iron rich foods like meat, green leafy vegetables, jaggery, etc. Vitamin C sources (lime, *amla*, guava, etc.) should also be encouraged, as they augment the absorption of iron.

Therapeutic supplementation of iron and folate tablets is also resorted to. A public health programme of distribution of iron folate tablets to pregnant women (during last trimester) and preschool children is in operation as a part of MCH services. This approach is designed to achieve results in a limited time, like in pregnancy. Details are given in the chapter on RCH programme.

Besides enriching the diet with iron it is also important to limit iron losses. Therapy and prevention of helminthiasis including hookworms is achieved through health

education, improving hygiene and sanitation, use of drugs and provision of safe drinking water. Excessive menstrual losses and blood loss due to IUDs (or any other pathological causes as piles, bleeding peptic ulcers, etc) should also be attended to. Good ante-natal care leading to early diagnosis and sustained treatment of anaemia is important not only to keep the pregnant mother anaemia free, but also to keep the next generation healthy (6).

## Iodine deficiency disorders (IDD)

The major nutritional deficiency leading to goiter and cretinism is iodine deficiency. Iodine deficiency disorders (IDD) are endemic in Sub-Himalayan belt in North India affecting nearly 120 million people. Recently new pockets of IDD have been identified in other parts of India particularly in tribal belts, in Gujarat, Madhya Pradesh, Andhra Pradesh, Maharashtra, Kerala and Karnataka, bringing the total affected population to 200 million. Although goitre is mainly due to iodine deficiency in some areas, goitrogens present in some of the habitual foods, may be contributing to the precipitation of iodine deficiency when iodine intake is marginal (1,7).

### Clinical features

IDD may presents as a spectrum of disorders and illnesses throughout the life cycle (8)

Foetus and neonate

Abortions, stillbirths, congenital anomalies (umbilical hernia, large anterior fontanel), high unexplained perinatal and infant mortality, lethargy, poor feeding, prolonged physiological jaundice.

Infancy & early childhood

Signs of cretinism (mental deficiency, deaf-mutism, squint, short stature, hoarseness of voice)

Child & adolescent

Poor scholastic performance, juvenile hypothyroidism, retarded mental and physical development.

Adult

Mental and physical underdevelopment. People appear to be slow and rather sleepy.

Prevention and control

Control and prevention of goitre has been principally based on providing extra iodine to the population through iodised salt distribution or iodised oil injection in hyperendemic areas. Iodisation of all salt is undertaken 30 ppm at source so as to give at least 15 ppm at the consumer end.

The importance of iodized salt in prevention of IDD has to be emphasized repeatedly to the community. It must be reiterated that only iodized salt must be consumed by all. It must be consumed within 6 months of iodization, as the concentration of iodine diminishes with time. The community must be made aware of the fact that selling of uniodized salt may attract legal action. All health education methods must be resorted to, for effective dissemination of this information eg through lectures, road shows, audiovisual aids, schools and women groups, etc. (9,10)

## Protein Energy Malnutrition (PEM)

Malnutrition is a range of conditions occurring when intake of one or more nutrients doesn't meet the requirements. PEM is a malnutrition resulting from the deficiency of protein and/or energy in diet. Protein energy malnutrition (PEM) is an important nutrition problem among preschool age children. This leads to various degrees of growth retardation. When growth retardation is severe, functional deficiencies, like resistance to infection and poor intellectual development may result. The main cause of PEM is food inadequacy ie the deficiency of energy or proteins or both. In these cases deficiency in other nutrients like vitamin A, iron, calcium and riboflavin is also seen. It is also known that infections like measles and diarrhoea aggravate PEM (1).

Protein Energy Malnutrition classically manifests as Marasmus or Kwashiorkor. Marasmus results from a continued restriction of both dietary energy and proteins. It is most common in children aged less than 5yrs (most cases < 1yr, in urban areas). In adults it may be said to be similar to a clinical manifestation of 'starvation'.

The term Kwashiorkor was introduced by Cicely Williams. It comes from language of 'Ga' tribe of Ghana, meaning “Sickness the other child gets when the next baby is born”. In 1959, Jelliffe introduced the term PEM, as there was close association between Kwashiorkor and Marasmus (4,11)

### Prevalence

The prevalence of clinical forms of PEM is estimated to be about 1% is in India. The prevalence of Marasmus is higher than Kwashiorkar. A mixed picture of Marasmic-Kwasiorkar is commonly seen. More than 80% cases are mild to moderate grade (12).

### Importance

Malnutrition is an important public health problem as it involves many children. It is a self perpetuating problem as the vicious cycle of malnutrition and PEM persists. It has got long term effects in the form of growth retardation and mental deficiency and mortality.

### Etiology

The old concept of 'protein gap' (deficiency of proteins in diet) has now given way to the new etiological theory of 'Food gap'(1). Inappropriate food (low in energy density, protein & micronutrients - Vitamin A, Iron, Zinc) which is poor both quantitatively and qualitatively is the chief cause of PEM. Under-nutrition in fetal life, esp last trimester, lactation failure, low energy dense weaning foods, incorrectly constituted formula, contaminated water and infections (Diarrhoea Measles, Acute Respiratory Infections, Intestinal worms etc.) also play important role in the causation of PEM.The other associated social factors are poverty, poor environmental conditions, large families, poor MCH services and poor cooking practices. Ignorance and the inability to provide adequate food also seem to be important contributory factors.

### Clinical features

Marasmus

**(a) Constant features**

(i) Growth retardation

(ii) Wasting of muscles & subcutaneous fat- 'Wizened old man's look'

**(b) Other features**

(i) Hair changes - Easily pluckable hair

(ii) Infection

(iii) Vitamin deficiency

(iv) NO psychomotor changes

Kwashiorkor

(a) **Constant features**

(i) Oedema

(ii) Growth retardation

(iii) Muscular wasting

(iv) Retention of some subcutaneous fat

(v) Psychomotor changes

(b) **Other features**

(i) Hair changes Flag sign

(ii) Diffuse pigmentation of skin and dermatoses- Flaky paint dermatosis

(iii) Moon face

(iv) Anemia

(v) Hepatomegaly

(vi) Associated vitamin deficiencies (Retinol, Tocopherols, Folate, Pyridoxin, Vitamin K)

(vii) Associated mineral deficiencies (Iron, Potassium, Zinc, Copper, Selenium, Magnisium)

(viii) Associated acute infections

**Assessment**

**Causation of edema in PEM (13)**

Due to a predominant deficiency of proteins hypoalbuminaemia results which leads to lower intravascular oncotic pressure, causing edema. In other words a low amino acid supply in diet causes a reduced hepatic synthesis of proteins leading to low circulating plasma proteins and edema. Another newer theory attributes edema to the imbalance between free radicals and antioxidants. Infections trigger inflammation and free radical injury. This leads to an oxidative damage to structural lipids of the cell membrane which becomes permeable to sodium and potassium and thus the fluids leak into the extracellular spaces causing edema.

The level of antioxidants is already low in infections which further aggravate the PEM being precipitated by poor diet. So it is a vicious cycle between infection, high free radical load, low antioxidants and PEM.

The condition can be assessed by using any of the 'malnutrition' classifications. The Gomez Classification is simple and is commonly used. It is a 'weight for age' classification. The weight of the given child is compared with a 'normal child'. 'Normal child' is defined as the 50th centile of Harward (Boston) standard.

**Prevention**

Health promotion

The following issues are vital:

(a) Good ante-natal care

$$\text{Wt for age (\%)} = \frac{\text{Wt of child}}{\text{Wt of 'normal child' of same age}} \times 100$$

Table - 2 : Interpretation of Gomez Classification

| Weight of child as compared to a 'Normal child' | Interpretation |
|---|---|
| 90-110% | Normal |
| 75-89% | 1st degree/mild malnutrition |
| 60-74% | 2nd degree/moderate malnutrition |
| < 60% | 3rd degree/ Severe |

(b) Education on food, hygiene and family planning

(c) Education on the importance of colostrum, diet during lactation

(d) Various measures under the ICDS initiative, like good nutrition, immunization, education, hygiene and sanitation etc.

(e) Promotion of breast feeding

(f) Good weaning practices, correct time of weaning, importance of low cost weaning foods

(g) Prevention and control of infections during weaning

(h) Improve family diet

(j) Correct knowledge on balanced diet

(k) Using of family planning practices

(l) Hygiene & sanitation

Specific protection

**(a) Diet**

Protein & energy rich food should be consumed by children. Special attention must be paid to diet during weaning. Adequate quantities of fruits and vegetables must be included in the diet.

**(b) Immunization**

The child must be immunized as per the national schedule.

Early Diagnosis & Treatment

**(a) Growth monitoring**

Vulnerable children must be identified. Children must be monitored through growth charts. Early diagnosis of growth failure must be done and treated as appropriate.

**(b) Early diagnosis and treatment**

Early diagnosis and treatment of infections is also vital. To achieve this, health worker must be alert and mothers should be aware of the signs and symptoms of common infections. Preparation and use of ORS should be known to all mothers.

(c) **Medical advise**

In extreme and serious cases early medical advice must be available. Hospitalization of the case remains the only choice in complicated cases.

## Conclusion

These four nutritional giants, if not prevented, may lead to many long lasting disabilities. PEM results in poor growth and development among children. Vitamin A deficiency leads to nutritional blindness. Anaemia leads to impaired work capacity, impaired resistance to infection and poor pregnancy outcome. IDD results in thyroid insufficiency, impaired metabolism, mental retardation and cretinism which may be irreversible. Therefore it is of utmost importance to take all preventive measures against them.

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# Rations, Catering and Food Inspections in the Armed Forces

## History of military nutrition

*'An army marches on its belly'*

**~Napoleon**

This dictum only crystallizes the fact that troops must be given enough to eat and are more efficient when well fed. The old armies were dependent largely on the efforts of foraging parties for their rations; if the land was barren of food, they faced starvation as had happened with the German forces advancing into Siberia in the II World War. Most armies in the olden times did not pay much attention to the nutritive value of different foods. Navies, on the other hand, were familiar with the fact that on long voyages, crews were decimated by scurvy. As early as in the 16th century the cure for scurvy with oranges and lemon juice had been described. During his second voyage to the South Seas (1772-75), *Captain Cook* kept his crew entirely free of scurvy -- an unprecedented feat. He used a variety of substances, including germinating seeds and lime juice. Perhaps, the earliest controlled human clinical trial ever undertaken was the one conducted by *James Lind* on prevention of scurvy in 1742 and published in 1752. Beriberi was the scourge of the Japanese Navy prior to 1882, when it was eliminated by *Admiral Takaki* who increased the allowances of vegetables, fish, meat and barley.

The science of nutrition was applied to military affairs in the modern sense only in the second decade of the 20$^{th}$ century. No convincing explanation of the influence of diet on diseases was available until the concept of vitamins was placed on a sound footing by *Hopkins, McCollum, Funk* and others between 1906 and 1913. In the First World War nutritional science was used for the first time in military medicine, in the true sense. Both the quantity and quality of rations were intensively studied. Shortage of food and limitations of shipping necessitated the observance of utmost economy in rations in 1916. Another instance of effectiveness of vitamins is that the health of *Allenbys'* troops improved considerably after entry into Palestine, with less wastage due to sickness and rapid healing of wounds. This has been attributed to the availability of citrus fruits and green vegetables in abundance in that area. (1, 2)

The state of nutrition of troops determines their potential fitness, that is, their capacity to overcome hardships and disease. Troops may be called 'fighting fit' when their nutrition is optimal, they have positive health, are adequately trained, and when all possible measures against disease have been taken. Unless nutrition is optimal, full benefit from training and minimal wastage from diseases cannot be expected. Nutrition is also a basic factor in morale; only well-nourished troops can show vitality and keenness at its highest.

## Responsibility of Medical Officers

Nutrition not only aims at preventing deficiency diseases but also at maintaining the highest possible level of fitness. To achieve this all medical officers should be acquainted with these factors: Nutritional characteristics of food, requirements under varying conditions (including war), ration scales, manifestations of malnutrition, organization of supply, inspection of rations, scope of catering and cooking etc.

## Feeding of Armed Forces personnel

### Principles

(a) During war or peace, the issue of rations in kind must be the mainstay.

(b) The standard ration scales must fulfill nutritional requirements under various circumstances.

(c) It must make every possible allowance for the habits and tastes of the consumers.

(d) Flexibility should be attained by authorizing substitutes through which fluctuations in supply and catering can be met and variety can be achieved.

(e) Where true nutritional equivalence is not possible, issues of substitutes should be limited so that the total nutritional balance of the ration scale is not seriously impaired.

(f) Ration scales should, as far as possible, be composed of fresh foods.

(g) Processed substitutes may be inevitable in war, but tinned and dehydrated foods should be treated as a means to an end and not as a perfectly satisfactory method of feeding troops.

(h) The importance of any given food in a ration is related not only to its absolute nutritive value but also to the quantity in which it is consumed. It is therefore, quite justifiable to sometimes use a food of limited nutritive value for the sake of variety, or to eek out short supplies.

(j) Canteens should serve more as places for providing diversion and an interlude to break the inevitable monotony of unit catering & not as a substitute for it.

The armed forces present diverse situations and problems as far as nutrition of the troops is concerned. Nutritional requirements and challenges for the armed forces personnel are not only different from the normal population but even within the armed forces they vary during training, stay in peace areas, exercises, field areas, high altitude and operations. These issues are discussed in the subsequent sections.

## Armed Forces Rations

Before the First World War, Indian troops received a cash allowance from which each man purchased his own food, with the result that no control on nutrition was possible. Experience in Mesopotamia in 1916 underlined the

danger of such a system. After the war the system was so modified that a cash allowance was made to units and not to individuals. Certain foodstuffs were also supplied in kind. Under the peace scale *atta* / rice 24 oz, *dal* 3 oz, potatoes and *ghee* 2 oz each, sugar 1½ oz and salt ½ oz were issued in kind. The field service ration scale included the same items as issued at present except that the quantities of meat and *dal* were less by an oz, vegetable by 2 oz and the milk issued was almost half of the present quantity. The *ghee* was supposed to be pure animal *ghee*, a fact which is still remembered by some old soldiers with nostalgia.

During World War II, the army expansion and rise in the cost of living brought difficulties in food supplies. In 1943, a modified field service scale was authorized in 'peace' areas, which was converted into a basic ration scale for all Indian troops in 1944. However, in 1945, due to shortage of food, further changes were made to overcome the food shortage in India.

**Administration**

A variety of rations have been formulated for different purposes and are published in 'Scales of Rations and Supplies' (SRS) issue by the ASC which are frequently amended to suit the supply position and requirements. The fundamental regulations regarding ration scales, provisioning and supplies are contained in DSR paras 884 to 901. In addition to the ordinary services ration scales, special rations are available for road and rail journeys, hospitals, and for special operational purposes. Ration scales are drawn up or amended by the respective HQs in consultations with their Medical Directorates. Policy matters regarding ration scales are dealt with on an inter services basis by the Armed Forces Health Sub Committee of the Medical Services Advisory Committee.

The fundamental consideration is to satisfy the quantitative and qualitative nutritional requirements of Armed Forces personnel working under different conditions. The bases for this consideration are the human requirements of energy, proportion of proximate principles in the diet, optimum quantities and proportions of vitamins, minerals and trace substances. These requirements are drawn out of various tasks required to be performed by the consumers. Various administrative, tactical and operational contingencies are also considered. The supply position is assessed and taken into consideration. The durability (shelf life) of various items is considered. The habits and tastes of various categories of personnel and acceptability of the items are also considered. Substitutes for short supply items and to relieve monotony are recommended with appropriate restrictions against continuous use. In drawing up ration scales the medical services, the ASC, purchase organizations and the food inspectorate actively collaborate.

**Routine rations**

Armed Force rations normally contain fourteen basic items- atta, rice, pulses, potatoes, onions, meat, vegetables, milk, sugar, tea leaves, oil, salt , fruit and condiments; firewood for cooking is also included in the ration scales. To provide variety and to meet the market fluctuations of availability of items, substitutes like fish, pork, eggs, fowl, nuts, and dry fruits are also included in the provisioning schedules. Not less than 40 percent of the vegetables are required to be green leafy vegetables. Tinned, dried, dehydrated or AFD (Accelerated Freeze Dried) items are provisioned for use under field conditions when the supply of standard fresh items becomes logistically difficult or impossible. When such an issue is unavoidable for more than two weeks and/or nutritional deficiencies jeopardizing the health of the troops are envisaged, the rations are fortified by authorizing synthetic vitamins under orders of Army Commanders with the advice of the DDsMS. The intention of controlling this is twofold; to restrict unnecessary use of the expensive item and to incidentally keep the Army Commander informed of the fresh rations breakdown.

**Energy value**

The energy value of the usual Armed Forces ration scales ranges from 3700 to 5000 Kcal (15.51 to 29.9 Mj). Values of rations for any special circumstances i.e. physical emergencies as in combat and training may vary according to the needs. The peace service scale for army personnel provides 3710 Kcal (15.54 Mj), field service scale 4040 Kcal (16.9Mj), high altitude ration scale 5080 Kcal (21.25Mj), the composite pack ration 3500 Kcal (14.64Mj) and emergency or survival rations still less. The usual peace scale ration for Army personnel contains about 120 gm of protein of which 21 gm is of animal origin, retinol 1206 mg, thiamin 4.9 mg, riboflavin 2.8 mg., nicotinic acid 32 mg, ascorbic acid 130 mg and iron 85 mg. Carbohydrate is mainly from cereals, pulses, sugar, and potatoes; animal proteins are drawn from meat and milk; vegetable proteins are drawn from cereals, pulses and a few vegetables; fats are drawn from vegetable oils and milk. 20g of salt evaporated is supplied to satisfy the salt demand and 20g of salt can also be issued extra in summers.

Field service rations contain more cereals, milk, meat and oil but less vegetable. The high altitude ration scale has a high carbohydrate and high protein proportion. High protein contained in a high altitude ration has been achieved by addition of extra meat, egg, gram flour (baisan) and milk powder; while higher carbohydrates are supplied as jam and extra sugar. Air force and Navy rations are richer in animal protein than Army rations.

**Various ration scales**

The summary of ration scales at present in force in the Armed Force is given in appendices 'A' to 'J'. These appendices show only the standard items and not the alternative/ substitute items. The authorities are :

(a) Scale of ration for troops in Peace/Field area (SAI 7/S/74)

(b) Scale of ration for Officers in Peace/ Field area (Annexure to Govt of India, Min of Defence letter no 3(I)-83/D(QS) dated 12 Mar 1983.

(c) Scale of ration for troops at high altitude of 9000

ft. (2700 m) and above (SAI 3/S/72)

(d) Scale of ration for officers in Jammu and Kashmir and NEFA area (SAI 3/S/72).

(e) Scale of ration for Indian Navy (NI 06/86)

(f) Scale of ration for Indian Air Force (AFI 18/S/68)

(g) Scale of ration for cadets of the National Defence Academy Khadakvasla and Indian Military Academy, Dehradun (AI 8/S/74 and AI 33/91- Same scales are also applicable for cadets at OTA, Madras, CME and AFMC Pune, MCTE, Mhow, MCEME, Secunderabad.)

(h) Ration scale for cadets at the Rashtriya Indian Military College, Dehradun (AI 10/S/74).

(j) Extra/ration for edentulous cases (AI 10/S/76).

(k) Hospital diets and extra (AI 94/76).

In addition to the above ration scales there are operational rations consisting of an emergency ration scale and composite pack rations (AO 157/73) and also survival rations.

## Provisioning and supply of rations

### Functions of Medical Services

Medical services are responsible for advice on the composition of ration scales and on any other matters relating to rationing which have a bearing on the health of the troops. The DGsMS (Army, Navy and Air force) are the advisers to their respective Chiefs of Staff. The DGsMS are assisted by ADG (H and P) and JDsMS(H) Navy and Air. Administrative Medical Officers at lower levels have the same responsibilities towards local commanders, their technical advisers being the ADsH at command and Corps and DADsH at Division and Area HQ levels. Officers of the equivalent appointments in Navy and Air force administrative HQs are advisers to their commanders. However, any medical officer may be consulted by Commanders on some aspect of food and nutrition. The information in this chapter should enable him to deal with most questions. Medical Officers act in an advisory capacity; the discretion of accepting or otherwise of medical advice rests with unit/ formation commanders. The provision, supply and handling of food are functions of the ASC. Medical officers should ascertain the effect of their advice and its implementation by checking the rations received, cooked and consumed. Hospital dietary is in a special category. The specialists should advise regarding hospital rations.

### Functions of ASC

The Quartermaster General (QMG) is responsible for provisioning and supplying rations. The Director General of Supplies and Transport (DG S & T) assists him. This organization has five main functions: provisioning; supply; inspection of food stuffs; training of cooks; and catering. Provisioning and supply is based on ration scale drawn up by the Service Headquarters in consultation with the Medical Services. Foodstuffs are ordered centrally through the Food Ministry or purchased from local markets. Local purchase requires less organization and is eminently suitable for perishable and fresh foodstuffs or for those with only localized distribution. Before finalizing the contracts for provisioning, representative samples of items are inspected by the Food Inspections Organization of the S & T directorate. Supplies are organized according to ration scales, strength of unit/formation and availability of articles. When the food has been passed as fit for acceptance it is held in supply depots for issue to troops in accordance with unit indents.

## Catering in the Armed Forces

### Army

At the Army HQ a catering cell with a specially trained catering officer and the Deputy Assistant Director (Catering) as its head, functions under the Directorate General of Supply and Transport. At the Command level the officer commanding of the Command School of Catering functions as the Advisor in Catering. In a Mountain Division, a catering JCO is appointed in its ASC battalion. At ASC School, Bareilly, there is catering wing for training of unit cooks. The IMA and NDA are authorized catering officers/ JCOs. At Command Hospitals there is an ASC catering JCO while at other large hospitals an AMC JCO is trained to carry out the duties of a catering JCO.

In each station there is a Station Messing Committee with the Station Commander as the Chairman; OsC of units, unit messing officers, the manager of the dairy farm, Naval and Air Force representatives and the formation/station catering officer/JCO as members and the ASC officer as the secretary. They assemble every month to discuss matters concerning rations, the supply position and catering. In each unit there is a similar unit messing committee with 2 IC as chairman and Coy JCOs, MO, messing officer, QM, senior cook and Mess NCOs as members. They also assemble once a month to discuss messing problems. A unit messing officer is appointed to ensure proper catering in all the JCO/OR messes. The catering officer/JCO from the formation HQ advises units on all matters.

### Navy

The Director of Supply is responsible for laying down the policy at Naval Headquarters. Under his direction the logistic officers on the staff of the senior administrative authorities afloat and ashore take steps to implement the various aspects concerning catering, by giving proper guidance and direction to other senior logistic officers of ships/establishments under them. At large establishments and for the fleet, commissioned store officers (catering) are responsible for carrying out the policy under the direction of senior supply officers.

### Air Force

There is a staff officer in charge of catering at the Air Headquarters. Under the AOC command there is a command catering officer who is responsible for detailed supervision of the policy as laid down by Air Headquarters. Station administrative officer is

responsible to the commanding officer for general administration of messing and supervision of rations at various air force stations. He has a station catering officer (when authorized) to advise him, otherwise a messing officer is detailed to carry out these duties. The station catering officer is assisted by WO (catering assistant) of catering.

**Functions of the Catering Establishments**

(a) Station Messing Committee

(i) To acquaint units with the current supply policy, matters regarding turnover of stocks and matters connected with free and payment issues.

(ii) To discuss matters concerning popularity, quality and variety of ASC supplies.

(iii) To discuss suggestions from Unit Commanders on improving supplies.

(iv) To discuss and give out a monthly/fortnightly forecast issue programme prepared by the OC supply depot.

(v) To hear and meet particular preferences of units within the authorized scales of rations.

(b) Duties of Station Catering Advisers

(i) To ensure that the men get the full benefit of authorized rations.

(ii) To advise unit commanders on all points in connection with the messing, cook houses and dining halls.

(iii) To see that the 'bill of fare' is prepared intelligently to provide variety and a balanced diet.

(iv) Training and welfare of cooks.

(v) Maintaining close liaison with medical, engineer and ordnance services on matters concerning nutrition, hospital diets, designing of cooking equipment, cook houses and dining hall equipment.

(vi) Liaison with ASC officers

(c) Unit Messing Committee

(i) To ensure that men are properly fed on the rations available.

(ii) To acquaint members of the unit messing committee with the current supply position.

(iii) To hear and remedy complaints and consider suggestions put forward by the members.

(iv) To draw up the 'bill of fare'.

(v) To see that adequate facilities exist in dining halls and there is no wastage of food.

(vi) To suggest alternate dishes.

**Unit Responsibility**

It is the responsibility of the OC unit / ship to see that the meals provided to troops under his command are satisfactory. The provision of good food is one of the most important factors for the promotion and maintenance of positive health and welfare of a unit. Unit should insist that rations supplied to them conform to the quality and quantity laid down in the regulations. Medical officers should advise accordingly. If there is a legitimate cause for dissatisfaction, the matter must be taken up by the OC with the local ASC officer; the procedure is laid down in DSR- Para 893 A.

The processes of drawing, storage and cooking of the rations are equally important for satisfactory nutrition. The commanding officer is assisted in efficient execution of these responsibilities by the unit messing committee and the unit messing officer/JCO. All rations should be drawn in suitable clean containers and stored in appropriate stores.

**Messing Arrangements**

Rations are issued daily to the kitchen NCO according to the 'bill of fare'. The unit catering officer is responsible for the messing arrangements and should always consult the medical officer and accompany him on his inspection rounds.

Vegetables should always be obtained fresh and cooked in a minimum quantity of boiling water. Fruits and vegetables which are eaten raw, should be first washed thoroughly in running water or in several changes of fresh water, then immersed for not more than three or five minutes in clean WSP solution made by adding one scoop full (2 gm) of WSP to 10 liters of clean water and again washed in clean running water. Cooking must be so timed that food is ready only few minutes before time of distribution. If the food is not cooked and served well it causes wastage and adversely affects the nutrition of troops. An examination of the table waste and swill bins should indicate which items of food are unpopular.

## Sanitation of Cookhouses and Dining Halls

A brief account of sanitation of cook house and dining hall is given here. A detailed description of hygiene aspects of receipt, storage, processing, cooking of food items including meat, milk, eggs, rice, tinned food, water etc. is given in relevant Army Order (AO) on prevention of food & water borne diseases. AO also deals with hygiene of food handlers, control of vermin, responsibilities of various authorities and investigation of outbreak (Refer AO 25/2004/DGMS) .

A high standard of tidiness and cleanliness of all premises used for cooking and serving the food should be ensured. The following important aspects must be considered:-

**(a) Cookhouse premises**

The entire cookhouse premises should be spacious, lighted, fly proof, rat proof, airy and spotlessly clean at all times. The cookhouse should have a separate kitchen or cooking room, a storeroom for fresh provisions, a preparation room, a scullery and a room for the cooks' clothing. Sinks should be provided in preparation room, kitchen and scullery and washing rooms. The floor, wall, ceiling, sinks tables, shelves, cooking appliances and utensils should be spotlessly clean. Fly proofing should be carried out by the use of wire gauze fitted to windows and

doors or use of old mosquito nets / camouflage nets.

**(b) Kitchen**

The kitchen should be spacious and sufficiently large. Properly constructed cooking range is recommended. This will not only economize the consumption of fuel but also keep the cookhouse clear of smoke and afford maximum comfort to the cooks. The kitchen should be fly proof and well ventilated. It should be meticulously clean and tidy. The floor should be well cemented and free from cracks and crevices.

Two flit guns are authorized for each cook house and dining hall for spraying a solution of pyrethrum extract just before the cooking starts. The cooking range should be flanked with platforms for cooks to sit and for prepared food to be kept, awaiting removal to a food serving hatch, racks or hot-plates. Chapati baskets must be lined with clean cloth which is washed daily. All food should be kept covered.

**(c) Preparation Room**

Provision of fly proof and ventilated preparation room for the preliminaries of cooking such as peeling, cutting and washing of food before they are cooked is necessary. The practice of preparation of vegetables on the floor or gunny sacking must be prohibited. This should always be done on a zinc-toped table or granite slabs fitted with a chopping board on it. The peeling and refuse should be deposited directly in a covered refuse bin specially kept for the purpose. The provision of meat chopping block is essential. The block should be washed immediately after use and covered with a layer of powered salt and kept in the sun.

**(d) Store Room**

A separate fly proof and airy store-room for raw fresh food stuffs should be provided. Fresh rations should be kept in baskets/ crates ensuring free circulation of air and stacked on shelves. Fresh fruits and vegetables should under no circumstances be kept in gunny bags. Meat, milk and curd should be kept in a fly proof meat and milk safe or cupboard. Dry rations should be kept in racks, away from the walls, either in neatly tied bags or in tins, on dunnage, preferably in a separate well ventilated store-room. Condiments, tea, oil and salt should be kept away from each other. Rations are issued daily to the kitchen NCO according to the 'bill of fare' and proper accounts maintained. A room for equipment and utensils and for the cooks clothing and other necessaries should be provided separately.

**(e) Scullery**

The scullery should be dry, clean and tidy. Sinks should be adequate, and draining boards should be sufficient and clean. If a proper scullery cannot be provided, as on field service, a properly constructed washing platform with a cement top or PBX top draining into a properly constructed soak-pit through a grease trap must be provided. Maintenance of the grease trap and soak-pit is extremely important to avoid fly, mosquito, cockroach and sand fly nuisance. All utensils after use should be thoroughly cleaned, washed, dried and kept in clean places. Tables should be scrubbed with washing soda and water twice a day using a hard brush.

**(f) Dining Room**

The dining room should be clean, fly proof, well lit, ventilated and cozy in winter and cool in summer. It should be close to the cook-house and afford about one square meter of floor space per man, including passages, for 85 percent of the strength in units and 90 percent in depots. In the field, camouflage netting can provide reasonable fly proofing and a condemned mosquito net can be utilized for protection of cooked food. While serving food, care should be taken to ensure that it is not exposed to flies or dust. It should be presented in a manner that will enhance the acceptability or appeal, and reduce wastage. An effort should be made to supply hot food at all meal times. To achieve this aim, a hot plate should be incorporated in the serving hatch or platform.

All necessary equipment including water jugs and drinking vessels should be presentable and attractively laid out. Water should be taken out by a ladle without dipping the hands. An occasional visit at meal time to see the arrangements for the protection, service and state of food is desirable. Provision should be made for the collection of inedible portions of the meal i.e. bones, peelings, cores etc. Salt and pepper containers should also be provided on each table. Dining tables must be scrubbed with hot water and washing soda after each meal. Officers, JCOs and NCOs messes should also conform to the same standards.

**(g) Cooks' Hygiene**

All men employed as cooks and in the handling of food should take a thorough bath before starting daily work, keep their hair and nails clipped short and invariably scrub and wash their hands with brush, soap and water after every visit to the latrine or urinal and before handling food or raw rations. They should be medically examined at regular intervals, vaccinated against the enteric group of fevers and inspected daily for personal hygiene. The list showing the names of the cooks, date of their employment, dates of immunization, details of medical examination and remarks of the medical officer should be displayed. If civilian cooks are employed, each should have an identity card bearing his photograph to prevent impersonation. They must also be subjected to similar medical examination procedures.

Cooks should be provided with special clothing consisting of 4 aprons, 4 caps (or pugrees), 4 shirts, 2 shorts, 2 trousers to wear while on duty. A clean set of jharons (mops) should be available to the cooks every morning. Facilities for scrubbing hands with brush and washing with soap and running water should always be available. Even in the field, improvised arrangements for provision of running water (tap fixed to a drum) is preferable to a basin of water, which should always be available in the cookhouse at all times.

**(h) Washing Arrangements**

Arrangements to clean and wash the mess tins or plates and hands should be made adjacent to the dining hall. Covered swill bins should be provided and kept on

impervious cement platforms. In the field service, mud platforms properly rammed down after mixing crude oil and covered over with PBX sheeting should be constructed. The lid of the swill drum should always be kept shut. A cement platform or sink should be provided for washing hands. A platform with three open drums containing coarse ash and fine ash (or sand) and for putting used ash should be provided A third platform with three drums for washing and sterilizing mess tins or plates should also be provided. Mess tins and plates should first be cleaned with coarse and then with fine ash, and then washed and rinsed in three drums placed over a kettle-trench. The first 'washing' drum should contain hot water and soap; the second, 'rinsing drum' should contain hot water and soda; the third, 'sterilizing' drum should contain water kept constantly boiling during the period it is being used. The drums should be clearly marked WASH/STERILISE. Utensils should be cleaned with sifted ash or sand before treating in the three containers successively. They may be washed with clean water if the arrangements to boil water are not feasible.

**Rules of the cookhouse and dining hall hygiene**

Rules of the cookhouse and dining hall hygiene as under should be incorporated in all unit standing orders and displayed in a prominent position in all messes, cookhouses and dining halls.

Unit Standing Orders for Cookhouse and Dining room Hygiene

(a) Any one who may be suffering from or under treatment for dysentery, diarrhea or any other communicable disease (a carrier of typhoid or para-typhoid) will not be employed in any capacity in the cookhouse untill certified fit by a medical officer.

(b) An up-to-date nominal roll of all men employed in the cookhouse showing the immunization record and the date of medical inspection will be maintained and displayed prominently in the cookhouse.

(c) Personnel employed in cooking of food will be provided with the authorized special clothing. Aprons will always be worn at work, kept clean, and changed and washed when dirty.

(d) Running clean water (hot during winter), soap, nail brush and clean towel will be provided in each cook-house. Cooks should keep their nails clipped short and invariably wash their hands before they handle the food and after visits to latrine.

(e) No personal clothing, accessories or private property of men employed in the cook-house will be permitted to be kept there; nor will they perform their toilet or washing or drying of their under-clothing in the cookhouse. Personal clothing on the body will be removed and kept in the place provided for the purpose and overalls are put on.

(f) Smoking in the cookhouse is prohibited.

(g) The NCO in-charge will be responsible to ensure that there is always a sufficient supply of clean jharons (mops) available for drying washed dishes and cooking utensils. The jharons used for handling hot and sooty vessels will be separate and distinct. After the last meal these cloths must be boiled in water containing washing soda and hung up to dry.

(h) All pots and pans will be freed from grease, cleaned and dried after the last meal and placed on a shelf on their sides with their interiors exposed to the air and to view.

(j) The cookhouse sinks, tables, chopping blocks, cutting-up boards, pastry slabs, mincing machines, knives, forks, spoons and all other utensils will be kept clean when in use and will be thoroughly cleaned after the last meal. All utensils when not in use, will be kept in the places allocated for them and will be available for inspection at any time.

(k) Only food which is to be used during the current day will be kept in the cookhouse. When not in the process of cooking or in preparation for cooking it will be protected from flies in fly proof food safes.

(l) Food scraps, vegetable peelings, etc will not be thrown on the floor, but directly deposited in covered refuse bins provided for the purpose.

(m) All cutting up of meat will be done on the cutting blocks/boards provided for the purpose.

(n) The bill of fare for the week will be displayed in the cookhouse.

(o) Adequate arrangements will be made for the washing, rinsing and sterilizing of eating and drinking utensils.

(p) Any defect in the cooking apparatus or in the utensils will be reported at once by the NCO in-charge to the unit quartermaster, who will take the necessary steps to have the defects remedied.

(q) The floors of cookhouse will be scrubbed daily and excess water must be dried up by mopping.

(r) The cookhouse and dining hall should be sprayed daily with 0.1 percent pyrethrum solution, preferably between 1000 to 1200 hours.

**Ration Stores**

It should be a fly proof and rat proof concrete building. Grains and flour should be stacked on racks placed away from the wall. In field camps, grains should be stored in iron or tin containers. Regular turnover of reserve rations should be ensured and their condition should always be examined by the medical officer to ascertain whether they are infested with weevils and other food pests. Vegetables such as potatoes, onions and tomatoes should be stored in ventilated shelves and not in gunny bags. Tinned foodstuffs should be periodically examined for damage to tins and the expiry of the date.

## Inspection of Food stuffs

The prevention of the Food Adulteration Act (1954) as amended, is meant to control the quality of foodstuffs offered for sale to the general public. The inspection of

foodstuffs is necessary to ensure that they are of adequate nutritive value, will not cause food borne diseases and conform to contract specifications. This is the responsibility of an ASC organization known as the Food Inspection Organization. The Deputy Director of Food Inspection (DDGFI) is responsible to the QMG for food inspection. He is a medical officer (specialist in PSM) appointed by the DGMS (Army) and has under him a number of technically qualified ASC officers along with other technical personnel.

Composite food laboratories (CFLs) are established for special tests and food analysis. The services of food inspection officers, at the CFL may be utilised if the quality of supplies is in doubt. However, all medical officers should know the elements of food inspection as they are frequently consulted. Medical officers in units should inspect periodically the rations at the ration stand, in food stores, cookhouses, and dining halls. They are also required to inspect slaughter houses, dairies and bakeries under military control. In addition they may expect to receive occasional appeals from units for a decision in respect of food thought to be unfit for consumption. In the vast majority of cases, an opinion regarding fitness can be given after an intelligent use of the senses. Chemical analysis may be required. The following notes on individual commodities have been compiled with the objective of serving as a short guide to the inspection of ration articles by medical officers. Further details may be obtained by consulting a standard text book on food inspection (3,4,5,6) the Prevention of Food Adulteration Act / rules (7,8) and the official army publication on ASC (9). This publication also gives comprehensive working information on the specifications and inspection procedure of various food articles (Chap X), various ration scales and their nutritive values and hospital rations (chap XI), hygienic requirements in butcheries, and inspection of meat, poultry and fish (chap XII) and pest control in ration stores (chap XV).

**Principles of Inspection**

Sampling of the products requiring inspection is the first important procedure if large consignments of food are involved. Samples should be adequate in quantity and fully representative of the consignment. For example, if tinned milk is being examined, it may be necessary to sort the consignment into different brands, and thereafter each brand into groups (rusted tins, 'blown-up' tins) and representative number of tins from each group examined in detail. Only by systematic sampling can the quality of large consignments be accurately assessed and suitable instructions for disposal formulated. In the analysis of the sample obtained, the following factors should be considered:-

(a) The appearance, physical condition, taste and /or smell of the commodity in relation to its normal characteristics and keeping qualities.

(b) For the foodstuffs in cans, bottles, cartons, the external and internal condition of the container, the date of manufacture, the date of expiry or the warranty period and the manufacturer's name or proprietary brand.

**Disposal of Food materials after Examination**

Food may be considered as fit for issue without conditions, fit for issue within a limited period, or unfit for issue. The procedure to be followed is laid down in para 900 of DSR. If a unit takes rations on charge, the ASC is absolved from further responsibility and the unit must adjust any loss, if the medical officer subsequently condemns the article. Any queries regarding fitness for issue or consumption of rations should therefore be raised before rations are accepted by units. If the ASC officer agrees with the unit's complaint, he will immediately replace condemned articles. If he does not agree, the OC station will give a final decision, usually after a formal board of enquiry has been convened to examine the disputed rations and to make recommendations as per instructions issued from time to time.

**Atta and Flour**

The only difference between these two wheat products, from the point of view of inspection, is that atta contains a larger proportion of the pericarp or bran and the germ of the wheat grain. It, therefore, has a grayish appearance as compared with the dead whiteness of refined flour. Fresh flour or atta smells sweet, is of uniform consistency and has a bland taste devoid of sharpness. Deterioration usually results from prolonged storage or from adverse storage conditions. The main reasons for rejection are as follows:-

(a) Poor Baking Quality

The baking qualities of bread are due to gluten, the wheat protein. If a small quantity of flour is made into dough and the starch thoroughly washed out under running water, the sticky mass remaining is gluten. With good quality flour and atta this is golden yellow and is sufficiently elastic to be stretched for several inches without breaking. Gluten from old flour is dull grey and is friable. The change is associated with an increase of rancidity in the flour due to splitting of fats by enzymes in the wheat grain. The ultimate criterion on which a decision to reject flour as unfit for baking purposes may be made, is the quality and palatability of a sample loaf, baked by a competent baker.

(b) Rancidity

It is due to oxidative changes in the fat of atta or flour, and gives rise to a distinctive flavour which is easily detected. It is not a cause for condemnation unless the commodity is definitely unpalatable.

(c) Mustiness

It is due to infestation with the flour-mite, a tiny 8 legged creature which is invisible to the naked eye. If the surface of some infested atta/flour is smoothened with a knife, the mites will, in a few minutes, raise small heaps on the smooth surface. A distinctive odour is present. A mild infestation with a slight musty odour may be ignored, but in the majority of cases infestation develops rapidly, and

by the time it has become obvious, the flour is usually unfit for human consumption.

(d) Larval infestation

It is common, especially during the monsoon. The usual agent is the weevil, a small beetle that is easily visible and lays eggs from which larvae hatch. Infestation with the larvae of certain moths may also occur and this condition can be detected by the webs of silky material produced. Such flour or *atta* can be cleaned by sieving through muslin provided infestation is not unduly heavy. With heavy infestation the excreta of larvae renders the flour objectionable

(e) Mouldiness

It may occur under moist conditions. The flour becomes lumpy owing to the network of mycelia produced. If such lumps are carefully removed without breakage by sieving, it is usually possible to retain much of the flour as fit for immediate consumption.

**Bread**

Ordinary bread is made from white flour and should be risen, evenly aerated, free from large cavities and has an elastic crumb. The commonest defects in bread are sourness, soddenness and heaviness, all of which may be due to bad baking or poor storage. In the examination of bread, the chief guides are its general appearance, colour, smell, taste, texture and the presence or absence of moulds and animal parasites. The loaf or loaves should be broken open, a chunk should be taken from the middle of the loaf, rolled into a tight ball and examined for resilience by dashing it against the wall or the floor. Good bread will rebound.

**Biscuits**

These are made of flour, sugar, oil, salt water, milk and bicarbonate of ammonia. On examination of biscuits, note should be made of appearance, color, odour, crispness, hardness, palatability and the presence or absence of insects. The commonest defects are rancidity, mustiness, softness and the presence of moulds.

**Rice**

The appearance of rice varies greatly according to the variety, the degree of milling, and any other treatment to which the rice may have been subjected, such as parboiling or polishing. The rice for consumption by troops shall be lightly milled or parboiled. Ration rice, therefore does not have the white appearance of highly milled rice but may be of greyish colour. Parboiled rice has a characteristic translucent appearance. Under good storage conditions, rice will not deteriorate, or may even improve in quality upto about 2 years. The chief defects are an undue degree of milling, infestation or mouldiness.

(a) Milling

Normally all ration rice is inspected before being purchased, but there are occasions when apparently highly milled rice may be issued to troops. Its thiamine content can only be assessed by laboratory assay for thiamin content (specified as not less than 2 mg/g) and for phosphorus pentoxide content (specified as not less than 0.4 %). Thiamine assay cannot be carried out as a routine but the phosphorous test gives a fairly safe indication of the degree of milling and of the thiamine content.

(b) Infestation

The condition is similar to that in *atta* and flour.

(c) Mouldiness

Under damp storage conditions, or if rice is exposed to rain while in transit, the growth of mould is likely. The mould may develop only in the layers of rice adjacent to the sack container especially if the dampness has been caused by rain, and in that case the rice in the centre of the sack may be perfectly good and sound.

**Milk and Milk Products**

Fresh milk should be inspected as described in chapter 15. Tinned milk may be either sweetened or unsweetened, and is condensed by means of evaporation to about half or one-third of its original volume. Sweetened tinned milk contains about 50 percent of added cane sugar which is an important preservative. The inspection of tins and their contents should be carried out as follows:

(a) Tins

One type of tin has ends soldered to the body without crimping, though the side seam is crimped and soldered. This type is fragile and with rough handling is liable to develop leaks. The other type has crimped and soldered seams and is less likely to develop leaks. Etching on the insides of tins is not a sufficient cause for the rejection of contents. The contents of leaking tins are liable to rapid deterioration. Bulging, badly dented and leaking tins should be rejected.

(b) Unsweetened Tinned Milk

The chief defect likely to be found, other than obvious deterioration within a leaky tin, is an increase in acidity. If this is high and an unpleasant sour taste is present, the milk is unfit for human consumption. A milder degree of acidity is not harmful but it is an indication for immediate use. In some tins the fat may have separated, leading to an appearance like clotted cream. Sometimes a deposit of calcium lactate takes place. Such milk is quite wholesome if sourness is not present.

(c) Sweetened Tinned Milk

It is not liable to deterioration due to bacterial action. But in hot climates caramelisation tends to occur resulting in a brownish discolouration or even separation of sugar crystals. This is harmless and is not a cause for rejection.

(d) Butter

It should contain not more than 16 percent of water and not less than 80 percent of fat. Adulteration in a small quantity is difficult to determine accurately even by chemical analysis. The smell, taste, color and consistency must be taken into account on ordinary inspection. The commoner defects are rancidity, too much salt and too much water. A decision whether or not to reject it must depend on the degree of fault in each case. Butter on bacteriological examination may show large number of bacteria found in milk, if it has not been prepared from pasteurized cream. Tinned butter will melt during hot

whether with the curds settled at the bottom of the tin. It is perfectly wholesome in this state and can readily be reconstituted by stirring thoroughly. The slight lumpiness in such reconditioned butter is not an adequate cause for rejection.

(e) Cheese

The most important guides to its fitness for consumption are the smell, general appearance, taste and presence of mould. Surface mould on cheese does not render the interior unfit for consumption.

**Oil**

Hydrogenated oil was being provided earlier. It has now been replaced with refined vegetable oil (cotton seed, groundnut, palm kernel or seasame oil). The product should be clean and wholesome. It must be free from unpleasant taste, smell and rancidity.

**Eggs**

Fresh eggs should not be less than 35 g each and not more than 25 eggs per kg. In the candling test an egg is fitted into an opening cut in a shield (e.g. a piece of cardboard) behind which is placed a bright light. Viewed in the dark, a fresh egg will appear uniformly pink and translucent, while a bad egg will show cloudy dark patches, or even opaque, owing to the presence of gases resulting from decomposition. In the floating test, an egg is placed in a vessel containing 10 percent sodium chloride solution. A sound egg slowly sinks while a bad egg floats.

**Fresh Vegetables and Fruits**

'ASC Specifications' lay down that fresh vegetables shall be freshly gathered, sound, crisp and free from discolouration. The vegetables shall be of good average size for their class and not coarse, stringy or old. Potatoes must be of good quality, free from disease and of such a size that they average not more than 32 to a kg and must not be capable of passing through a 2.5 cm circular mesh. Fruits must be in good order, sound, freshly plucked, free from mould and all unpleasant taste and smell, of good average size, ripe and in a suitable condition for consumption and not over-ripe, bruised or otherwise damaged. Deterioration in fruit and vegetables must be judged on the merits of each case, but all rotten products should be rejected. Freshness is of nutritional importance, since old, limp or bruised fruits and vegetables have lost much ascorbic acid through the action of oxidases.

**Tinned Fruits and Vegetables**

Tinned fruit and jam keep well because the sugar in them acts as a preservative. The can as well as its contents should be inspected. The can may be 'blown' when the ends bulge and cannot readily be pressed in. On puncturing, a hiss of escaping gas is heard. With tinned fruit and jam (and less commonly with other tinned products), blown cans may be due to hydrogen formed by the action of the acid of the fruit on the tin coating, which lays bare pin points of the underlying steel and may catch fire if the tin is punctured near a lighted match. So long as the can remains intact, the contents remain perfectly sound and wholesome but at a late stage the acid erosion may produce small perforations and spoil the contents by bacterial action. If the gas in the blown can is carbon dioxide due to fermentation of sugar, small bubbles will be seen throughout and an alcoholic smell will be present. Advanced fermentation renders a product unfit for consumption.

**Dehydrated Vegetables**

If no advanced deterioration e.g. attack by mould is present, no judgement can be passed until the product has been reconstituted, cooked and compared with the cooked fresh product as regards appearance, smell and flavour. A good dehydrated product should resemble the fresh product when cooked. Dehydrated potatoes frequently have a somewhat dark yellow color which disappears almost entirely on reconstitution and cooking, and is no cause for rejection. The condition of the container is of utmost importance for the keeping quality of all dehydrated foods. If tins are not hermetically sealed, the contents will deteriorate rapidly by becoming damp and mouldy and in some cases, fermented. The freeze-drying process produces dried products of a much better nutritive and keeping quality and the reconstituted freeze dried products resemble more closely to the cooked fresh food than do the dehydrated products.

**Peas, Beans and Dals**

Pulses of all kinds are liable to attack by certain insects, the larvae of which develop within the seed and eat away its substance until nothing but a hollow shell is left. One species of larva makes a neat circular hole in the pulse, through which it escapes. This is preceded by the appearance of a circular mark. However, in the absence of the mark or the hole, the pulse is not necessarily uninfested. The only sure method of estimating the extent to which a consignment is infested is to take a sample and cut each individual seed into half. A grossly infested consignment should be condemned. If pulses have been exposed to rain, germination may occur. In the absence of fungus infection this is harmless. The decision regarding whether to accept or reject should be based on the palatability of cooked samples.

**Sugar**

The commonest defects are dampness, dirt and the presence of animal parasites. In examining it, colour, solubility and sweetening power must be considered. Sugar may be considered sound, if it is sweet and is readily soluble in half its weight of water to form clear bright syrup with no parasites.

**Condiments**

Condiments such as mustard, pepper, turmeric and ginger do not normally deteriorate. If however, they are not properly packed and become damp, they ultimately develop mould growths and are spoilt. Garlic, and to a lesser extent chillies, contain a higher percentage of water than other raw condiments, and if not properly dried before storage, may deteriorate rapidly. Garlic tends to germinate, rot and become black. Chillies become mouldy. Parasite infestation is not uncommon in condiments.

### Tea

Tea should be blend of medium quality with good colour and a fair size leaf producing good liquor. It should be dry and free from impurities and adulteration.

### Salt

Salt is of two types. 'Edible common salt' is pale pink, light gray or white in colour and may contain a small quantity of insoluble matter. The sodium chloride content should not be less than 96 percent. Refined salt is a white crystalline powder. It should dissolve freely in water with not more than a trace of insoluble matter. The 'running quality' in table salt is produced by blending it with bee's wax. Iodised salt protects from Iodine deficiency disorders. As per PFA act specifications, the concentration of Iodine at source and at consumer end should be 30 and 15 PPM (mg/ Kg) respectively.

### Meat

Inspection of meat, fish and poultry is described in subsequent chapters.

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# Milk Hygiene and Military Dairy Farms

## Fresh Milk

### Inspection of milk

The main objectives of inspecting fresh milk supplies are to detect visible dirt, deterioration and adulteration; assess nutritive quality and keeping quality; and ascertain efficiency of pasteurization. The important points to remember are:-

(a) Visual Inspection

Ropy milk or slimy milk may be due to a disease of the udder or contamination by Lactis vascosus. Blue milk, may be due to the poor condition of the animal (e.g. due to tuberculosis) or occasionally to infection by Pscyanogena. Red milk may be due to a crushed udder; but milk for the first few days after calving is highly coloured owing to the presence of colostrum. Dirty milk is due to manurial dust from the flanks and tail of the cow, or dirt in the container. The measurable amount of dirt on standing should be less than 100 ppm and when this residue is diluted with water and centrifuged, the insoluble dirt should be less than 50 ppm of the milk. Ropy milk or excessively dirty milk or red milk, other than that due to the presence of colostrum, should be condemned at once. Blue milk should not be accepted as sound whole milk.

(b) Taste

Bad taste in milk may be due to the feeding of the cow (e.g. with turnips). Medicinal taste may occur if the cow is being administered some drugs. Rejection is justified if the taste is definitely unpalatable. Ordinary souring of milk, though not harmful, is not acceptable. Souring of milk is not necessarily indicative of feacal contamination by pathogenic organisms; they are lactose non-fermenters and hence do not make milk sour. Therefore, non-sour milk is not necessarily always safe either.

(c) Laboratory Tests

The specific gravity of milk should be 1.029 to 1.033 but watered milk can be readily restored to its normal specific gravity by adding sugar or cornflour. A further analysis is necessary to detect adulteration. Most military dairy farms possess the Gerber's apparatus for simple qualitative laboratory test on fresh milk. Tinned or powdered milk should be sent to Composite Food Laboratories. Fresh milk, for detailed analysis chemical and bacteriological tests and to assess the efficiency of pasteurization, may be sent to the Command Path Lab.

**(i) Gerber's Test**

In this test fat estimation is carried out by thoroughly mixing 10 ml of sulphuric acid, 1 ml of amyl alcohol and 11 ml of milk in special tube provided with the apparatus and centrifuging it for 5 to 7 min when milk fat separates as a clear supernatant layer. This is read off from graduations on the tube, which shows the percentage of fat in the sample.

**(ii) Total Solids**

These are estimated by the evaporation of whole milk in a water bath and then weighing the dried residue or by using Richmond's formula viz. Total solids= 0.25 G + 1.2 F + 0.14 (G means specific gravity above thousand i.e. 28 or 30 and F means percentage of fat). Solids not fat (SNF) are estimated by deducting the fat value from the total solids.

**(iii) Methylene Blue Test**

It is carried out for testing the keeping quality and bacterial contamination in the milk. The basis of the test is that the dye is reduced and decolourised by the bacterial enzymes. The rate of reduction is an index of the extent of bacterial contamination. One ml of methylene blue solution of 1:300,000 strength is added to 10 ml of milk sample in a test tube and then incubated at 37 ºC in a water bath or incubator. The mixture should not decolourise within 5½ hours. If kept at room temperature above 37 ºC it should not decolourise within 4½ hours.

**(iv) Phosphatase Test**

This test is meant for ascertaining the efficiency of pasteurization and depends on the fact that the enzyme phosphatase is destroyed by the pasteurization temperatures; but not completely destroyed at a lower temperature, or in a shorter period than that required for pasteurization. Milk containing as little as 0.25 percent of raw milk in the properly pasteurized milk still contains detectable quantities of enzyme. The test is performed by addition of disodium phenyl-phosphate to pasteurized milk. The enzyme phosphatase, if present, splits up the phenol by means of a phenol test reagent which gives different shades of blue colour depending upon the amount of phosphatase enzyme present. The colour is matched against the standard colours in a Lovibond colorimeter. Pasteurized milk must not contain more than 2.3 Lovibond units.

**(v) Bacteriological Tests**

These are rarely carried out as a routine but when indicated, are used for detection of *M tuberculosis* or *B abortus.* Under such circumstances 100 ml of milk is centrifuged at 3000 rpm for half an hour. The deposit is mixed with a little saline and injected into two guinea pigs. One of them is sacrificed after 4 weeks and the other after 8 weeks. Lungs and other organs are examined for tubercular granulomas. Serum from these guinea pigs can be used for agglutinating B abortus culture, or the spleen of the killed guinea pigs can be cultured in a liver extract-agar medium containing gentian violet of concentration of 1 in 250,000 in the presence of 10 percent CO2. Deposits of centrifuged milk also can be cultured for other organisms in appropriate media such as the Wilson Blair medium for the enteric group of organisms and the tellurite medium for *C diphtheriae.*(1)

## Military Dairy Farms

Military dairy farms have been established for the purpose

of ensuring a pure, wholesome and protected milk supply for the military population. The buildings should conform to the principles mentioned here under. A dairy consists of the farm, the milk depot and the pasteurization and bottling / packing plant, milkers changing rooms, and a manure disposal yard. The 'milk depot' or the dairy proper has milk receiving, pooling and cooling rooms and the blending room. The plant contains the boiler house, the bottle and churn sterilizing rooms, pasteurization plant, bottling / packing and cooling plant, the butter and cream separation room. All of these are housed in permanent, solid, fly and dust proof structures.

Milk can become a good nidus for non lactose fermenting organisms of *salmonella* and *shigella* group, of *streptococci* and *staphylococci,* a vehicle for viral hepatitis and poliomyelitis virus and transmitting medium for bacilli (*Brucella abortus*, *tuberculosis*) and *Rickettsia burnetti.* Organisms of cholera, salmonella and shigella group and viral hepatitis and poliomyelitis can be transferred to the milk extrinsically through a milkman's contaminated hands or through water, flies, dust or containers and cause dysentries, diarrhoea, cholera, typhoid, paratyphoid, bacterial type of food poisoning, viral hepatitis and poliomyelitis. *Mycobacterium tuberculosis* and Brucella abortus are transmitted intrinsically to the milk from the infected cow and cause tuberculosis and brucellosis. *Coxiella burneti* infection can be transmitted to man by handling of animals and their products, consumption of infected milk and meat and also by aerosol spread. *Streptococcus and staphylococci* can be transmitted to milk both extrinsically by the milk man suffering from a hand infection, an open sore or boil any where in the body , a running nose or ear and also intrinsically from the cow suffering from mastitis and cause a toxin type of food poisoning, septic tonsillitis, nasopharingitis or scarlet fever like syndromes. Diphtheria is known to have occurred in hostels due to infected milk. Table - 1 depicts the diseases conveyed through milk. (2)

Milk borne outbreaks of acute infection like food poisoning, typhoid or viral hepatitis may occur where milk from various sources is pooled to provide to large community-feeding establishments like students' hostels, Armed Forces Personnel, or large hotels and restaurants. The outbreaks are explosive, affecting persons in a circumscribed area with a common milk supply from a common source. Such outbreaks occur through consumption of ice creams or puddings, etc made of milk or cream. In order to assess the nutritive standard and initial purity the raw milk should be subjected to various tests, described above. To prevent outbreaks of milk borne diseases hygiene of cattle, personnel, equipment, process (of milching and pasteurization), packing and delivery should be ensured.

A periodical medical examination of personnel, inspection of premises and equipments, veterinary inspection of cattle, scrutiny of the process in the dairy, inspection of functional efficiency of the farm, depot and plant, and laboratory tests for purity and quality of pasteurization are required to be carried out. These measures should ensure the following:-

(a) The live stock of milching cattle is healthy, free from infections and protected against any illness; ill animals are isolated and contacts are segregated to prevent spread of infection; ill animals are not milked.

(b) High sanitary standards of the surroundings are maintained.

(c) Milk handlers are healthy, free from and protected against infections and are prohibited from handling milk if evidence of ailment is seen.

(d) Water supply is pure and protected.

(e) Containers are clean, regularly washed, sterilized and protected from contamination.

(f) Milk is protected against contamination by flies, dust or other extraneous matter.

(g) Milk is treated to destroy pathogenic organisms and thereafter kept protected.

Table - 1 : Diseases conveyed through milk

| Disease | Organism | Reservoir/Source |
|---|---|---|
| Tuberculosis | *M tuberculosis (bovine)* | Cattle |
| Brucellosis | *B abortus / melitensis* | Cattle, Goat |
| Q Fever | *Coxiella burnetti* | Cattle |
| Septic Sore throat | *Streptococcus pyogenes* | Cattle, milk handlers |
| Food Poisoning, toxin type | *Staphylococcus aureus* | Cattle, milk handlers |
| Diarrhoea and dysentries | *Shigella,E hystolytica* | Milk handlers |
| Cholera water, milk | *Vibrio cholera* | contaminated |
| Enteric fever | *Salmonella species* | Milk |
| Viral hepatits, polio | *Hepatitis A, Polio viruses* | Milk |

### Care of Cattle

The quality and the quantity of milk depend upon the particular breed and also on the care that is devoted to the cattle. The milk yield is also sensitive to their comfort, feeding, watering, and cleanliness; hence a clean, airy, cool and spacious cattle shed is of prime importance. Ample water supply to wash the cattle sheds and bathe the cattle should be available. There should be adequate arrangements for storing the fodder and water. Facilities for cleaning the stalls, gang-ways, gutters etc. should exist. Adequate arrangements for bathing the cattle should be there. It is healthier to bathe the cattle daily with cool water (or warm water during severe winter), but in any case a bath must be given at least twice a week. Cattle should be groomed and their udders washed, and then wiped with a damp cloth every time the animal is milked. Ample water supply for drinking is absolutely essential. Fodder and other victuals like cottonseed, oilcake, bran and meal consisting of a coarsely crushed

mixture of grains, according to the scales laid down must be given to each animal. Meal, cottonseed and fodder stores should be rat proof. Rat and flea nuisance are as much detrimental to the health and comfort of animals as they are for human beings. Measures to keep them under control must be taken and maintained throughout the year. Salt blocks for cattle to lick should be kept at vantage positions.

Sick animals must be immediately isolated and contacts segregated. In order to ensure this, the cattle should be inspected by a veterinary surgeon at least once a month, or as often as required. Segregation and isolation sheds must be available. Preventive inoculation against common diseases must be ensured. In well developed farms, tuberculin tests followed by segregation, examination, treatment or sacrificing of the infected and sick animals according to their stage of disease, is resorted to. Thereby herds free from tuberculosis can be raised. Each cow or buffalo must have a history card showing the date of birth, state of parity, milk yield since the first milking day, medical history, immunization given, any test for absence of tuberculosis and a history of brucellosis and mastitis at any time during its milking life. When the milk yield consistently shows a fall, the reasons for it should be investigated. Unless it is due to seasonal, periodical or prenatal waning, appropriate action to treat the animal or if due to senility, to dispose off the animal, should be taken.

### Cow Sheds

A properly constructed cow shed and its cleanliness is one of the important requirements for production of safe milk. The site should be well drained, higher than the surrounding ground and the building should run North-South. The approaches to the shed should never cross a manure yard. The best layout is a double range shed with a 2 meter broad para-central dunging passage with a central channel, a 3 meter cow standing on either side of the passage, and 1 meter broad mangers flanking among the sidewalls. The floor area per cattle head should be minimum 6 $m^2$. The space allowed per cow should be 18 $m^3$ if the cows are allowed to graze, or 24 $m^3$ if the cows are not turned out. The walls should be of reinforced concrete and whitewashed inside. Good cross ventilation is essential and should be secured by hopper windows on opposite walls and by air inlets along the walls near the floor with outlets along the ridge. The shed should be well lit by not less than 1/3 $m^2$ of window per animal, but should be capable of being darkened during the heat of the day. The whole flooring should be of impervious concrete. No inaccessible drain or trapped gulley should be allowed in the shed. An isolation shed for sick cattle must be provided. The sheds should be washed every day and cleaned twice a day. They should be sprayed with insecticide once a week.

### Disposal of Cattle Dung and Sullage

All channels carrying sullage and liquid cattle dung should always be made of concrete and continue for some distance beyond the shed to a suitable place for disposal, such as a septic tank with large soakage pits or central sewerage system. Semisolid cattle dung is a potent source of fly breeding and pollution of milk in dairy farms. It should be removed daily to a cow dung depot made of concrete and situated at least 200 m away from the cattle sheds. In large dairies a suitable method of removal is in wheeled iron tubs running on a length of small gauge rail line. In small dairies iron wheel barrows may be used but the path from the shed to cattle dung depot should be of concrete. The cattle dung can be either sold to the contractor or converted into manure and used in the farm. All cattle dung should be removed daily from the cattle dung depot. When regular removal from the dung depot is not possible, a system of 'tight packing' on concrete or impervious platforms and proper composting, about 400 m away from dairy farm and buildings should be adopted. The cattle dung under such circumstances should be removed direct from the sheds to the place of final disposal without the intervention of a cow dung depot. Antifly measures by the use of camouflage nets impregnated with dieldrin or organophosphorus insecticides should be carried out at the cattle dung disposal yards and dung depots. These places should be on the leeward side of the farm as the breeze may carry dried cattle dung to milk.

### Health of Workers

There are three categories of personnel i.e. those working on the farm outside the plant houses, those working inside the plant, and the administrative staff including those engaged in grooming the cattle or disposal of manure etc. but not coming in direct contact with milk. All employees of the first two categories should be permanent, selected after a thorough medical examination and should be issued identity cards. Medical inspection of the employees should be carried out very regularly and frequently, strict attention being paid to personal cleanliness. Exclusion of carriers of communicable diseases should be rigidly enforced. A regular immunization against enteric group of fevers and when so advised by the MO, against cholera should be ensured. Record of medical inspection and immunization should be maintained for all personnel. The manager should keep a daily list of all those absent without adequate reasons. They should not be allowed to return to work until medically inspected. The manager is responsible for reporting to the MO, all cases of illnesses, especially diarrhoea, dysentery, enteric fever, infected fingers or boils, running nose or ears, sore throat or cough among his employees.

All indoor workers should remove their clothes on arrival for work and these should be kept in a cupboard. They should then be made to scrub their hands thoroughly with soap, hot water and a nail brush and put on their working clothes which should be clean and suitable to each man's particular duties. Milkers should similarly change into their milking suits and overalls and should wear cotton milking caps; workers handling milk should wear masks made of gauze. All workers should have adequate sanitary and bathing facilities and should be made to use them consciously and through regulations. After using the sanitary annexe, they should be made to wash their hands

with soap and water before entering the processing premises or milking. They should be provided with clean sheets and should use milk pails with baffles and covers. As soon as a pail is full it should he covered as a protection against flies and dust and immediately removed to the milk room, without transferring it to any other vessel.

**Milk Depot and Dairy**

The dairy and milk depot should be adjacent to but entirely separate from the cowsheds and should be sited with a view to avoid contamination of milk by flies, dirt dust and manure. The whole block should be well ventilated, well lighted and fly proof. All ceilings and interior walls should be smoothly plastered with cement and lime washed frequently. The lower one meter of the walls may be paved with glazed tiles. Floors should be made of concrete and should be drained by shallow surface channels, leading to a suitable drain outside the building. The dairy and milk depot should have a milk receiving room, milk pooling and cooling room, a fat assessment room, a sterilizing room for bottles and cans, a storeroom and a change room for workers.

In certain stations especially in semi-permanent field stations, where military dairies cannot be established, milk depots are organized under the orders of the Station HQ and ASC control. In these depots, milk brought from local contractors is pooled, tested for fat contents and keeping quality and distributed to units without boiling or sometimes after boiling and immediately cooling. In some places blending is also carried out. An extremely strict hygienic control is necessary. Raw milk must be subjected to tests before being accepted under the following circumstances: -

(a) A milk receiving room should be used only for receiving milk from the sheds and for which special racks should be provided. A fly-proof hatch fitted with a jet steaming device should be provided, through which each milker hands in his full pail and receives in exchange an empty pail; under no circumstances should any milker or other outside worker be allowed to enter the receiving room.

(b) Milk straining, pooling and cooling rooms should open off the receiving room but should be entirely separate from it. A metal milk strainer with removable cotton wool discs which can be burnt after use, should be used. The milk cooling apparatus should be capable of cooling milk to below 7 ºC.

(c) Sterilizing Room : A piped supply of pure water, hot water in abundance and steam for sterilizing is essential. Separate galvanized iron washing tanks for washing bottles, cans and churns are required with emptying plugs leading to a proper drain. Sterilizing apparatus are required separately for bottles and cans. Cans and churns should be thoroughly washed with soda ash, scalded by exposing to steam for 20 min. In smaller dairies cans can be sterilized separately by inverting them over a steam jet, which emerges from the center of wooden block over which the mouth of the cans fit. This must, however, be considered as only an improvisation. For sterilizing bottles, a galvanized iron tank with the inside of the lid padded with an asbestos gasket and into which current steam can be blown, is the only satisfactory type of sterilizer. The sterilized bottles, cans and churns should be stored in metal racks.

**Pasteurization Plant**

This includes a pasteurization room, packing/bottling room, and cream and butter separation rooms. The premises should be fly and dust proof.

(a) Pasteurization Room

The pasteurization plant should receive milk directly from the milk straining and cooling room without being exposed to outside environment. Equipment in the pasteurization room should be made of stainless steel and protected from dust, flies and human nasopharyngeal droplets. The room should be fly and dust proof.

(b) Bottling /packing Room

The mechanical bottling / packing and sealing machines are necessary and should be insisted upon whenever pasteurization plants are provided. There should not be any likelihood of the contamination of milk while bottling / packing and sealing.

(c) Creamery

The hygienic standard of the butter room and of the methods of separating cream and butter making must be high. The personnel employed should be reduced to a minimum and should be permanent and under direct and close supervision. All cream should be pasteurized before being churned and the butter should not be touched by hand at any stage in its manufacture.

(d) Blending Room

Milk for issue to troops as daily ration is 'standardized' or 'blended' in a separate room with all precautions necessary to prevent exposure to pollution, flies dirt & dust. Water must be properly clarified and chlorinated but must also be boiled prior to blending. Standard or blended milk samples are tested for their fat content, which should be 3.7 percent. Skimmed milk powder should be from an authorized and approved source. Blended & standard milk should be subjected to pasteurization before packing / bottling or delivery from cans (3,4).

## Pasteurization

Boiling kills the microorganisms in any liquid but is likely to adversely affect its quality, taste and flavour, if the components of such liquid are heat-labile, such as are found in milk. Pasteurization involves rapidly heating a liquid (to less than the boiling point), maintaining it uniformly over a definite period and subsequent rapid cooling. This destroys most of the pathogenic microorganisms, reduces the total quantity of all the microorganisms and makes all of them less viable without affecting its inherent qualities unduly or its taste and flavour unfavourably. It may not sterilize the liquid but makes it non-infective, retains its nutritive and aesthetic

qualities and improves its keeping quality. The important pathogens that are destroyed by pasteurization of milk are *M tuberculosis, B abortus, Streptococci and Staphylococci* and the non-lactose fermenting pathogenic organisms of the *Salmonella-Shigella* group. The subsequent rapid cooling of the heated milk inhibits the multiplication of any viable residual microorganisms or of the ones subsequently gaining access to the liquid. The low temperature must be maintained till the milk is consumed.

The nutritive value of pasteurized milk remains reasonably satisfactory. Its fat, protein, calcium, phosphorus, and vitamins A and D contents are not affected. There is a 10% loss of vitamins B and 20% loss of vitamin C. Pasteurization improves the keeping quality of milk, reduces the number of bacteria, and destroys tuberculosis bacilli and other pathogenic organisms except spores and thermoduric bacteria. However, milk with a high bacterial count in a raw state will not pasteurize so efficiently as clean milk. Pasteurized milk can be preserved for 8 to 12 hours at 18˚C.

**Methods of Pasteurization**

The methods of pasteurizing milk are as follows :

(a) Holder (Vat) method

This method consists of heating the milk to the temperatures between 63ºC and 65.5º C and holding it in large tanks at that temperature for 30 min before cooling it rapidly to 5˚C. None of the milk escapes heating, and the pathogenic bacteria are killed with certainty. There are leak-proof inlet valves with an air relief, leak proof and close coupled outlet valves, air space heaters, accurate thermometers and automatic temperature controls. From the holding tank the milk runs directly to the cooler and then to the packing / bottling machine through a closed system.

(b) Continuous Flow Method

This method is the modification of the Holding method. The milk is first heated to 63ºC or more and then led through a series of heated metal coils so that the milk remains at that temperature in the apparatus for 30 min.

(c) High Temperature Short Time (HTST) Method

In this method milk is heated to 72˚C for 15 seconds and then rapidly cooled to 4ºC.

(d) Ultra high temperature (UHT) Method

Milk is rapidly heated usually in two stages, the second stage being under pressure, between 125º to 150º C for a few seconds only. It is then rapidly cooled and packed / bottled as quickly as possible.

(e) Pasteurisation in Bottles

The filled bottles should be well sealed with an effective stopper and heated by a shower of hot water or by steam. The simplest method is to place the milk bottles in water-bath brought to 63ºC held there for 30 min and then chilled. Several types of machinery are in use for this purpose. One type consists of a revolving drum in a metal cylinder, in which the filled bottles are subjected to a spray of hot water, and before completing the revolution are chilled. In another type of device the endless conveyors carry the bottles through a trough of hot water and then they are cooled. The theoretical risk of contamination after pasteurization is entirely eliminated. However, the temperature stratification occurs in heavy glass bottles.

The pasteurization process needs constant supervision and the following are the most important factors to ensure efficient pasteurization:-

(a) Raw milk must be clean and free from extraneous matter.

(b) A pasteurization chart should show the range of and the period for which the temperature, as specified for the method, was maintained.

(c) Milk must be protected from contamination during cooling and bottling / packing; unprotected open coolers are undesirable.

(d) Excessive foaming of milk must be avoided during pasteurization. In excessive foaming the temperature of the foam is too low to kill pathogens and may even encourage the growth of thermophilic organisms.

(e) The apparatus must be efficiently cleaned and sterilized after each day's work

(f) Besides ensuring efficient supervision, the process of pasteurization should be checked from time to time by the colorimetric phosphatase test as described earlier.

(g) If there is any doubt, about the effectiveness of pasteurization, the issue of such milk must be reconsidered. It is much safer for the consumer to assume that the milk he receives is untreated and is therefore boiled rather than to enjoy a false security.

## Inspection of Dairies and Milk Depots

These are carried out by the administrative departmental, technical, veterinary and medical officer. The medical officer should inspect the dairy in a definite sequence and with a view to scrutinizing all details in the process of production of milk and milk products, their wholesomeness, quality and safety for consumers. He should cover all the points described above. All recommendations and comments should be verbally conveyed to the manager of the dairy and important ones conveyed in writing to the higher medical authorities with intimation to the manager, if so indicated. Sampling of milk may be carried out periodically at the dairy farm or milk depot and also at various points on the consumer line. The tests for nutritional ingredients, adulteration,

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Lt Col Rajul K Gupta

# Inspection of Meat and Slaughter House Sanitation

## Fresh Meat

Medical officers are sometimes asked to give an opinion whether meat kept for sometime after slaughtering is fit for human consumption or not. Smell is the most reliable indication of decomposition but consistency and general appearance are also important considerations. The outside of the carcass and the skewer thrust into the substance should be smelt. Meat with an unpleasant smell is unfit for consumption. Decomposed meat loses its firm elastic consistency and tends to become soft and slimy. The fat becomes pale and the muscle appears dark brown to black. However, the smell is always a good indicator.

## Fresh Fish

The common signs of deterioration are as follows:-

### (a) Smell

It is probably the most important test of soundness. Fish with an unpleasant smell should be rejected, even if all other tests are in its favour.

### (b) Appearance

When freshly caught the gills are bright pink, but after death they rapidly become darker and in a matter of an hour or so assume a liver colour. The longer the fish is kept, the darker are the gills. This is not, however, a completely reliable sign of deterioration.

### (c) Firmness

The flesh should be firm to touch, not rapidly separated from the bones, and should not tear easily. If flesh pits readily under pressure, early decomposition must be suspected.

### (d) Colour

It should be uniform. There should be no evidence of discoloured patches on the skin. These are usually seen first along the line of the backbone.

### (e) Eyes

These should be prominent and not sunken, collapsed or dull.

### (f) Floatation Test

If not eviscerated, a sound dead fish sinks in water while an unsound one floats, belly up.

## Tinned Meat and Fish

The interior of the tin and its contents are subjected to heat, though an absolute sterility is not achieved, but the growth of remaining live organisms and spores is so inhibited that hermetically sealed cans should normally remain sound for several years. Under tropical conditions, the rate of deterioration is somewhat accelerated and spoilage may result even in an intact tin. The date of packing and the recommended last date for usage, must therefore always be kept in mind. Sardines packed in oil have an exceptionally good keeping quality. Fish packed in tomato sauce may deteriorate if the acidity of the sauce causes erosion of the tin and eventually results in pin point leaks. Cans and contents should be systematically examined before giving a final opinion. Cans should not be condemned as a result of external inspection only. It is essential to verify conclusions by examination of the contents.

### (a) Inspection

Damaged, dented or rusted tins must be viewed with suspicion. Dents near a seam may indicate a leak. Tins should be of normal contour. If they are excessively convex (in the absence of marked denting), the tin is 'blown' owing to the formation of gas from decomposition. The pressure inside may be tested by putting a little water on the end of the tin (preferably near the edge, in a hollow) and carefully puncturing through it. If the pressure is negative, the water is sucked into the hole; if positive, a stream of bubbles rises through the water. A positive pressure is due to gas formation and indicates bacterial action which may make the contents unfit for use.

### (b) Palpation

A sound tin has a solid 'dead' feel. One in which for any reason the negative internal pressure has been destroyed is under pressure and is known as a 'springer'. Springers should be tested by perforating through water and then opened for inspection of the contents. The latter may or may not be fit for consumption.

### (c) Percussion

A sound tin, when tapped by the fingers, or by a piece of wood, gives a dull note, while one with gas is definitely tympanic. A tympanic tin must always be viewed with suspicion.

### (d) Contents

All tins showing external defects should be opened and the interior of the tin and its contents examined. The interior of the tin is normally somewhat blacked and this is not a cause for rejection of the contents. Tinned meat which has been exposed to tropical conditions may show varying degrees of softening or liquefaction of the fat. This may not be a cause for rejection unless definite decomposition indicated by tainted smell and taste, is present. Any tin, the contents of which are perceptibly tainted, should be condemned.

### (e) Laboratory Tests

The above routine indicates whether or not decomposition has occurred. The salmonella group of organisms, which are responsible for the large majority of food poisoning outbreaks, do not cause any alteration in the physical appearance of the food. Food appearing perfectly sound, may produce severe poisoning. When considered necessary, the tins should be sent to a laboratory for bacteriological and chemical analysis, and for feeding tests on animals. Such food should not be used till cleared by lab tests.

## Dehydrated Meat and Fish

The same general principles as discussed in the preceding para apply. Dehydrated meat and fish tend to become acidic after a short time. There may be a slight odour which disappears when the tin is opened or on cooking. This may not indicate the 'unfitness' of food for consumption. At a later stage when marked rancidity or decomposition occurs, the product should be condemned. Dehydrated meat and fish are liable to infestation by insects especially *Dermestes* (the larder beetle). If it has been present for some time, adult beetles will be seen on opening the tin, together with the discarded skins or larvae but in more recent infestations only the larvae will be found. In heavily infested meat the muscle tissue is largely eaten away, leaving mainly fibrous tissue. Infested meat or fish should be destroyed. The accelerated freeze-drying process, now employed, results in better quality of dried products without loss of its nutrients and keeping quality.

## Refrigerated Meat

### (a) Chilled meat

It is preserved at a temperature of 14 ºC to 16 ºC. It can only be relied on to remain sound for a few weeks after slaughter, extendable to six weeks if the air in the cold storage space contains 10% carbon dioxide. The carcass is cold to touch and stiff, but is not frozen solid; and if carefully and slowly thawed before jointing, it is difficult to distinguish from fresh meat. As a rule, however, the bark has lost the characteristic shine of fresh meat and may be even dirty looking or torn in places. Mould may be present but is harmless unless it has penetrated deeply. The cut muscles surface loses the marbled pink appearance of fresh meat and assumes a uniform dark-red, or even brick colour, due to extravasations of pigment from muscle cells (ruptured by freezing) into the interfibrillar fat. If the carcass is thawed too rapidly the surface 'sweats', and the meat becomes sodden and water logged.

### (b) Frozen Meat

It is preserved at a temperature below 8° C. The carcass is frozen solid and can only be cut with a saw and keeps indefinitely so long as it remains at this temperature. The exterior is white and the bark is often torn and has completely lost its bright appearance. Ice crystals are apparent on the surface and after sawing in the interior. Moulds are frequently present on the surface. On thawing, the appearance closely resembles chilled meat, but the colour is usually somewhat darker, the fat more stained, and the meat more sodden and moist. Putrefactive and pathogenic bacteria are inhibited but not killed by freezing. When frozen meat is thawed, decomposition sets in very rapidly.

## Poultry

Although it is the custom in temperate climates to allow poultry and game to hang for some days in order to improve flavour and tenderness, this is usually not practicable in India. Fresh poultry have bright prominent eyes, the feet are limp and pliable, the flesh moderately firm and the skin pale. Staleness is shown by stiff and dry feet, dull & collapsed eyes, soft & flabby flesh and probably a greenish discolouration around the crop.

## Inspection of Animals and Carcasses

In stations where a veterinary officer of the RVC is available the responsibility of ante and post-mortem examination of all meat issued, as rations to troops will devolve on the veterinary officer. Where a veterinary officer is not available, an ASC officer trained in meat inspection carries out this duty. A medical officer may have to carry out the meat inspection, if neither of them is available or after the rations have been received in the unit and there is doubt regarding fitness of the meat for consumption. Every animal should be examined prior to slaughter and in this task the medical officers must rely on its general appearance. If the animal looks well and has no obvious signs of disease, it can be passed as fit for food in the vast majority of cases. On the other hand, one should hesitate before passing a poor looking animal, even if presenting no obvious signs of illness. In general, the thin diseased body, rough and staring coat, hanging head, quick laboured breathing, injected conjunctivae, dribbling saliva, diarrhoea, a raised temperature and a high pulse rate are signs of disease. To prevent substitution, all animals examined ante-mortem and passed, as fit should be suitably branded. The normal temperature of sheep is 40 ºC, of swine is 38.8 ºC and of cattle 38.6 ºC; and pulse rates are 40, 75 and 75 respectively.

The carcass should be examined for its nutritional condition; evidence of bruising, haemorrhage or discolouration; local or general oedema; the efficiency of bleeding; swelling or deformities of bones or joints; or abnormalities in musculature. The pleura and peritoneum should always be examined and their removal or tampering with, before examination, is never permitted. After the carcass is split (those of bovine are always split those of swine only if disease is suspected), the sternum, ribs, vertebrae and spinal cord should be examined. The head including the tongue, the palate, the retropharyngeal, sub maxillary and parotid glands should be examined and the cheek muscle incised by a linear incision parallel to the lower jaws for evidence of actinomycosis, foot and mouth disease, cysticercosis and glandular tuberculosis.

All viscera should be examined as they are removed from the carcass, or after ensuring that the viscera are of a particular carcass. Every organ and its associated lymph glands should be examined visually and by palpation. If any abnormal condition is observed, the nature and significance of which cannot be determined by such examination, the organ and/ or glands should be incised, care being taken to avoid soiling the rest of the carcass with infective material. The examination of lymph of glands should be by multiple incisions into their substance. Very often the slaughtering takes place in the middle of the night or in the early hours of the morning when a veterinary officer is not available on the spot. To identify viscera of the particular animal with a view to enable the veterinary officer to carry out a postmortem

examination, the viscera of individual animals must be hung alongside the carcass. This will enable the veterinary officer to trace the infected carcass in the event of tuberculosis being later revealed in the viscera.

**(a) Stomach, intestine and Spleen**

The outer and where necessary, the inner surfaces together with the omentum and glands should be examined. The spleen is commonly the site of pyaemic and tubercular abscesses.

**(b) Liver**

The liver and its associated glands should be examined. Lumps in its substances may be tubercular, pyaemic or hydatid in origin. The bile duct should be examined for flukes.

**(c) Kidney**

The renal and adrenal glands should first be examined and then the kidney should be inspected. If necessary the organ may be split by an incision. The kidney should be smooth, uniform in consistency and of an even brown colour. Tubercular abscesses are not uncommon.

**(d) Uterus and Ovaries**

The inner and outer surface of the uterus and the substance of the ovaries should be seen for infection and new growths.

**(e) Lungs**

The lungs should be examined, together with the bronchial and mediastinal glands, by inspection, palpation, and unless obvious disease renders this unnecessary, by incision. Tuberculosis, pneumonia and in the sheep, strongyloides infection are common.

**(f) Heart**

The pericardium should be opened and the heart examined. If necessary it may be incised. The base of the heart is a common site for tuberculosis and cysticercus infection.

**(g) Udder**

It should be examined by inspection, palpation and incision at the base of the teats. Incisions should also be made into any indurated regions and into the supramammary gland.

**(h) Scrotum**

The testicles, penis and superficial inguinal glands should be examined.

**(j) Lymph glands**

These must be examined as a matter of routine. The important groups are the bronchial, mediastinal, hepatic, mesenteric, retropharyngeal, submaxillary, popliteal and the prescapular glands.

## Common diseases of meat yielding animals

A brief description of two important conditions Anthrax and Foot and mouth disease is given here:

**(a) Anthrax**

It is a disease rapidly fatal to animals and usually diagnosed only after death. Post-mortem appearances are: muscles - pale with blackened areas due to haemorrhages; blood - black and tarry; organs - haemorrhages into the substance paranchyma; Lungs - pulmonary congestion; spleen - greatly enlarged, dark purple in colour and intensely engorged with blood. In pigs there is usually oedema of the glottis but enlargement of the spleen is absent. Blood tinged discharges from the nose and rectum are seen. When the animal is suspected to have been died of anthrax, it should be opened for post-mortem examination. The examination of an animal suspected to have anthrax should be carried out with the greatest care to avoid self infection and contamination of the surroundings. The usual plan is to take a sample of blood from the ear of the dead beast and examine it microscopically. If an examination of the direct smear leaves any doubt, a mouse is inoculated. The carcass should be destroyed by burning in a meat destructor or by proper burial.

**(b) Foot and mouth Disease**

It is most common in cattle and pigs but other animals may be affected. It is intensely infectious. The disease begins with small clear vesicles on the toothless border of the upper jaw which then spread to the nasal septum, the tongue, the skin above the hoof and the skin in the cleft of the hoof. The udder and external genitals may be affected. Later the vesicles enlarge, coalesce and burst, leaving pale watery looking erosions or septic ulcers. At a late stage septicaemia may occur. It is also called epizootic eczema or aphthous fever. When generalized, the whole carcass must be condemned. When strictly confined to the mouth and feet, only those parts need be condemned.

Judgement regarding fitness for human consumption or otherwise depends upon the nature of the disease and the extent to which the carcass is affected. Broadly speaking if animals show evidence of generalized pathological conditions (including pathological emaciation) the whole carcass should be condemned. If a pathological condition is localized and obviously not liable to be because of systemic infection (e.g. simple abscesses, benign tumours, cirrhosis of the liver etc.) only the affected organ or portions of the carcass and portion contiguous there to, should be condemned. In the absence of obvious pathological conditions, meat which is well cooked will not give rise to disease; but since thorough cooking is not invariably carried out, a careful inspection of carcasses and raw meat is necessary. If any doubt still exists, and expert advice is not available, it is better to condemn and be safe than to take a risk.(1,2)

## Slaughter House Sanitation

Slaughter house may be private or public. The private ones are not encouraged as it might be difficult to monitor them. They are not only a source of very serious nuisance but also facilitate the slaughter of diseased and dead animals. Nuisance in a slaughter house arises from the unhygienic way animals are kept, slaughtered and managed. The removal of carcasses and garbage is delayed which decompose there itself. Filthy slaughter houses are always a menace to the public health due to large collection of offal undergoing putrefaction and the

continuous flow of blood, urine and faecal matter in the surrounding areas. A poorly managed slaughter house emanates rotten smell and it becomes a source of disease. Fly breeding and contamination of meat are the two major health hazards. Thus, for proper sanitary control, all slaughtering should be carried out in licensed public slaughter houses (abattoirs) wherein hygiene rules must be followed strictly. It therefore becomes imperative for the AMA to inspect the abattoir regularly and thoroughly.

The salient points pertaining to a good slaughter house are enumerated below:

**Design**

The slaughter house should be well ventilated and totally fly proof. It should have sufficient running water supply. Adequate provision should be there to deal with blood, offal and waste animal products. It should be fitted with scaffolding having chrome plated hooks for dressing of animals.

**Building**

The slaughter house should be built with brick and concrete and well protected against rodents, cats and dogs. A concrete boundary wall is desirable. Adequate toilet/wash and hand-washing facilities (with soap and water) must be available.

**Floor and walls**

Special notice should be taken of the floor and general cleanliness of the place where the carcasses are dressed. Floor should be made of impervious concrete. The interior walls should also be of smooth concrete, which should be lime washed frequently.

**Drains**

Concrete channels should drain all liquid waste from the lairs and the slaughter room to a place of disposal outside, through covered drains. All the drains must be cleaned frequently. The manholes must also be frequently checked. Drains must be in a good state of repairs as damaged/broken drains are unhygienic.

**Waste disposal**

The liquid waste should be run into a water carriage sewer, and all solid refuse should be burnt in an incinerator. In case the above measures are not possible (as when slaughtering under unit arrangements, or in the field service when meat-on-hoof is supplied), the best method of disposal then is daily burning of all refuse and offal in the beehive incinerator. On rare occasions when burial has to be adopted, the pits should be well limited and covered with the rammed oiled earth. Special covered receptacles made of non absorbent material with close fitting lids should be provided for holding blood and offal, pending incineration or burial. This offensive material must be hygienically disposed off at the earliest. Semisolid manure should be dealt with in a similar manner as the manure from a dairy.

**Employees**

Preferably the employees must be permanent. They must wear clean clothing and be free from communicable diseases. They must undergo initial and periodical examination. They must also take routine immunization.

It need no further emphasis that the sanitation of slaughter house extremely important. In very large commercial establishment mechanism of functions is necessary. A regular inspection of slaughterhouses is essential to ensure cleanliness in the production of meat for human consumption and to ensure that it does not become a center for the spread of infections. (3)

The most important points to note are: -

(a) The method of disposal of offal, blood, animal excreta and discarded animal tissues.

(b) The fly proofing, rat proofing and dog proofing of the premises.

(c) The sanitation of the lair, the structural soundness of the building. The construction of the floor which should be made of cement concrete and provided with rat proof drains.

(d) The spaciousness of the separate slaughtering, skinning and hanging rooms and their ventilation.

(e) Availability of water for maintaining the sanitation.

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Lt Col Rajul K Gupta

# Nutrition during Training and Operations

Under normal conditions, maintenance of adequate nutrition can be attained to a large extent by the provision of rations in accordance with well-designed ration scales and of suitable facilities for messing. But the same may not be possible during training and operations.

## Training

The nutritional requirement of recruits under training is high. An average new recruit, who is recruited during the peace time may be reasonably well nourished but one who is recruited during war time may not be so. When troops are put on arduous administrative or operational tasks under active field service conditions or under intensive training for a task force assignment, their nutritional requirements increase and are the same as of recruits under training.

## Operations

During operations conditions are often different and more or less abnormal as far as the logistics of provisioning, supply and cooking of food is concerned. The following problems may be faced during operations:

(a) Expansion of armies may require enrolment of men with poor constitution necessitating special feeding to make them fit

(b) Shortage of food may necessitate the modification of normal ration scales;

(c) Limited logistics may result in failure to supply

(d) Consideration of climate and distance may make impossible the use of certain valuable but perishable foods

(e) Tactics may dictate the use of rations not exceeding a given weight and bulk

(f) The unusual physical stress or exposure to diseases may cause important changes in nutritional requirements.

Unless these difficulties are tackled effectively and on a sound nutritional basis, the 'fighting fitness' of troops will be impaired, possibly to a degree, which will jeopardize the success of operations.

### Depleted feeding during operational situations

When ration meets three quarters of the full requirement, no serious effects are noticed for 6 to 10 days. Thereafter the energy output will tend to fall off until intake and output are balanced, but no specific deficiency effects appear if the diet is balanced. If forced hard work is continued, slow inanition may ensue. If the period exceeds about 10 days, a well-balanced ration, meeting full nutritional requirements is essential for continued efficiency. When rations meet half the daily requirements, there is severe hunger after two or three days; serious diminution of efficiency follows and slow starvation dominates the picture.

Nutritional requirements are affected by the operational, tactical or training conditions. For example, if rations are required to be carried on a man-pack basis or while under seige, ration issue may have to be restricted or reduced in bulk and weight. When reduction in rations is visualized as a probable operational necessity, nutritional reserves should not be depleted during training. Good pre-feeding may be the best possible prelude to underfeeding and men should go into battle with ample bodily reserves. However 'excess feeding' must be guarded against to avoid obesity!

When shortage of rations is due to the tactical situation as during a seige or logistic blocks, preservation of fitness for the longest possible time is vital. Under such situations restricting physical activity to an essential minimum can lower requirements; infections which raise nutritional demands should be prevented.

Steps to replenish the depleted reserves of men by good feeding and rest should be taken early after the operations. However, after a period of insufficient feeding, small easily digested meals at frequent intervals should be given initially rather than copious and indigestible meals. Possibility of inanition, malnutrition and infections among troops recovered or escaping from enemy custody should be remembered.

### Principles of feeding during operations

Special pack rations are devised for operations when transport is limited, normal cooking and catering arrangement are not available, limitations on weight and bulk are severe, and a compromise has to be reached between what is nutritionally desirable and what is practicable. Such special ration packs are not the normal method of feeding troops. There are three operational ration scales and also the composite pack rations and the survival rations. The design of a special pack is influenced by the following factors:-

(a) Concentration

The highest possible energy value must be put into a given weight packed into the smallest possible space. It is extremely difficult to concentrate food beyond 418 kj per 30 g of weight (including packing material) without serious loss of palatability; so a normal ration should be expected to weigh about 1 kg. Energy value can be increased for a given weight by utilizing high energy value of fat, excluding low energy foodstuffs and dehydrating or freeze drying the pre-cooked foods.

(b) Nutritive Value

It may not be possible to consume the concentrated ration for a long time continuously as the nutritional requirements may not be met in a balanced manner. Extra vitamin supplements should be provided in such a food.

(c) Palatability

Variety and attractiveness can be achieved beyond a certain point only at the expense of weight. Consideration of customs and habits and the availability of facilities for

cooking are also important.

(d) Keeping Quality

The ration must retain its nutritive value as well as its keeping quality. The latter is largely a question of devising a pack which will withstand the rough handling, humidity and heat

**Composite packs & "Meals Ready to Eat"**

The composite packs contain multivitamin tablets, matchboxes, hexamine cooker, water sterilizing outfit and tin opener. The use and role of composite pack rations is given in the pamphlet 'Operations Feeding -Use of Special Rations Pack India'. These rations provide food of adequate variety and nutritive value of about 3500 Kcal (14.6 Mj) which does not require cooking and which is packed so as to facilitate easy handling. Their principal use is in the operations, 'between' the initial assault and the establishment of a normal chain of supplies and cooking facilities, in jungle operations, or for air dropping. The type 'A' ration pack is meant for meat eaters and type B contains cooked dal for vegetarians. These rations are not to be used when basic rations can be provided. The use of Composite Rations will be restricted to a maximum period of two weeks at a stretch. The present container has 5 men's ration for one day.

Another type of pack rations are "Meals Ready to Eat" (MRE) for individual persons. Each pack weighs approx 2.32 Kg and contains one person's breakfast, lunch and dinner. It contains ready to eat suji halwa (300 g), veg pulao (300 g), veg peas and mushrooms curry (300 gm) dal makhani (330 g), chapaties or parathas (320 g), tea mix (tea, sugar and dairy whitener), soft bar (110 gm), hexamine cooker and tablets, matchbox, paper plates etc These packs are stocked in selected supply depots to be issued to troops when necessary and as ordered by the authorities.

**Emergency rations**

The emergency rations are normally issued to the 'teeth' part of the field force before going into operations, to be carried by each individual on his person in the tin or cardboard container provided for the purpose in the WET of the unit. It is consumed by the troops under specific orders only when the other types of rations cannot be made available. It is intended to be substituted only for 24 hours. The pack consists of 230 g service biscuits and 110 g raisins providing about 1200 Kcal (5.09 Mj) without any special regard to the nutritive value as a whole or its requirement for any special task.

## Appendix A

**Scale of Rations for Officers in Peace / Field**

(Annexure to Govt of India, Ministry of Defence letter No 3 (1) 83 1 D (QS) Dated 12 Mar 1983)

| S.No. | Commodity | Scale per officer per day in grams |
|---|---|---|
| 1 (a) | Atta or Rice (Undermilled or parboiled) | 450 |
| (b) | Atta | 200 |
| 2. | Dal | 40 |
| 3. | Oil hydrogenated | 80 |
| 4. | Milk fresh / standard / blended | 250 ml |
| | OR | |
| | Milk tinned sweetened or unsweetened | 92 |
| | Whole milk powder | 36 |
| 5. | Sugar | 90 |
| | OR | |
| | Gur | 110 |
| 6. | Tea | 09 |
| | OR | |
| | Coffee soluble powder | 03 |
| 7. | Vegetables fresh | 170 |
| | OR | |
| | Vegetables tinned curried | 90 |
| | OR | |
| | Dal whole or germinating | 90 |
| | OR | |
| | Peas dried or beans dried | 90 |
| 8. | Potatoes fresh | 110 |
| | OR | |
| | Potatoes tinned | 80 |
| | OR | |
| | Dal | 60 |
| | OR | |
| | Vegetable fresh | 110 |
| 9. | Onions fresh | 60 |
| | OR | |
| | Onions spring green | 90 |
| | OR | |
| | Onions dehydrated | 07 |
| 10. | Fresh fruits citrus | 110 |
| | OR | |
| | Fresh fruits non-citrus | 230 |
| | OR | |
| | Fruit tinned | 90 |
| | OR | |
| | Fruit dried | 28 |
| **S.No.** | **Commodity** | **Scale per officer per day in grams** |
| 11. | Salt evaporated | 20 |
| 12. | Condiments | 20 |

Contd. ....

## Appendix A

**Scale of Rations for Officers in Peace / Field (Contd.)**

| | | |
|---|---|---|
| 13. | Meat fresh (with bone) dressed | 260 |
| | OR | |
| | Meat on hoof | 640 |
| | For vegetarians (In lieu of meat) | |
| | Milk fresh / standard / blended | 500 ml |
| | OR | |
| | Milk tinned | 200 |
| | OR | |
| | Whole milk powder | 73 |
| 14. | Baison | 30 |
| 15. | Eggs | 03 |
| 16. | Butter | 20 |
| 17. | Dhalia | 20 |
| 18. | Corn flour / Gelly Crystal | 07 |
| 19. | Jam | 44 |
| 20. | Fire Wood | 1400 |
| 21. | LPG | 150 |
| 22. | Dried Coconut | 04 |
| 23. | Raisins | 04 |
| 24. | Pickle | 15 |
| 25. | On Medical Recommendation | |
| | (To meet special fatigue or bad weather conditions) | |
| | Coffee solution powder | 03 |
| | and | |
| | Sugar | 30 |
| | And | |
| | Milk fresh / blended / standard | 40 ml |
| | OR | |
| | Milk tinned | 16 |
| | OR | |
| | Rum 25° U.P. | 60 ml |
| | OR | |
| | Rum London proof (100 percent proof) | 40 ml |
| 26. | Compound vitamin tablets | No. 1 |
| | (To be issued on medical recommendation) | |
| | | |

- Or Rs.58.80 / month

## Appendix B

**Scale of Rations for Troops in Peace / Field Areas (SAI 7/S/74)**

| S.No. | Commodity | Scale per Men per day in grams |
|---|---|---|
| 1. | Atta | 620 |
| | OR Atta | 220 |
| | And Rice | 400 |
| 2. | Dal | 90 |
| 3. | Oil Hydrogenated | 80 |
| 4. | Milk fresh / standard / blended | 250 ml |
| | OR Milk tinned | 100 |
| | OR Whole milk powder | 36 |
| 5. | Onions fresh | 60 |
| | OR Onions spring green | 90 |
| | OR Onions dehydrated | 07 |
| 6. | Potatoes fresh | 110 |
| | OR Sweet Potatoes | 110 |
| | OR Vegetable fresh | 110 |
| | OR Potatoes tinned | 80 |
| 7. | Vegetables fresh | 170 |
| | OR Vegetables tinned curried | 90 |
| | OR Grams whole white Kabuli | 90 |
| 8. | Sugar | 90 |
| | OR Gur | 110 |
| 9. | Salt rock | 10 |
| | OR Salt evaporated | 20 |
| 10. | Tea | 09 |
| 11. | Condiment powder | 16 |
| 12. | Meat fresh (with bone) | 110 |
| | OR MOH | 275 |
| | OR Fish fresh | 190 |
| | OR Eggs | No. 2 |
| | OR Dahi | 170 |
| | OR Milk fresh | 200 ml |
| | OR Milk tinned | 90 |
| | OR Skimmed Milk Powder | 60 |
| | OR Whole Milk Powder | 32 |
| | OR Fowl / Chicken (Live weight) | 156 |
| | OR Fowl / Chicken (dressed) | 78 |
| 13. | Fresh fruits citrus | 110 |
| | OR Fresh fruits non-citrus | 230 |
| **S.No.** | **Commodity** | **Scale per Men per day in grams** |
| Items to be issued under orders of Local Military Commanders to meet fatigue or bad weather conditions. | | |

Contd. ....

## Appendix B

**Scale of Rations for Troops in Peace / Field Areas (SAI 7/S/74) (Contd.)**

| | | |
|---|---|---|
| 14. | Coffee solution powder | 03 |
| | and Sugar | 30 |
| | and Milk fresh / blended / standard | 40 ml |
| | OR Milk tinned | 16 |
| | OR | |
| | Tea | 07 |
| | and Sugar | 30 |
| | and Milk fresh / blended / standard | 40 ml |
| | OR Milk tinned | 16 |
| | OR Rum 25° U.P. | 60 ml |
| | To be issued on Medical Recommendations | |
| 15. | Compound vitamin tablets | 01 No |
| 16. | For Vegetarians Milk Fresh | 220 ml |
| | Cheese | 25 |
| | OR Nutramul | 30 |
| | OR Milk powder | 32 |
| | Egg for veg (additional) | 01 No |

## Appendix C

**Scale of Rations for Troops at High Altitude of 2700m (9000 ft) and above (SAI 3/S72)**

SAI 3/S72 dealing with ration scales for officers in J&K, NEFA is also applicable for men / officers at high altitude with incorporated amendments.

| S.No. | Commodity | Scale per Men per day in grams |
|---|---|---|
| 1. | Atta | 570 |
| | OR Atta | 430 |
| | And Rice | 140 |
| 2. | Dal | 85 |
| 3. | Baison | 30 |
| | OR Dal Channa | 30 |
| 4. | Oil hydrogenated | 85 |
| 5. | Butter tinned | 34 |
| 6. | Sugar | 168 |
| 7. | Tea | 14 |
| | OR Coffee | 28 |
| 8. | Condiment powder | 16 |
| 9. | Salt evaporated | 21 |
| 10 | AFD Meat | 18 |
| | OR Meat fresh dressed | 110 |
| | OR Meat tinned | 85 |
| | OR Fish tinned | 85 |
| | OR Fowl(live) not more than two issues daily ration per week | 156 |
| | OR Fowl dressed | 78 |
| | OR Eggs | 02 no |
| | OR Whole milk powder | 32 |
| | OR Meat on hoof | 275 |
| **For vegetarian** | | |
| | Milk tinned | 90 |
| | OR Whole milk powder | 32 |
| 11. | Egg fresh | 03 no |
| | OR Eggs powder | 30 |
| | OR Fish tinned | 38 |
| | OR Meat tinned | 38 |
| **For vegetarian (non-egg eaters)** | | |
| | Vegetables fresh | 60 |
| | OR Vegetables dehydrated | 07 |
| | OR Vegetables tinned | 30 |
| 12. | Milk tinned evaporated | 100 |
| | OR Whole milk powder | 36 |
| | OR Cow milk / standard milk / reconstituted milk | 250 ml |
| **S.No.** | **Commodity** | **Scale per Men per day in grams** |
| 13. | Whole milk powder | 28 |

Contd. ....

## Appendix C

**Scale of Rations for Troops at High Altitude of 2700m (9000 ft) and above (SAI 3/S72) (Contd.)**

| | | |
|---|---|---|
| | OR Milk tinned | 78 |
| | OR Cow milk / standard milk / reconstituted milk | 195 ml |
| 14. | Onions dehydrated | 07 |
| | OR Onions fresh | 60 |
| | OR Vegetables fresh | 90 |
| 15. | Potatoes fresh | 138 |
| | OR Potatoes tinned | 98 |
| | OR Potatoes dehydrated | 30 |
| 16. | Vegetables fresh | 170 |
| | OR Vegetables tinned | 90 |
| | OR Vegetables dehydrated | 20 |
| 17. | Fresh fruits (citrus) | 60 |
| | OR Fresh fruits (non-citrus) | 110 |
| | OR Fruit tinned | 50 |
| | OR Fruit dried | 15 |
| 18. | Copra (dried coconut) | 04 |
| | OR Cashew nuts | 04 |
| 19. | Raisins | 04 |
| | OR Cashew nuts | 04 |
| | OR Jam tinned | 13 |
| 20. | Jam | 42 |
| | OR Sugar | 09 |
| 21. | Pickles | 15 |
| 22. | *Rum | 60 ml |
| | For Non-Drinkers | 14 |
| | Tea or Coffee | 21 |
| | And Sugar | 28 |
| | And Milk tinned | 10 |
| | OR Whole milk powder | |
| 23. | Vitamin C tablets | 100 mg |
| | OR Lemon orange powder | 17 |
| 24. | Kerosene | 378 ml |
| | OR LPG | 150 |
| | | |
| | | |

*25 issues in a month. Substitutes will be issued to non-drinkers on all days and to drinkers on days when rum is not issued.

## Appendix D

**Rations for Officers in Jammu & Kashmir and NEFA Area (SAI 3/S72)**

| S.No. | Commodity | Scale per Men per day in grams |
|---|---|---|
| 1. | Atta / Rice | 450 |
| | Not more than 230g of bread and 60g of flour may be drawn for equivalent quantity of atta/rice. | |
| 2. | Dal | 40 |
| 3. | Oil hydrogenated | 80 |
| 4. | Sugar | 90 |
| 5. | Milk fresh | 250 ml |
| | OR Milk tinned | 100 |
| | OR Whole milk powder | 36 |
| 6. | Meat fresh dressed | 260 |
| | OR Meat on hoof | 640 |
| | OR Fish fresh | 430 |
| | OR Fowl including duck/chicken (dressed) whichever is economical | 175 |
| To be issued in lieu For vegetarian | | |
| | Milk fresh | 500 ml |
| | OR Whole milk powder | 73 |
| | OR Milk tinned | 200 |
| Either of the following may be drawn in lieu of 30g of meat once a week: - | | |
| | Ham | 28 |
| | OR Pork lunchen meat | 30 |
| | OR Bacon | 30 |
| | OR Sausages | 28 |
| | OR Liver fresh | 30 |
| | OR Kidney | 30 |
| 7. | Potatoes | 110 |
| | OR Potatoes tinned | 80 |
| | OR Vegetables fresh | 110 |
| 8. | Vegetables fresh | 170 |
| | OR Vegetables tinned or curried | 90 |
| 9. | Onions | 60 |
| | OR Onions spring green | 90 |
| | OR Onions dehydrated | 07 |
| 10. | Egg fresh | 02 no |
| | OR Eggs powder | 20 |
| For vegetarian | | |
| | Vegetables fresh | 110 |
| | OR Whole milk powder | 28 |
| **S.No.** | **Commodity** | **Scale per Men per day in grams** |
| 11. | Tea | 09 |

Contd. ....

## Appendix D

**Rations for Officers in Jammu & Kashmir and NEFA Area (SAI 3/S72) (Contd.)**

| | | |
|---|---|---|
| | OR Coffee | 04 |
| 12. | Fruit fresh non-citrus | 110 |
| | OR Fruit fresh non-citrus | 230 |
| 13. | Dahlia | 20 |
| | And Sago | 07 |
| | OR Cornflour | 07 |
| | OR Jelly | 07 |
| | OR Ice cream powder | 07 |
| | OR Cornflakes | 30 |
| | OR Semolina | 30 |
| 14. | Butter | 20 |
| 15. | Condiments | 20 |
| 16. | Salt | 20 |
| 17. | Jam | 28 |
| 18. | Kerosene oil | 378 ml |
| | OR LPG | 150 |
| | | |
| | | |

## Appendix E

**Scale of Ration for Indian Navy standard scale of Ration for Sailors (N I 6/86)**

| S.No. | Commodity | Scale per Men per day in grams |
|---|---|---|
| 1. | Bread / Atta / Rice / Biscuit / Flour / Suji | 600 |
| 2. | Oil hydrogenated | 80 |
| 3. | Sugar | 70 |
| 4. | Tea | 08 |
| | OR Coffee | 05 |
| 5. | Salt evaporated | 20 |
| 6. | Dal | 90 |
| 7. | Condiments | 16 |
| 8. | Meat fresh (with bones) | 180 |
| | OR Meat tinned | 110 |
| | OR Fowl (live weight) | 240 |
| | OR Fowl (dressed) | 125 |
| | OR Fresh Fish | 160 |
| | OR Eggs | 03 no |
| | OR Fish tinned | 130 |
| For vegetarian | | |
| | Milk fresh | 350 ml |
| | OR Milk tinned | 140 |
| | OR Whole milk powder | 50 |
| 9. | Potatoes fresh | 110 |
| | OR Potatoes tinned | 80 |
| 10. | Vegetables fresh (other than onions and Potatoes) | 160 |
| | OR Vegetables tinned | 80 |
| 11. | Onions | 60 |
| | OR Onions spring green | 90 |
| 12. | Milk tinned (sweetened or unsweetened) | 76 |
| | OR Milk fresh | 190 ml |
| | OR Whole milk powder | 27 |
| 13. | Fruit fresh citrus | 50 |
| | OR Fruit fresh non-citrus | 100 |
| | OR Fruits tinned | 40 |
| 14. | LPG | 95 |
| | OR Steam coal | 1400 |
| | | |

## Appendix F

**Scale of Ration for Indian Air Force (AFI 18/S/68 *)**

| S.No. | Commodity | Scale per Men per day in grams |
|---|---|---|
| 1. | Bread / Atta / Rice / Flour | 600 |
| 2. | Dal | 90 |
| 3. | Ghee / Oil cooking<br>(In lieu of 30g of ghee/oil cooking 20g of butter and 30g of jam/Marmalade/honey may be given) | 80 |
| 4. | Sugar | 70 |
| 5. | Tea | 08 |
| 6. | Salt evaporated | 20 |
| 7. | Condiments | 16 |
| 8. | Meat fresh (with bones) | 180 |
| | OR Meat dehydrated | 70 |
| | OR Meat tinned | 110 |
| | OR Fresh Fish | 160 |
| | OR Fowl / Chicken (live weight) | 240 |
| | OR Fowl / Chicken (dressed) | 125 |
| | OR Eggs | 03 no |
| For vegetarian | | |
| | Milk fresh | 350 ml |
| 9. | Potatoes | 110 |
| 10. | Vegetables fresh (other than onions and potatoes) | 160 |
| 11. | Onions | 60 |
| 12. | Milk fresh / blended | 150 ml |
| 13. | Fruits fresh (citrus) | 50 |
| | OR Fruits fresh (non-citrus) | 100 |

- Additional Ration for Air crew is also given in the same AFI.

## Appendix G

**Scale of Ration for Cadets of NDA, IMA, OTA, CME, MCTE, MCEME and AFMC (AI 8/S/74)**

| S.No. | Commodity | Scale per Men per day in grams |
|---|---|---|
| 1. | Bread / Atta / Rice / Flour (not more than 340grams of bread will be issued, balance being atta/rice/flour) | 510 |
| 2. | Dhallia (three times a week) | 30 |
| | Cornflakes (once a week) | 28 |
| | Semolina (three times a week) | 30 |
| | Sago (once a week) | 28 |
| 3. | Cornflour (thrice a week) | 07 |
| | Custard powder (thrice a week) | 07 |
| | Jelly (once a week) | 07 |
| | Ice cream powder (once a week) | 07 |
| 4. | Milk standard / fresh / blended | 550ml |
| | OR Milk tinned | 220 |
| | OR Whole milk powder | 81 |
| 5. | Butter fresh | 28 |
| 6. | Eggs (thrice a week at the scale of 2 ½ eggs per cadet per diem and four times a week at the scale of 1 ½ eggs per cadet per diem) | 2 ½ / 1 ½ |
| | Bacon (fresh or tinned) issued twice a week | 30 |
| | Sausage / Salami (fresh or tinned) issued twice a week | 30 |
| | Liver / Kidney (issued once a week) | 60 |
| For Vegetarians | | |
| | Milk standard / fresh / blended (for preparation of curd) | 210 ml |
| | OR Cheese | 28 |
| 7. | Meat fresh (four times a week) | 340 |
| | Fish fresh (two times a week) | 600 |
| | Chicken dressed / Fowl dressed (once a week) | 255 |
| For Vegetarians in lieu of Meat fresh and its alternatives | | |
| | Milk standard / fresh / blended | 660 ml |
| | OR Oil hydrogenated | 30 |
| | And Vegetables fresh | 340 |
| | OR Eggs | 08 no |
| 8. | Oil hydrogenated | 85 |
| 9. | Dal-four times a week | 40 |
| | Baked beans / dried beans- once a week | 40 |
| | Kabuli Channa- once a week | 40 |
| | Mothi red- once a week | 40 |
| 10. | Potatoes fresh | 110 |
| **S.No.** | **Commodity** | **Scale per Men per day in grams** |
| 11. | Onions fresh | 60 |

Contd. ....

## Appendix G

**Scale of Ration for Cadets of NDA, IMA, OTA, CME, MCTE, MCEME and AFMC (AI 8/S/74) (Contd.)**

| | | |
|---|---|---|
| | OR Onions spring (non-citrus) | 90 |
| 12. | Vegetables fresh | 230 |
| 13. | Cheese tinned or cream- thrice weekly | 14 |
| 14. | Sugar | 100 |
| 15. | Tea | 09 |
| | OR Coffee soluble powder- six times weekly | 04 |
| | Chocolate drinking- once weekly | 14 |
| 16. | Salt | 20 |
| 17. | Condiments and spices | 20 |
| | OR Pickles / chutney / vinegar | 20 |
| 18. | Jam / Marmalade | 14 |
| | OR Jam / marmalade- thrice weekly | 14 |
| | And Golden syrup- once weekly | 14 |
| | And Fruit fresh- thrice weekly | 20 |
| | And Sugar | 10 |
| 19. | Firewood split | 500 |
| | OR Steam Coal | 700 |
| | OR LPG | 150 |
| | | |

## Appendix H

**Scale of Ration for Cadets at Rashtria Indian Military College, Dehradun (AI 10/S/74)**

| S.No. | Commodity | Scale per Men per day in grams |
|---|---|---|
| 1. | Atta / Rice / Flour<br>(not more than 280grams of bread will be issued, balance being atta/rice/flour) | 430 |
| 2. | Dhallia (four times a week) | 10 |
| | Cornflakes (once a week) | 14 |
| | Semolina (twice a week) | 10 |
| 3. | Cornflour / Custard powder and other cereals for pudding | 08 |
| 4. | Milk standard / fresh / blended | 500ml |
| 5. | Butter fresh | 28 |
| 6. | Eggs | 21 / 2 no |
| 7. | Meat fresh (with bones) four times a week | 200 |
| | Fish fresh- twice a week | 340 |
| | Chicken dressed / Fowl dressed- once a week | 140 |
| **For Vegetarians in lieu of Meat fresh and its alternatives** | | |
| | Milk standard / fresh / blended | 390 ml |
| | OR Milk tinned | 160 |
| 8. | Oil hydrogenated | 80 |
| 9. | Dal | 10 |
| 10. | Potatoes | 110 |
| 11. | Onions fresh | 60 |
| 12. | Vegetables fresh | 200 |
| 13. | Fruits fresh (citrus) | 110 |
| | OR Fruits fresh (non-citrus) | 230 |
| 14. | Cheese tinned or cream- thrice weekly | 14 |
| 15. | Sugar | 90 |
| 16. | Tea | 07 |
| | OR Coffee soluble powder | 03 |
| 17. | Salt rock | 20 |
| | OR Salt evaporated | 30 |
| | | |

## Appendix J

**Scale of Ration for Edentulous Outdoor Cases (AI 10/S/76)**

| S.No. | Commodity | Scale per Men per day in grams |
|---|---|---|
| 1. | Rice | 230 |
| 2. | Bread | 230 |
| 3. | Dal | 60 |
| 4. | Sugar | 90 |
| 5. | Tea | 09 |
| 6. | Salt evaporated | 10 |
| 7. | Milk standard / fresh / blended | 660 ml |
| 8. | Butter fresh | 30 |
| 9. | Eggs | 02 no |
| 10. | Potatoes fresh | 110 |
| 11. | Vegetables fresh | 110 |
| 12. | Fruit fresh citrus | |
| | To be issued on Medical Recommendations | 60 |
| 13. | Compound vitamin tablets | 01 no |
| | | |

NOTE: - Following category of persons who are entitled for free rations will be issued above scale of rations for maximum period noted against them :

| Category | Maximum period |
|---|---|
| a) Edentulous patients who are awaiting the fitting of artificial dentures. | 90 days |
| b) Cases of maxillo facial injury after discharge from hospital. | 60 days |
| c) Edentulous cases where dentures have been withdrawn by authorities for remaking. | 4 weeks |

# Occupational Health Sciences


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# Occupational Health

## Introduction

Rapid industrialisation of the country has led to a sharp increase in the labour force in the twentieth century. The expansion of the workforce has taken place more in the unorganised sector. Today a staggering 92.5% of the Indian labour is employed in this sector (1). It comprises largely the needy small and marginal farmers, the contract labourers and the agricultural workers. However, precious little seems to have been done to combat the health hazards associated with their workplace. This is primarily because their "unorganised" nature fails to put pressure on agencies to enforce legislation for their safety and welfare.

The organised sector, considered better off, employs 280 lac employees. Out of these 195 lacs are in the public sector and 85 lacs in private sector. By definition, the organised sector includes all the establishments in the public sector and non agricultural establishments employing 10 or more persons (1) It is this 'unionised' sector that has made the State enact legislation for Health and Safety at the workplace.

Industrial enterprise in India began during the Industrial revolution in 1850. The conditions of the working class during this period were abysmal. Their salaries and working conditions were determined by market forces. There was absolutely no legislation for protection or compensation from occupational diseases and injuries. With the organization of industries, the laws regarding their working became necessary and were enacted from time to time (2). Social Security legislations were framed to protect and compensate the worker from Occupational diseases and injuries.

The concept of Industrial health has undergone considerable changes in the last century. Earlier the term implied occupational diseases of workers employed in the classical occupations like foundries, textile mills, mines, etc. Gradually the term "Industrial Health" has been replaced by a broader word viz "Occupational Health". This embraces all occupations- ranging from the humble housemaid (Hunter describes them as having housemaid's knee- a type of chronic bursitis) to the most sophisticated software engineers (suffering from eye strain or repetitive strain Injury due to prolonged use of the key board similar to the erstwhile Telegrapher's Cramps). Infact, the peculiar problems faced by Armed Forces personnel categorise them into a separate occupational group. Two health disciplines viz Aviation Medicine & Marine Medicine have specialised institutes & personnel dedicated to cover health problems faced by pilots & submariners. Occupational Health is thus a comprehensive subject comprising the health, safety and welfare of the workers in the "workplace" and "off work" environments. Consequently in occupational health, the teamwork of several disciplines such as medicine, engineering, administration, physics, nutrition etc. have to be integrated for high industrial production and well being and contentment of the workers (3).

### Role of Medical Officers

Medical officers are frequently required to extend medical supervision to ordnance factories, Armed Forces workshops, unit workshops and other mechanical units and to provide medical care to the personnel working there. Moreover, Air Force and Naval MOs have to deal in their day-to-day duties with personnel who are virtually industrial workers as they are to function under similar circumstances. The following paragraphs may serve as a guide to them when called upon to carry out inspection of such places and extend medical supervision and care to workers in these units and establishments.

### Historical Perspective

The workmen were neglected in ancient medical practice & occupational diseases ignored in medical science. Ramazzini (1633-1714) is known as the father of occupational medicine. His textbook 'De Morbis Artifactum Diatriba' is a masterpiece that describes vividly the diseases of miners of metals, potters, tinsmith, glassworkers, cleaners of privies & cess pits, millers, well diggers & 50 other occupations. He advises rest for long duration work, spacious workplaces and good housekeeping for prevention of occupational diseases - a concept that no modern industry can afford to neglect. Infact, Ramazzini brought in the concept of occupational physician by cajoling all doctors to add to the Hippocratic Art by asking each patient- 'What is your occupation?' Hutchinson's Clinical Methods has further amplified this by stating that no history is complete without a detailed occupational history. Doctors need to ask their patients the exact nature of his occupation including past occupations. Merely recording say "Hyderabad Industries" as occupation gives no indication of the nature of work. On probing further one would know that this factory is an asbestos unit & only then can one suspect the symptoms to be of asbestosis (a type of pneumoconiosis). In case an occupational history was not taken the patient would probably have been diagnosed as "Tuberculosis" which is not an occupational disease. Thus, a proper occupational history can not only help in treatment & control of the

| Stalwarts in Occupational Health | |
|---|---|
| Bernardino Ramazzini | Father of Occupational Health |
| Charles Turner Tackarrah | First Practitioner of Industrial Medicine |
| John Simon | First Medical Officer of Factories |
| Karl Marx | Rise of Trade Union Movement |
| Sir Thomas Morrison Legy | First Medical Inspector of Factories |
| Philippa Howerday | First Industrial Nurse |
| Donald Hunter | Wrote "Diseases of Occupations" |

disease but also assist the worker in getting his entitled compensation from the employer.

The introduction of machinery during the Industrial Revolution (1760-1830) gave a great fillip to the concept of occupational health. As the steam engine was invented, so the test for colour blindness was made obligatory for Railway Drivers (1876). This concept is today called Periodic Medical Examination. Rapid industrialisation led to mass migration from villages to cities as workers were needed to run the factories & mills. This led to the creation of "Shanty Towns" - a term used to describe the resultant overcrowding, filth & cholera & typhus outbreaks in these labour colonies.

The first man documented to practice Industrial Medicine was Charles Turner Tackarrah. His book had a really long name viz "The Effects of the Principal Arts, Trades & Professions & of Civic States, habits of living on health & longievity with suggestion for the removal of many of the agents which produce disease & shorten the duration of life". This however, is considered superior to the work of Ramazzini. It has vividly described postural deformities, tuberculosis in tailors & lung disease in miners & grinders of metal (silicosis). Tackarrah has documented that knife grinders who did dry stone grinding lived for only 28 years whereas their counterparts who did wet stone grinding survived for 40-50 years. These deaths were attributed to silicosis. John Simon, the First Medical Officer of Factories has clearly spelled out that "Tackarrah's work in Industrial Medicine is like Jenner's is to Small Pox".

Occupational Medicine has found a place in fiction also with Charles Dickens in his famous "Oliver Twist" describing scrotal cancer in chimney sweeps. Thereafter, the popular novel "Alice in Wonderland" immortalised mercury poisoning by using the term "Mad as a Hatter" to describe the psychotic symptoms of the mercury felt hat.

Later Karl Marx in his famous book "Manifest De Komunistein" stated "Proliterans have nothing to lose but their chains. They have a world to win. Working men of all countries unite". This practically laid the foundation of the Trade Union movement. Rise of socialism led to legislation in industry as workers got more bargaining powers by forming Trade Unions. This promised not only better wages but also more Safety, Health & Welfare for the industrial workers in the organised sector. The first Medical Inspector of factories Sir Thomas Morrison Legy (1870-1932) did pioneering work on lead poisoning. Philippa Howerday (1878) was appointed as the fist Industrial Health nurse. She divided the day in looking after the workers during the morning & visiting their houses in the evening to look after the families. Donald Hunter is credited with writing the book "Diseases of Occupations" which remains the Bible of Occupational Health till date.

## Occupational health and the Armed Forces

The Armed Forces by virtue of its diverse role in varying climatic conditions, terrain and often uncongenial psycho-social environment is exposed to peculiar physical, chemical, biological, mechanical and psychosocial factors in the workplace and off it. Occupational health is thus of prime importance for optimising the efficiency, well being and contentment of the personnel of our three services. Occupational health aspects peculiar to the Navy (Marine Medicine) and Air Force (Aerospace Medicine) have been dealt with separately in this manual. The focus of our discussion in the succeeding paras will pertain to the common occupational health problems of the Armed Forces.

The occupational health hazards, may be grouped into: -

(a) Physical Hazards
  (i) Effects due to heat and cold.
  (ii) Effects due to altitude.
  (iii) Effects of noise especially during firing of heavy weapons.
  (iv) Mechanical factors injuries, accidents.
  (v) Effects of excessive blindness or glare - Snow blindness.
  (vi) Effects of ultraviolet radiation especially in high altitude and snow-bound areas.

(b) Chemical Hazards
  (i) Hazards due to Chemical Warfare.
  (ii) Dusts especially while travelling through unmetalled desert tracks.

(c) Biological Hazards
  (i) Vector-borne diseases esp malaria and zoonoses due to frequent movements and living outdoors.
  (ii) Fungal infections due to prolonged use of uniform and boots.
  (iii) Potential for rapid spread of airborne infections due to living in barracks.
  (iv) Common source food and water-borne disease outbreaks.
  (v) STD/HIV infection increased chances of personnel visiting CSWs as they stay for long without their families.
  (vi) Nosocomial infections & needlestick injuries in health workers.

(d) Psychosocial Hazards
  (i) Long periods of deployment in operational situations away from families may result in heightened emotional stress, frustration, alcoholism, hostility, anxiety, depression and psychosomatic disorders.
  (ii) Long periods of isolation in high altitude or other areas resulting in psychosomatic problems.

(e) Hazards due to Warfare
  (i) Conventional warfare-deaths /injuries due to bullets, shells, bombs, mines etc.
  (ii) Psychological problems "shell shock"

(f) Accidents

The occupational hazards specific to certain Arms and

Services of the Army are discussed in the succeeding paragraph. Though, it may be kept in mind that certain trades are common to all Arms or Services and as such the occupational hazard discussed under a particular head may be applied to a similar trade in another Arms/Services.

(a) Army Service Corps (ASC)

Personnel from this service are employed in supply, transport and clerical duties. The peculiar hazards of occupation are: -

(i) Drivers

- Poor ergonomics in vehicles may lead to various musculoskeletal disorders esp backache.
- Long hours of driving leading to increased eye, mental and physical fatigue and thus enhancing the proneness to accidents.
- Effects of vibration (Raynaud's phenomenon).
- Risk of acquiring STD due to staying away from their families and hence proneness to visit CSWs.

(ii) Clerks

- Musculoskeletal disorders like backaches.
- Repetitive Strain Injuries (RSI) due to typing.
- Working with computers for long hours may lead to eyestrain (due to glare) and other effects of radiation.

(b) Medical Personnel

(i) Increased risk of Hepatitis B, HIV, etc due to accidental needle stick injuries.

(ii) Long hours of standing during surgeries, dental and other procedures may lead to varicose veins.

(iii) Risk of acquiring various infections esp airborne infections during the course of patient care.

(iv) Effects due to radiation amongst personnel working in radiology and radiotherapy.

(v) Contamination hazard due to improper handling of cytotoxic and bio- medical wastes.

(vi) Increased risk of infections among lab workers dealing with blood and other body fluids.

(c) EME

(i) Effects of high noise levels in the workshop floor resulting in deafness.

(ii) UV radiation effects due to arc welding leading to blindness.

(iii) Effects due to inhalation of various fumes and gases.

(iv) Irritant dermatitis due to repeated exposure to various chemicals like grease, oil etc.

(v) Musculoskeletal disorders amongst vehicle mechanics due to awkward postures and excessive bending at work.

(vi) Effects due to prolonged exposure to vibration.

Injuries during handling of various types of machinery.

(vii) Electrical injuries.

(d) Engineers

(i) Injuries during blasting, mine-laying/removal, construction work.

(ii) Effects of prolonged exposure to vibration during drilling and handling of heavy machinery.

(iii) Injuries during handling of heavy equipment during earth moving and bridging.

(iv) Drowning while assisting in river crossings.

(e) Armoured Corps and Mechanised Infantry

(i) Claustrophobia due to cramped spaces in armoured vehicles.

(ii) Effects of excessive heat inside their vehicles.

(iii) Effect of noise due to firing of guns.

(iv) Effect of dust.

(f) Artillery

(i) Effects of high levels of noise generated during firing of artillery guns may lead to rupture of tympanic membrane and conductive deafness.

(ii) Injuries during handling of heavy equipment.

(iii) Effect of dust.

(g) RVC

(i) Risk of acquiring zoonoses.

(ii) Animal bites.

(h) Signals

(i) Injuries among linemen due to fall from telephone poles.

(ii) Long hours of work under the sun esp among linemen resulting in heat stress disorders.

(j) Infantry

The occupational hazards in the Army discussed in the preceding paras are mostly applicable to Infantry, more so due to their repeated participation in CI Ops.

(k) Recruits/Regimental Training Centres

(i) Stress fractures.

(ii) Psychosocial stress.

(iii) Overcrowding having the potential for explosive disease outbreaks like meningococcal meningitis, exanthematous fevers, etc.

(iv) Common source outbreaks - Food poisoning, viral hepatitis.

(l) Troops on foreign mission

The specific hazards are discussed elsewhere in a separate Chapter.

## Occupational lung diseases

### Pneumoconiosis

The concept of using the term Pneumoconiosis has undergone a change. Earlier, this term was used to describe all lung related problems caused by any kind of dust (4). However, the term should only be used for all dust damage to the alveolar part of the lung, including the airways that have no mucociliary lining (5). Therefore, by convention Pneumoconiosis does not include bronchitis, asthma or cancers. In other words, basically it is the inorganic dusts like silica, asbestos & coal that cause Pneumoconiosis since they affect the lung parenchyma, rather than the airways. On the other hand, organic dusts like cotton dust or cane sugar principally cause 'bronchitic' changes in the lungs & so do not qualify to be called Pneumoconiosis. Nonetheless, the control measures for both organic dust & inorganic dust remain the same.

Standard distance, full size, posterior-anterior films taken & processed as recommended by ILO (6) play an important role in the prevention & early detection of occupational diseases of the alveolar part of the lung. For epidemiological purposes, the classification of individual X-rays of pneumoconiosis is a difficult task and even those experienced in radiography vary in their judgement. In general, rounded opacities are fairly specific for pneumoconiosis due to mineral dusts. Other changes such as irregular opacities (which are frequently seen after exposure to asbestos dust) are less specific. In exposure-response epidemiological studies it is recommended that random groups of X Rays be examined by atleast three experienced medical workers independently, using standard ILO X Rays for comparison. In order to ensure repeatability, a certain number of X rays should be re-examined & use should be made of trigger films. However, it should be pointed out that this approach may not be suitable for long term serial studies because film processing techniques change over a period of time. It is therefore, not surprising to note that most cases of Pneumoconiosis in India are diagnosed as Tuberculosis.

### Silicosis

Silicosis is a disease caused by breathing air containing silica in its free state, as quartz (SiO2) .The pathological result is a generalised fibrotic change and development of miliary nodules of variable sizes in both lungs. The clinical manifestations are shortness of breath, decreased chest expansion, a lessened capacity for work, and chronic bronchitis with the absence of fever and characteristic X-ray findings. There is an increased susceptibility to tuberculosis. The diagnosis of the disease mainly depends upon occupational history, symptom complex and the radiological findings. The pathological process starts only when the dust particles, which contain silica in a free state such as quartz (SiO2), reach the alveoli. Most of the dust inhaled is expelled by the ciliated epithelium and some part is eliminated by phagocytosis, which brings up the particles and discharges them to the ciliated epithelium and the cough mechanism expels them. However, when the fine particles are present in the atmosphere in a large quantity, some find their way to the finer air passages. They first cause the inflammation of the ciliated epithelial cells with their subsequent destruction, reducing the first line of defence. Epithelial cells crowded with silica dust get aggregated into definite clumps around which fibrosis occurs. This damage produced in the lung is permanent. It is liable to activate the preexisting tubercular focus and develop tuberculosis. The disease finally produces emphysema and corpulmonale. The factors of importance in the causation of the disease are dependent upon the nature of the work process and the environmental working conditions. They are as under: -

(a) The dust must contain silica in a free state as quartz (SiO2) and the particles must be of respirable size.

(b) These must be present in sufficient concentration in the atmosphere and must be breathed for long periods.

(c) The larger particles tend to flocculate and settle out of the atmosphere. Particles of 0.5 to 5 microns are dangerous as they are capable of getting into the lungs.

(d) Therefore, the dust, which cannot be seen by the naked eye, is much more dangerous than the dust, which is visible.

(e) The work in enclosed places is more dangerous than in open places.

(f) Wet processes carry less risk or none at all but dry processes are definitely dangerous.

(g) It is generally held that 10 years or longer is necessary for the development of a significant degree of silicosis; but in more severe exposures, such as in sand blasting and rock drilling under ill-ventilated conditions, it may occur early (7,8,9,10).

#### Prevention

Very little can be done once the disease has set in and, therefore, prevention is most important. Preplacement & periodic health examinations of the worker are important. Chest X Ray is to be taken to see if the individual has pulmonary tuberculosis or any other lung disease. Basic lung function tests should be carried out, including measurement of the Vital Capacity & Forced Expiratory Volume in one second. Dust control is the most important engineering procedure to reduce risk as shown in Table 1. If a significant number of workers develop silicosis within 20-25 years of first employment, the dust control measures should be suitably revised.

### Asbestosis

Asbestos is a fibrous material. These are silicates; silica combined with bases like magnesium, iron, calcium, sodium and aluminum. These are of two types-serpentine and amphibole. However, 90% of production is of serpentine variety. Asbestos used in the manufacture of asbestos cement, fireproof textiles, roof tiling, brake lining, gaskets, and such other items.

Asbestos fibres are inhaled and fine dust gets deposited in the alveoli. These are insoluble and cause chronic irritation resulting in pulmonary fibrosis of lungs. It can also cause carcinoma of bronchus and mesothelioma of

pleura and peritoneum (more due to amphibole variety). These possibilities are more when exposure is coupled with smoking. The disease appears after an exposure of 5 to 10 years. The fibrosis is peribronchial, diffuse and more near the bases in contrast to fibrosis due to silicosis. Clinically, patient gets cough, pain in chest and dyspnoea disproportionate to the clinical signs in lungs. In advanced cases there may be clubbing of fingers, cardiac failure and cyanosis. Sputum shows asbestos fibres coated with fibrin called "asbestos bodies". X-ray chest shows a ground glass appearance in lower parts of lungs. Disease is progressive even after removal from exposure.

Prevention

(a) Adopt all measures for dust control. The legal exposure limit in India is 2 fibres/ml of air.

(b) Substitute it with safer materials like glass fibres, calcium silicate, plastic foam etc. where feasible.

(c) Use safer varieties of asbestos (chrysotile & amosite).

(d) Periodic medical examination of workers and elimination of susceptibles from workforce.

(e) Use of personal protective measures.

(f) Good housekeeping & the use of vacuum cleaners.

(g) Use of respirators & protective clothing is to be encouraged.

(h) Health education of the workers.

(j) Continuing research to find safer substitutes (7, 8, 10-16).

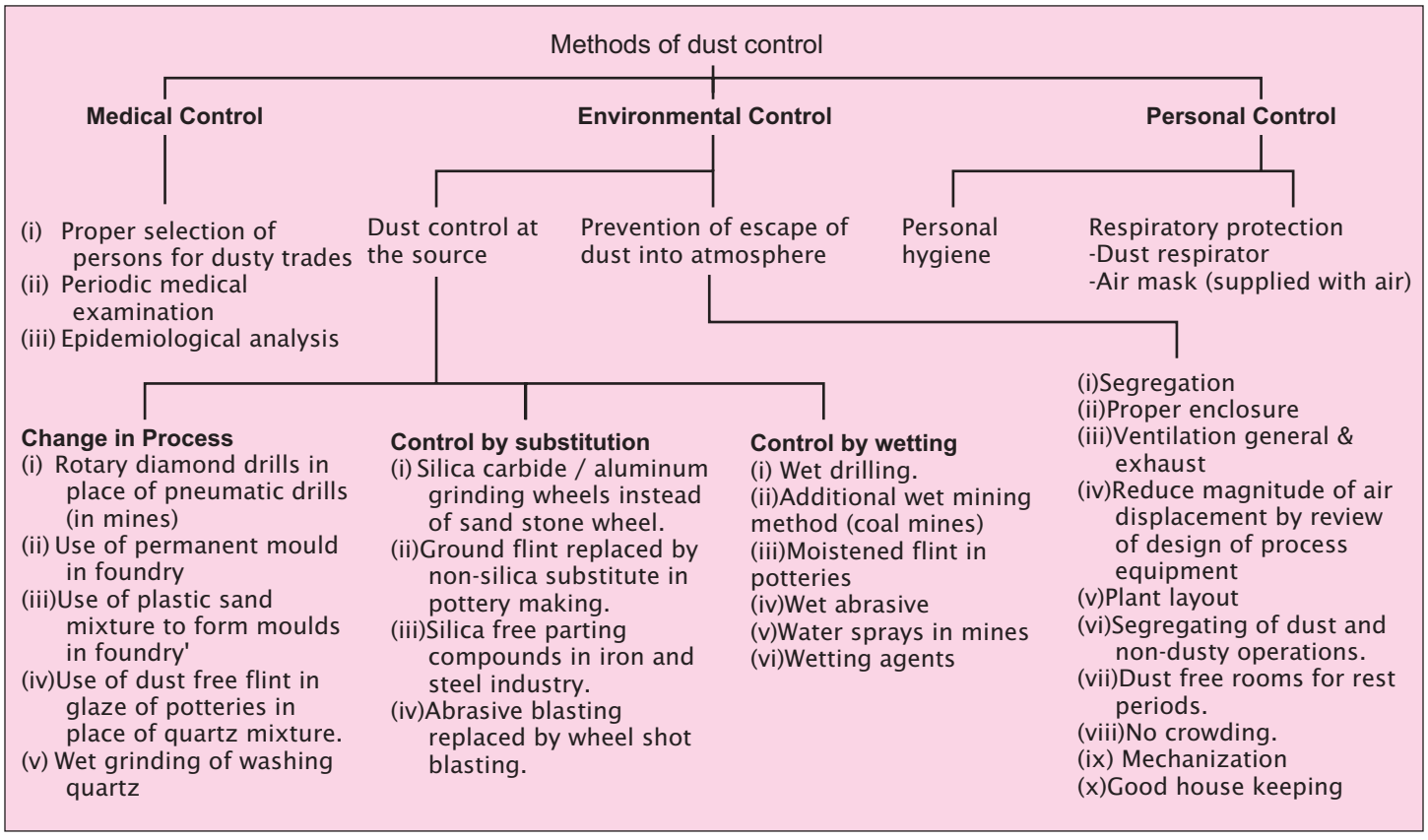
**Bysinossis**

Bronchopulmonary diseases caused by exposure to airborne dust of cotton, flax & soft hemp leads to Bysinossis. It is a chronic respiratory disease characterised by tightness of the chest & breathlessness at work after the weekend or other absence. It is also called 'Monday Fever". This is probably due to a histamine releasing substance. In addition to histamine release, exposure to cotton dust causes irritation in the upper respiratory tracts & bronchi, which after prolonged exposure slowly progresses to chronic obstructive pulmonary disease. In early stages there may be decline in FEV1, which may be symptomless in some workers. Within, one or two days, most symptoms tend to disappear except for irritation in the upper respiratory tract. As the disease progresses, the chest tightness is accompanied by breathlessness, the symptoms becoming worse & persisting for a longer time. In its late stages the disease resembles chronic bronchits & emphysema, except for the history of chest tightness & decline in ventilatory capacity, characteristically worse at the beginning of the work week. Chest X rays do not show any specific changes.

Prevention

Preplacement examination should include Chest X ray, VC and FEV1. Periodic medical examination is recommended every year. In groups of workers, a drop of more than 10%

Table- 1: Methods of dust control



## Work Environment

### Design of Building

All buildings, permanent or temporary should be structurally safe and sound to withstand the stress and strain of machinery. Single storey construction is the usual rule as it allows flexibility of layout. Any intensity of natural light can be obtained in it by a combination of wall and roof lighting and it is easier to manage natural ventilation. By careful orientation, direct exposure to the tropical sun can be avoided. Protection from conducted heat can be achieved by a choice of suitable material. Asbestos lining of the walls and ceilings will reduce the noise or machines by controlling the reverberation, resonance and sympathetic vibrations. This will also make the building fireproof.

### Space Requirement

A floor area of 3.8 sq.m. and 14.2 cu.m. of space per worker should be provided. The height of the work rooms should not be less than 3 m. In calculating the space, no deduction need be made for furniture, machines and material, but a height above 4.2 metres should be excluded. The floor should, however, not be crowded with machinery. Individual machines or process units should have sufficient space around them to permit safe operation.

### Lighting

Workrooms should be adequately provided with natural and / or artificial lighting. Any special type of work should have special, extra or spot lighting suitable for the operations. In all places where persons work or pass through, enough diffuse background lighting should be ensured. Natural lighting is ensured by the provision of skylights and windows located and spaced with devices to avoid glare. Artificial lighting should be provided where the daylight illumination is insufficient. It should be uniform and free from sharp and contrast shadows and direct or reflected glare. Supplementary lighting specifically designed for particular visual task should be so arranged as to avoid glare, flicker or after-image. Emergency lighting should be provided in all important stairway exits and passages, to and from work places and windowless buildings. The fluorescent tube in strip lighting is being increasingly used. Their efficiency is high and running costs are low. They give uniform illumination and there is low heat formation with absence of shadows. However, in course of time when the tube gets exhausted it develops a flicker, which is irksome to the eyes and also produces a stroboscopic effect (7,8).

### Ventilation

Modern concept of ventilation requires replacement of vitiated air by supply of fresh outdoor air. The quality of the incoming air should be such that its temperature, humidity and purity are conducive for healthful working. Clean fresh air should be supplied to enclosed work places and it is recommended that in work rooms and assemblies there should be 4 to 6 air changes in one hour. If the air is changed more frequently, i.e. more than 6 times in one hour, it is likely to produce a draught which should be avoided. Where an adequate supply of fresh air cannot be obtained by natural ventilation, mechanical ventilation should be provided. All dust, fumes, gases, vapours or mists generated and released in industrial processes should be removed by local exhaust ventilation at their point of origin (7, 8).

### Thermal Comfort

Temperature and humidity should be maintained in enclosed work places suitable to the kind of work performed. In localities subject to high or low seasonal temperatures appropriate means such as heat insulation of roofs, walls and floors, and even of doors and windows should be adopted. All employees should be protected against radiant heat and excessive temperature from heated machines or hot processes by heat insulation of the equipment and / or by suitable protective clothing. In industries involving exposure of workers to high or low temperatures, 'transition rooms' should be provided so that the workers can gradually adjust themselves to the external climatic environments. Roof-shelters and windbreakers should be provided for yard-workers where necessary. Measurement and indices of thermal comfort have been dealt in detail in another chapter.

### Working Comfort

Seats and workbenches of suitable shape and height should be provided for workers. The seats should be so placed that working material can be reached easily without strain or having to bend forward unduly. Seats should also be provided for all workers who have to work in a standing position, for rest during occasional short interruptions in their work.

### Sanitary Conveniences

These should be conveniently located: -

(a) Latrines

Scale of latrine accommodation is 4 for the first 100 workers and 2 for subsequent 100 workers or part thereof.

(b) Urinals

Two urinals for every 100 workers upto 500 and there after one for 100 workers are to be provided. For female workers separate sanitary conveniences are to be provided.

(c) Wash Basins

Adequate hand washing facilities should be provided. For persons whose work involves contact with any injurious substances, there should be at least one tap for every 15 workers.

(d) Bath-rooms

Adequate number of bathrooms for bathing and washing of clothes should be provided.

(e) Spittoons

Sufficient number of spittoons should be placed at convenient places.

(f) Cloak Rooms

Well-ventilated rooms with individual lockers should

be provided for dressing purposes and storage of personal clothing (17).

### Drinking Water

An adequate supply of cool and safe drinking water should be provided in a readily accessible place. Water coolers are ideal and most hygienic. Proper precautions to prevent contamination of water in tanks, pails and other containers must be enforced, Section 18 of the Factories Act lays down that every factory having more than 250 workers will provide cool drinking water during hot weather (17).

### House-keeping

It implies general cleanliness and orderliness of the plants, the tools and the products. Cleaning and sweeping should be done during non-working hours; vacuum cleaning or wet mopping should be adopted. Effective drainage should be maintained where wet processing is carried out. False floors, platforms, mats or other dry standing places along with suitable footwear should be provided in oily and greasy places. However, 'house-keeping' means much more than merely keeping the working places clean. That there is a place for everything and everything in its right place, is a tried and true axiom of industrial safety. Stumbling and tripping due to improper house-keeping is another potential cause of accidents.

### Miscellaneous Requirements

Infestation with rodents, insects and vermin should be eliminated by suitable measures. Workrooms and work places should not be used as living or sleeping quarters. No food, drink, betel nut or leaves or tobacco should be consumed or brought by any worker into any workroom in which dangerous and obnoxious materials, particularly lead and radioactive substances, are in use. Anyone suffering from communicable diseases should be at once isolated and preventive and control measures instituted.

## Industrial Toxicology

Industry uses and manufactures wide variety of substances, which are either known or suspected to cause toxic effects in the persons working with them. Industrial toxicology is concerned with the study of various substances used in industry either as media for processing some other materials or as raw materials or the finished product. The genesis of toxic effects is shown below in a schematic manner:

| | |
|---|---|
| Things used or manipulated → | Solids, liquids, gases |
| may produce | dusts, fumes, gases, rays |
| which may be → | inhaled, swallowed, absorbed by or attack |
| the | skin, |
| and cause | harmful effects, (Occupational hazards/ diseases) |

### Permissible Exposure Limit (PEL)

It is defined as exposure to a maximum time weighed average (TWA) of concentration of a toxicant for an 8-hour work. The PELs of some important substances as recommended by Factories Act 1947 (modified in 1987) are given in Table 2.

Table - 2 : Permissible Exposure Limit (PEL) of gases and vapours

**(Factories Act 1948 as amended 1987)**

| Substance | Parts per million of air by volume |
|---|---|
| Acetone | 750 |
| Ammonia | 0.25 |
| Arsine | 0.2mg/$m^3$ |
| Benzene | 10 |
| Bromine | 0.7 |
| Carbon disulphide (skin) | 10 |
| Carbon monoxide | 50 |
| Formic acid | 5 |
| Hydrogen cyanide(skin) | 10 |
| Nitrogen dioxide | 3 |
| Phenol(skin) | 5 |
| Phosgene | 0.1 |
| Pyridine | 5 |
| Sulphur dioxide | 2 |
| Toluene | 100 |
| Trichloroethylene | 50 |
| Vinyl chloride | 5 |
| Xylene | 100 |

### Prevention - Engineering Measures

General rules for prevention/reduction of hazards from dangerous and obnoxious substances are as under :

**(a) Substitution**

Wherever practicable the use of offending substances should be prohibited. Failing that, a harmless substance should be substituted for the harmful one e.g. the use of yellow phosphorus substituted by phosphorus sesquisulphide in the match industry, sand-blasting may be substituted by shot blasting; and acetone may be used in place of benzol as solvent.

**(b) Total Enclosure**

Through airtight enclosure, personal contact with harmful substances such as dusts, fibres, fumes, gases, mists or vapours can be prevented.

**(c) Local Exhaust Ventilation**

Where an airtight apparatus cannot be used, the harmful products should be removed at or near their point of origin by means of fume chambers or suction hoods

properly connected to efficient exhaust systems.

**(d) Dust Suppression**

Where practicable the materials should be used in a moist or wet state to prevent the evolution of dust e.g. lead.

(e) **Duration of Exposure**

Limitation of the duration of exposure or employment should be compulsory in certain trades e.g. in radioactive processes.

(f) **Restriction of Employment**

Children below 14 years are not permitted to work in any industry. Women and young persons between 15-18 years are prohibited from working in hazardous industries.Women are prohibited from working underground in a mine.

(g) **Personal Hygiene**

Provision of adequate washing facilities and insistence on washing / bathing e.g. for workers in lead, chromes and radioactive processes. Prohibition of the preparing or taking of meals and smoking in workrooms.

(h) **Environmental Monitoring**

The atmosphere of workrooms should be tested periodically to ensure that the concentration of irritating or toxic dusts, fibres, fumes, gases, mists or vapours is kept within safe limits.

(j) **Health Education**

By far the most important safety factor is the co-operation of the worker in obeying the given safety orders and instructions. Too often, the safety notices / posters are couched in purely negative terms; the worker is exhorted not to perform one or other action and is left in doubt as to the reason for the prohibition. A positive approach has been found to be more effective. If the notices give an indication of the nature of the hazards to which the workman would be exposing himself, there could be less temptation for disobeying the restrictions.

## Legislation - Notifiable Diseases

Occurrence of any of the diseases listed here under should be notified under "The Factories Act, 1948 as modified in 1987" (17).

(i) Lead poisoning including poisoning by any preparation or compound of lead or its sequelae.

(ii) Lead tetraethyl poisoning.

(iii) Phosphorus poisoning or its sequelae.

(iv) Mercury poisoning or its sequelae.

(v) Manganese poisoning or its sequelae.

(vi) Arsenic poisoning or its sequelae.

(vii) Poisoning of nitrous fumes.

(viii) Carbon bisulphate poisoning.

(ix) Benzene poisoning including poisoning by any of its homologues, their nitro or amino derivatives or its sequelae.

(x) Chrome ulceration or its sequelae.

(xi) Anthrax.

(xii) Silicosis.

(xiii) Poisoning by halogens or halogen derivatives of the hydrocarbons of the aliphatic series.

(xiv) Pathological manifestations due to radium or other radioactive substances and X- rays.

(xv) Primary epitheliomas of the skin.

(xvi) Toxic anaemia.

(xvii) Jaundice due to hepatotoxic substances.

(xviii) Oil acne or dermatitis due to mineral oils and compounds containing mineral oil base.

(xix) Byssinosis.

(xx) Asbestosis.

(xxi) Occupational or contact dermatitis caused by direct contact with chemicals and paints. These are two types, that is, primary irritants and allergic sensitizers.

(xxii) Noise induced hearing loss (exposure to high noise levels).

(xxiii) Beryllium poisoning

(xxiv) Carbon monoxide

(xxv) Coal miners pneumoconiosis

(xxvi) Phosgene poisoning

(xxvii)Occupational cancer

(xxviii)Isocyanates poisoning

(xxix) Toxic nephritis

Medical Examination

A proper pre-placement medical examination followed by periodical medical inspections at appropriate intervals for workers exposed to hazardous occupation should be enforced.

## Chemical Hazards

**Lead**

Lead is ubiquitous in industry and poisoning due to absorption of lead and its compounds is still common.

Table - 3 : Categories of lead absorption

| Test occupation | Normal population | Acceptable absorption in occupation | Excessive absorption in with signs & symptoms |
|---|---|---|---|
| Blood lead | 10ug/dl | 10-80ug/dl | >80ug/dl |
| Urinary lead | 10-65 ug/g Cr | upto 150 ug/g Cr | >150 ug/g Cr |
| Zinc protoporphyrin | 16-35 ug/dl | Upto 100 ug/dl | >100 ug/dl |

Hazardous processes are lead smelting, burning and making paint, painting, welding, riveting, battery manufacture, and lead baths connected with heat treatment of metals, specially when carried out in confined spaces. Inhalation of lead dust and fumes is the chief route of poisoning; the next common route is ingestion; cutaneous absorption is rare. It is rapidly absorbed into general circulation when inhaled and produces ill effects much more rapidly and probably in a more severe form than when ingested. Young persons are more prone to lead poisoning than adults. Lead concentration in the working atmosphere should be kept below 2.0mg per 10 cu m of air ( 7,8, 18-22).

(a) Symptoms

The commonest manifestations of lead poisoning are blood changes and lead palsy. Lead makes the RBC fragile and causes haemolysis, which results in anaemia with compensatory stimulation of the bone marrow. So immature RBC or reticulocytes appear in the blood. The RBC count is generally below 3 million with haemoglobin under 70 per cent (Sahli). In 'Lead palsy' there is a typical degenerative neuritis and subsequent fibrosis. In acute lead encephalopathy, there is involvement of the meninges with oedema and increased intracranial pressure. There, may be some capillary damage as well. The lead line showing blue discolouration of the margins of the gums is a classical sign. A diagnosis of lead poisoning should be based on clinical findings, biochemical evidence of excessive lead absorption and by evidence of unusual exposure. Table-3 lists biochemical tests for estimating the degree of lead absorption and Table-4 show signs and symptoms of lead poisoning.

(b) Prevention

It depends on good housekeeping, personal protection and education of workers and medical supervision for the detection of hazards before the occurrence of poisoning followed by its rectification.

(i) Exhaust ventilation measures so arranged that whatsoever position the worker assumes the lead dust and fumes are drawn away from his face.

(ii) Strict periodical inspection of the exhaust system; all ducts and their angles should be cleaned periodically.

(iii) Avoidance of crowding in the workrooms where metallic lead is heated.

(iv) The floor should be impervious to water, and smooth so that no lead dust can accumulate.

(v) The floor should be constantly kept wet and swept before and after the day's work with a vacuum cleaner.

(vi) Workers should wear special work clothes which should be removed before leaving the factory and deposited in specially provided lockers in

Table 4 : Table showing manifestation of lead poisoning

| System | Evidence of absorption | Evidence of incipient poisoning | Evidence of definite poisoning |
|---|---|---|---|
| General appearance | Restive, moody, easily excited, emotional, lead line. | Pallor, leadline, jaundice. | Anaemia, leadline, jaundice, emaciation, “premature ageing”. |
| Digestive System | Persistent Metallic taste, slight anorexia, slight constipation. | Metallic taste, definite anorexia, slight colic, constipation. | Metallic taste, increasing anorexia, nausea and vomiting, marked colic, rigid abdomen marked constipation, blood in stool. |
| Nervous system | Irritability, unco-operativeness. | Slight headache, insomnia, slight dizziness, palpitation, increased irritability, increased reflex. | Severe headache, increased insomnia, increased dizziness ataxia, confusion, marked reflex changes, tremor, fibrillary twitching, neuritis, visual disturbances, encephalopathy hallucinations, convulsions, coma, paralysis. |
| Miscellaneous | | Muscle soreness, easily fatigued. | General weakness, arthralgia, hypertension. |
| Urine examination | Abnormal lead content. | Abnormal lead content, albumin, casts. | Abnormal lead content, albumin, casts, porphyrinuria, haematuria |
| Blood changes in increase in cells showing | Polycythemia, polychroma-tophilia, increased platelets, | Normal red cell count and | Decrease in haemoglobin, decrease haemoglobin, reticulocytosis,RBC, |

order to ensure the prevention of contamination of private clothes.

(vii) Suitable respirators against lead dust and fumes should be used and inspected regularly.

(viii) No food, drink and tobacco should be taken in a place where there is a risk of lead poisoning; special rooms should be provided for this in factories.

(ix) Personal cleanliness should be ensured by providing bathing and washing facilities.

(x) Health education to avoid dusts and fumes of lead being inhaled or ingested.

(xi) Medical Surveillance : Pre-employment medical scrutiny of the prospective workers in the hazardous process should include the history of previous exposure to lead and elimination of those with a positive history of symptoms of lead poisoning. Quarterly medical examination during employment with attention paid to the loss of weight, gastro-intestinal symptoms, weakness of wrist muscles and blood picture. Removal from exposure should be followed by active treatment

(c) Treatment

When lead poisoning is diagnosed, the further exposure should be discontinued. The use of penicillamine and Ca-EDTA, chelating agents, help in bringing down the blood lead levels by promoting lead excretion in urine. A saline purge will help to remove unabsorbed lead from the gut and also will relieve constipation.

**Tetraethyl Lead**

Exposure to high concentrations of vapour of leaded petrol, especially in hot weather, is responsible for an acute form of lead poisoning (lead encephalopathy). In industry this hazard occurs by spillage in petrol filling sheds/holds/barges with inadequate ventilation, inhalation from clothing saturated with petrol from spillage and splashing and absorption through the skin, which is relatively slight. In some cases a chronic form of lead poisoning occurs. Spillage should be prevented by use of filling apparatus. Proper ventilation of the shed is important. The operation of filling should be carried out in the open air. Exhaust fans may be necessary. Special precautions must be adopted when containers are loaded in the holds of the barges. Only containers in sound condition should be accepted for loading and care should be taken in the storage of the containers. The holds of the barges / tanks should be provided with adequate ventilation. Short shifts at frequent intervals during the work and overall turnover of the labour, so that each man is employed for one week in four on this work, are essential preventive measures. Other precautions are the same as have been described under lead poisoning. With the current trend on use of unleaded petrol, it is presumed that toxicity due to this cause will be on the decline.

**White Phosphorus (WP))**

White phosphorus (WP) is being used in smoke producing ammunition. After white phosphorus exposure burnt skin is washed with 5% sodium bicarbonate and 3% copper sulphate in 1% hydroxyethyl cellulose. Phosphorus particles become coated with black cupric phosphide allowing easy identification. Copper Sulphate also decreases rate of oxidation of phosphorus particles, limiting damage to underlying tissue. Since blackened particles continue to elicit tissue injury, they can be removed. Of late, copper sulphate is found to be toxic and systemic copper poisoning can manifest as vomiting, diarrhoea, oliguria, haematuria, hepatic necrosis and cardio- pulmonary collapse. Thus presently the following treatment is followed: -

(a) Self Aid

(i) If burning particles of WP strike and stick to clothing, take off the contaminated clothing.

(ii) If burning WP strike the skin, smother the flame with water/ a wet cloth. Keep the WP covered with wet material to exclude air until the particles can be removed.

(iii) Try to remove the WP particles with a knife, stick or available object. It may be possible to remove some particles with a wet cloth.

(b) Treatment

(i) At the earliest opportunity, all WP particles must be removed.

(ii) Affected area is bathed in a bicarbonate solution to neutralise phosphoric acid which will then allow removal of visible WP particle. In dark surrounding, fragments are seen as luminescent spots.

(iii) Do not apply oil based ointments until it is certain that all WP has been removed as WP is readily soluble in oil. Following complete removal of the particle, treat the lesion as thermal burn.

(iv) If eye is affected, treatment must be started immediately. The most effective treatment is to neutralise any phosphoric acid by irrigating with 5% bicarbonate solution. Continue irrigating for 10-15 min with copious amount of normal saline or water at room temperature. On completion of irrigation, a wet dressing/cloth should be applied to stop WP burning by depriving it of oxygen. All WP particles easily accessible should be removed promptly. The lids must be separated and a local anaesthetic instilled to aid removal of embedded particles. Once all particles have been removed from the eye, atropine eye ointment should be put and patient be transferred to care of an Ophthalmologist as early as possible (7, 8, 18 21).

**Mercury Fulminate**

It is a brownish yellow, heavy, crystalline solid prepared by the action of alcohol on mercuric nitrate. The chief hazard is dermatitis affecting those who are employed in filling

operations where a fine dust is raised, which comes in contact with the naked skin. The susceptibility of some individuals may not enable them to withstand exposure even for a day. The exposed parts of the body become erythematous. accompanied by violent itching, swelling and oedema of the face, eye-lids, ears, neck and forearms. Teeth become black owing to the formation of mercuric sulphide. Cleanliness of the plant is important. All precautions as for a lead factory should be taken. Exhaust ventilation should be fitted, and all persons should be provided with well fitting overalls, aprons, rubber gloves, and if necessary, respirators as well. Additional hand washing facilities should be provided (8, 18-22). Details of occupational dermatitis are given in Table - 5.

**Chromium**

Chromic acid and bichromates of sodium and potassium are used in chromium plating of metals, manufacture of explosives and for tanning of leather. Characteristic chrome ulcers occur on nail beds and the nasal septum. They are small, deep ulcers varying in size from the head of a matchstick to the end of a lead pencil. The tissues around the ulcers are heaped up and are covered by crusts. They may cause perforation of the nasal septum. The ulcers are as a rule not painful but heal very slowly (7,8, 18-22).

(a) Prevention

Mechanical lateral exhaust ventilation should be provided for the removal of the vapour and spray at the point of origin. The floor of rooms containing chrome baths should be impervious, maintained in good condition and flushed out daily. Suitable rubber gloves, aprons and other protective clothing should be provided and maintained properly. Water taps should be installed in workplaces, to enable the workers to wash hands frequently. Shower bath and a change of clothing should follow the day's work. All cuts, abrasions and other injuries on hand and forearm should be protected by adhesive strapping before starting work. The hand and forearm should be inspected twice a week and any breach of continuity of the skin should be immediately reported to the factory doctor. A protective ointment should be applied in the nostrils.

(b) Treatment

Chrome holes are only slightly painful and tend to heal spontaneously but may be troublesome if secondarily infected. They can however be treated adequately with a 10 % solution of Calcium EDTA. For ulceration of nasal septum use of liquid paraffin on plugs of cotton wool is enough. The man should be removed from the exposure until completely cured.

**Metal Fume Fever**

It is an acute transient illness and is commonly known as 'Brass Founders Ague', 'Zinc Fever' or 'Metal Chill'. It follows the inhalation of high concentrations of finely dispersed zinc or brass fumes, usually in the form of oxides. After heavy exposure, the nose and throat feel dry and sore giving rise to a dry cough. In a few hours, the symptoms appear. There is shivering which may last for

TABLE 5 : Occupational Dermatitis

| Predisposing Factor | Machine causes | Physical causes | Chemical causes | Biological causes | Preventive measures |
|---|---|---|---|---|---|
| Type of Skin<br>Age<br>Personal hygiene<br>Weather conditions<br>Pre-employment conditions of skin<br>Nutritional state<br>Environmental conditions<br>Protective clothing<br>Mechanical factors<br>Excessive sweat<br>Emotional status | Repeated friction<br>Sand, dust, coal particles<br>Metal particles<br>Glass fibres<br>Fish scale / bone pricks | Heat<br>Humidity<br>Sunburn<br>Radiation (U.V.Rays, X-rays)<br>constant exposure to water | Primary Irritants:<br>Alkali soap (dissolve keratin)<br>Organic solvents (Dissolve fats)<br>Inorganic acids (Dehydrate tissues)<br>Heavy metal salts (Precipitate tissue proteins)<br>Chromates and bleaches (oxidation of tissue)<br>Coal tar and petroleum (Keratogenic action)<br><br>Cutaneous Sensitisers:<br>Combine with tissue proteins and forms complex antigens<br>Acridine compounds (acriflavin, mepacrine)<br>Dyes (Diamine, Rosamine, Chrysodine)<br>Solvents (Petrol, TNT)<br>Developers (Metol, hydroquinone)<br>Antioxidants (Guanidine)<br>Resin, perfumes, waxes<br>Miscellaneous group (fluorides, mercury fulminate, bichromates, insecticides, fungicides, streptomycin, penicillin). | Bacteria<br>Parasite (Mite)<br>Plants (Liliaceae)<br>Vegetables (Asparagus, spinach, beans, pyrethrum)<br>fruit (Orange, lemon, tulip) | Selection of workers<br>Health education<br>Periodic inspection<br>Plant design<br>Substitution<br>Personal protection<br>Thermal comforts<br>Barrier cream<br>Keeping up morale of workers |

some time and this is followed by profuse perspiration, the picture simulating that of an attack of malaria. Considerable prostration follows the attack, but by the next morning recovery is almost complete. Some degree of insusceptibility is produced by low-grade inhalation but is lost in 48 hours. Workers therefore, are likely to suffer more on Monday mornings. Metal fumes should be eliminated by proper exhaust ventilation. When conducting replacement or transfer medical examinations, cases with a history of chronic bronchitis, asthma or any other respiratory trouble should be withheld.

**Mineral Oils**

Mineral oils are insoluble and soluble. The insoluble ones are used mainly as lubricants for cutting tools and the soluble ones are used as cooling agents. Cutting oils have the property of defattening the skin. They also plug the pores of the skin and form comedones. After some days of use they may contain steel slivers, which may injure the skin and thus start dermatitis affecting the forearm and thigh. Small blackheads due to blocking of the sebaceous glands appear in these areas.

(a) Prevention

Cleanliness of persons, their clothes and machines should be ensured by the provision of adequate washing and shower bath facilities. Suitable industrial cleaners should be placed at convenient locations in the washroom. Clean rags or cotton waste free from sliver should be provided. Time should be allowed for workers to carry out thorough cleansing, change of clothes and dressing. Those who give a previous history of dermatitis should be excluded by preplacement examination. Persons suffering from seborrhoea, acne and excessive sweating should be prohibited from employment in such jobs (Table-5). If the dermatitis occurs or comedones appear, the person should be temporarily withdrawn from the process and re-employed when the skin condition clears up.

(b) Treatment

The treatment is usually by soothing lotions or cream like calamine. Barrier creams may help in getting the skin of the beginners slowly conditioned to the contact with cutting oils but cannot serve as a permanent protective measure for persons whose skins are excessively sensitive.

**Benzene**

This is a colourless aromatic hydrocarbon with a characteristic pleasant smell. It is extensively used as a solvent and as a starting material in the synthesis of numerous chemicals (7,8, 23-27).

(a) Acute Poisoning

Clinically, acute poisoning is of three general types, depending upon the severity of its anaesthetic effects on brain centres. Very high concentrations of benzene inhalation may result in unconsciousness, followed by death from respiratory failure. With somewhat, lower concentrations there may be dizziness, weakness, apprehension, collapse and unconsciousness. Death may occur from respiratory failure. In the third type of poisoning death occurs in several days usually without recovery from coma.

(b) Chronic Poisoning

The haemopoetic system is mostly affected but degenerative changes are also observed in the kidneys and heart. There is weakness, dizziness, rapid pulse, persistent headache, malaise, loss of appetite, shortness of breath, undue fatigue, decreased resistance to infections, and ulcers in the throat. Due to decrease in platelets, there is bleeding from the mucous membrane and haemorrhage in tissues. Macrocytic anaemia gives more reliable indication of the poisoning than leucopenia, especially in the early part of the disease.

(b) Prevention

The ventilation of the workroom should be improved by mechanical exhaust ventilation. A monthly examination of the employees should be carried out including a complete blood count, and findings recorded in a special register. There should be a rotation in duties of the personnel. Worker's showing an altered blood picture should be removed from exposure. They should report for medical examination, if bleeding from the nose, gums or other mucous membranes is noticed. Toluene, xylene, cyclohexane or trichloroethylene can be used as comparatively safer and satisfactory substitutes for benzene.

(c) Treatment

Penicillin should be given in adequate doses if infection is suspected. Repeated blood transfusions may be necessary. Since anaemia is frequently of the macrocytic type - folic acid and vitamin B12 should be given. The diet should be rich in protein, especially animal proteins and in vitamin C and Vitamin B group.

**Trinitrotoluene (TNT)**

It is a yellowish crystalline solid, which looks like brown sugar. It is used extensively as an explosive. TNT is mainly absorbed by the skin and to a certain extent by inhalation. It forms methaemoglobin, which decreases the oxygen carrying capacity of the red blood corpuscles. It has a deleterious action on the bone marrow and can also cause massive necrosis of the liver. Breathlessness, cyanosis, and dermatitis of the hands and forearms are the early symptoms of poisoning which appear 7 to 14 days after exposure. Later jaundice and aplastic anaemia may develop. Control of the dust at the point of generation and dissemination by local and general exhaust ventilation and dilution with uncontaminated air by the plenum system of general ventilation together with good housekeeping reduce the danger of TNT poisoning. Workers should be subjected to a rigid pre-placement medical examination. Habitual alcoholics, mouth breathers and particularly persons showing any indication of anaemia, and those with liver, kidney, and chronic respiratory and skin diseases should be eliminated. Subsequent to employment they should be examined at monthly intervals with special attention paid to the blood

picture. If anaemia develops, repeated blood transfusion might be needed in addition to a high protein diet and anti-anaemia therapy (7,8,23).

**Tetryl**

It is a light yellow crystalline powder used as an important propellant in conventional military missiles. It causes dermatitis, beginning on the face. There may be blisters on the skin, and eyes may become oedematous. Hands or the parts of the body coming in contact are discoloured yellow. As a rule there are no constitutional disturbances. Exhaust ventilation, protective clothing, barrier ointments and personal cleanliness reduce the incidence. Sodium sulphate incorporated in soap quickly removes the stain caused by tetryl (7,8,23).

**Nitroglycerine**

Nitroglycerine is prepared by adding glycerine to a mixture of nitric and sulphuric acids. It is principally used for making dynamite. It is absorbed mainly by inhalation and to a lesser degree through the skin. It is a strong vasodilator. The symptoms of poisoning are flushing of the face, throbbing in the head, intense headache, palpitation, and nausea, vomiting and fainting. All operations where nitroglycerine is washed and neutralised should be enclosed as completely as possible and exhaust ventilation should be provided. Since it is also absorbed through the skin, it is essential that special attention is paid to housekeeping (cleanliness of workshops) and personal hygiene, which should include changing of working clothes daily, washing of hands and wearing of protective clothing as, described above.

**Trichloroethylene (Trilene)**

It is a colourless liquid with chloroform like odour. It is largely used in the metal industry as a degreaser. When the exposure is sudden,the worker may die and the post-mortem examination may reveal oedema of the lungs and petechial haemorrhages. Fatty degeneration of the liver, kidneys and heart is present if death is delayed. Repeated exposure affects the central nervous system leading to paralysis of the hypoglossal nerve, sensory fibres of the fifth nerve, second cranial nerve and polyneuritis in the limbs. Mild poisoning may cause various grades of unconsciousness as occurred in the past in laundry workers. Trichloroethylene should be used only in closed systems or in rooms with a downward exhaust ventilation system. Workmen with dry and fissured skin should not be permitted to handle the chemical. Inhalation of a mixture of 95 per cent carbon dioxide is of great value in the treatment of poisoning. Artificial respiration may be necessary (7, 8, 22, 23, 27).

**Carbon-Monoxide**

It is a colourless and odourless gas formed from the incomplete combustion of materials containing carbon. It is encountered in various industries such as foundries, gasworks, coke-ovens, blast furnaces and in automobile garages. It is a chemical asphyxiant. It forms a relatively stable compound, carboxyhaemoglobin when it combines with haemoglobin, as its affinity for the haemoglobin is about 300 times that of oxygen (7,8).

(a) Symptoms

Acute poisoning causes a sudden onset of unconsciousness, rapidly developing cyanosis and death. Initial symptoms of subacute carbon monoxide poisoning, which are more likely to be encountered in industry than the acute poisoning are shortness of breath, palpitation on exertion accompanied by slight headaches which tends to increase in severity. With the increased concentration of this gas in the blood, judgement becomes fogged and the affected individual may not realise his own danger. If the exposure continues mental aberration is followed by unconsciousness resulting in death from respiratory failure. Chronic poisoning shows all these symptoms coming on gradually and then continuing for longer periods.

(b) Prevention

Minimising its leakage by ensuring efficient ventilation, and finally by observing the rules of personal protection can prevent carbon monoxide poisoning. No person should be allowed to work single handed in a place where there is a danger of production of this deadly gas. No workman should enter or approach a place until the gas has been flushed out by fresh air and a suitable breathing apparatus is used. Safety posters in common languages should be displayed at strategic points explaining the deadly nature of symptoms of poisoning and means of rescue and first aid. Workmen should be given practice drill in rescue operations, artificial respiration and resuscitation. A cylinder containing a mixture of 95 per cent oxygen and 5 per cent carbon dioxide with a close fitting mask, should be available at all times for immediate use.

(c) Treatment

The victim should be removed immediately into fresh air and should not be made to walk even if he is conscious. The oxygen and carbon dioxide mixture should be administered or oxygen should be administered under positive pressure if available. If the breathing has stopped or is shallow, artificial respiration must be started and continued until normal breathing returns. If the heart has stopped beating, cardiac massage and stimulants should be given. Absolute rest in bed and warmth are essential. A close vigil should be maintained because of the tendency to relapse. Artificial respiration, administration of oxygen-CO2 mixture and cardiac massage should not be stopped until it is quite certain that heartbeat cannot be revived.

**Hydrogen Cyanide**

It is a colourless gas, with a penetrating bitter almond odour. Sodium and potassium cyanide baths used in the heat treatment of steel and iron are potential health hazards (7,8).

(a) Symptoms

Hydrogen cyanide like carbon monoxide is a chemical asphyxiant and prevents the tissue from using the oxygen carried in the blood. When inhaled in high concentration it

causes sudden collapse and almost immediate death. In lower concentration symptoms are delayed; the patient complains of headache, dizziness, vomiting, general weakness; slow and irregular respiration and pulse is almost imperceptible. There is a smell of bitter almonds in the breath, and if inhalation continues for some time coma supervenes, followed by death from respiratory failure.

(b) Prevention

Efficient plenum and exhaust ventilation, respiratory devices, protective hoods and respirators ensure safety.

(c) Treatment

Immediate first aid measure comprises of removing the patient to fresh air, keeping the patient warm and at rest and removing contaminated clothing. Contaminated skin is washed well with water. Treatment consists of inhalation of amyl nitrite for 15-20 secs every 2-3 mins along with Oxygen inhalation and artificial respiration. If patient is comatose or becomes drowsy then Dicobalt edetate (300 mg in 20 ml glucose sol) should be given by slow IV injection over 3-4 mins. If there is no return to consciousness then give Sodium thiosulphate (12.5 gm in 25 ml of 50% sol) IV over 5-6 mins. If the symptoms reappear or persist, half the dose of the antidotes should be repeated one hour later. If cyanide has been swallowed, gastric lavage is essential.

### Nitrous Fumes

The chief constituents of nitrous fumes are nitrous oxide, nitric acid, and two forms of nitrogen dioxide, $NO_2$, $N_2O_4$; the last two lend a brown colour to the fumes. Nitrous fumes are present in industries where sulphuric and nitric acids are manufactured, and in the manufacture of explosives. The fumes are also a hazard in certain operations e.g. welding, metal cleaning and electroplating. Toxicologically nitrogen dioxide $NO_2$ is the most important of the oxides of nitrogen (7,8).

(a) Symptoms

The principal symptoms of nitrogen dioxide poisoning are vertigo, headache, tightness in the chest, nausea and cough. In high concentration it may produce bronchitis, pulmonary oedema and death. It is one of the most insidious hazards in industry. When a workman happens to inhale some fumes, for a time he is little inconvenienced. He goes home and has his meal, still suffering from no ill effects. During the night, pulmonary oedema develops and he may be dead by next morning or noon.

(b) Prevention

The fumes should be controlled at the point of origin by efficient general ventilation and by local exhaust ventilation. Isolation of the offending operation is helpful where the process does not yield readily to the above measures of control. Respiratory protective devices such as chemical filter respirators are justified as a last resort when all other measures of control have proved ineffective. These masks need periodical examination and proper maintenance. The education of the worker in the use of the respirator is of utmost importance.

### Alkalies

The alkalies used in industry are chiefly ammonia, potassium and sodium hydrates. The industrial hazard from ammonia is invariably due to the accidental escape of the liquid or gas. It is very irritating to the upper respiratory passages and may give rise to pulmonary oedema. Burns may follow the splashing of ammonia and other alkalies, especially in the eyes. Prevention is achieved by taking precautions to obviate the escape of ammonia and the use of goggles or eye shields. If splashing occurs, frequent irrigation of eyes by a 4 per cent solution of ammonium chloride should be ensured to reduce the fixed alkalies. Penicillin drops or ointment should follow irrigation.

### Acids

The common acids used in industry are sulphuric, nitric and hydrochloric acids. When splashed into the eyes they cause severe burns of the cornea and conjunctiva. Prevention of splashing by protective devices, training of workers in work methods and personal protection are important precautions. Tubs full of water, 'plunge baths' should be kept in the sections which involve the risk of chemical burns so that the affected individual can immediately plunge into it for washing the chemical without vigorous rubbing. In cold weather, the bath water should be kept at 38°C (about the body temperature) during working hours. A number of undines containing 3 per cent boric acid solution should be placed in strategic places and workmen should be taught how to irrigate the eyes immediately. Splashing clean water into the eyes is also helpful. Arrangements should be made for the mechanical transport of carboys containing acids covered with baskets and handled as little as possible.

## Physical Hazards

Physical hazards arise from poor-working conditions such as: -

(a) Extremes of temperature especially in hot working environments may lead to causation of heat effects, which have been discussed in another chapter.

(b) High humidity contributing to thermal discomfort.

(c) High or low barometric pressure.

(d) Radiant energy producing harmful effects (see next chapter).

(e) Noise and vibrations.

(f) Poor ventilation and lighting.

(g) Overcrowding of men, machine and equipment, which are important agents for causing accidents.

(h) Improper seating arrangements producing postural defects in the workers.

(j) Lifting heavy loads or incorrect technique of carrying loads.

(k) Industrial accidents arise from various causes. They are tabulated in Table -2

The effects of each of these hazards can either be eliminated or reduced by a careful study of working

conditions and planned action. A close collaboration of the factory engineer and supervisory staff is essential to guard against such health hazards.

### Welding Hazards

Welding is employed to join metal parts while the edges are in a molten state. There are mainly two methods of welding, oxyacetylene welding and electric welding. Excessive exposure will produce ultraviolet conjunctivitis, 'Arc-Eye' or 'Welder's Eye' which causes swelling of the eyelids, photophobia, a feeling of 'sand in the eyes' and conjunctival injection. Infrared radiation can also cause 'heat cataract'. The unprotected skin around the neck and face may receive burns from the ore or from the molten metal. Carbon monoxide, nitrous and metal fumes are produced which can be prevented from toxic effects by use of respirator. Screening by coloured glass in the form of very dark goggles, hand shields, or shields fixed on the working benches or helmets prevent exposure of the eyes to injuries. Good work method training is essential.

## Health Hazard in Foundry work

Founding consists of pouring molten metal into a mould which is made to the outside shape of a pattern of the article required and contains, in some case a core which will determine the dimensions of any internal cavity.

The basic principles of foundry work have hardly changed over the years though a lot of modernization has come, making plants more mechanized and automatic.

Molten metal is introduced into the mould. After cooling occurs, the mould is subjected to a 'shakeout' procedure which releases the casting and removes the core. The casting is then cleaned and any extraneous metal is removed from it. The basic process is as follows:

(a) Moulding and pattern making:

Hardwoods, metals or resins are used by pattern makers in this forming process. The moulding mix usually contains silica, sand, coal dust, and organic binders such as dextrine and carbon oil. The casting of non- ferrous metals often utilises graphite or metal dies in the moulding operation.

(b) Coremaking:

The processing of traditional cores involves oven curing that produces a choking odour. Several new binding systems contain various synthetic resins such as phenol formaldehyde and various amines. The curing of these resins is achieved by chemical reaction or heating. Gases may be used as catalysts for reactions. The mixing of sodium silicate with sand, and the passing of carbon dioxide through the mixed core, is also utilised. Silica gel and sodium carbonate are formed through this process which forms a rigid core.

(c) Melting and pouring:

Electrically powered induction furnaces are used to process higher grades of cast iron and steel. Large amounts of carbon monoxide are generated during cupola operations. Roasting ovens are used, in addition to furnaces, for refining copper and zinc. The molten metal is poured from the furnace by tilting or tapping the furnace, and the metal is then passed to the moulds.

(d) Shakeout (knockout):

The removal of the cooled casting from the mould is termed 'shakeout'. The moulding sand is dry and friable at this stage, and particles of metal, sand and core material can become airborne during this process. If coal dust is incorporated into a sand mould, carbon monoxide will be generated during cooling and shakeout.

(e) Dressing and cleaning:

In this process, the castings are mechanically tumbled with metallic abrasives in an enclosed drum. Abrasive blasting techniques are still utilised. A variety of non-metallic (corn husks, pecan shells, etc) and metallic (steel grit or shot) abrasives are used. A great deal of dust is generated by this blasting. Pneumatic grinding and chipping tools may be used for cleaning castings. Hydraulic blasting or vibration processes may be employed to remove cores from the castings.

### Health Hazards

The various processes outlined in the preceding section give rise to heat, molten metal splashes, dusts, noise, gases and vapours in the foundry environment. If these hazards are not controlled or contained, serious health effects in exposed workers can result. Foundry work also involves various manual operations which carry a risk of physical injury. The hazards are:

(a) Silicosis

**Silica dust presents a prominent hazard of silicosis.** This dust is generated during mixing, moulding, shakeout and dressing operations, and during sand conditioning for re-use. The dust arises from quartz in the sand, and the concentration of free silica in the air varies with the handling process, the efficiency of dust control, the chemical composition of the sand and the physical state of the sand, that is, whether the sand is screened or unscreened, wet or dry. Used sand is either dumped or re-milled, with water and binder added before it is re-used. The amount of respirable dust is increased by such re-use. Sand is dry at the mixing or 'mulling' stage prior to mould making, and at the shakeout stage; this dry sand is potentially more hazardous than wet sand. Screened sand does not produce as much silica dust as unscreened sand, and pure quartz sand is more hazardous than olivine sand. Abrasive blasting processes may involve the use of sand containing high concentrations of free silica.

(b) Irritation, allergy, asthma, metal fume fever, malignancy:

In addition to dusts, the air in foundries may contain the potential irritants like formaldehyde, various amines and phenol. These contaminants are generated primarily by the coremaking and moulding processes, and may irritate the eyes and the respiratory tract. Some hardwoods used in pattern making can release products which may cause asthma in exposed workers. Vapours from various resins can initiate severe allergic reactions. Carbon monoxide gas is produced in substantial amounts by a variety of furnaces. Exposure to concentrations of 500 to 1000 ppm for approximately 30 minutes may precipitate headache, accelerated breathing, nausea, dizziness and mental

confusion. Thus a possible secondary effect of exposure is an increased risk of accident and injury to the worker. Various metal fumes may be generated during founding processes, especially during melting and pouring operations. Lead, magnesium, zinc, copper, aluminium, cadmium, antimony, tin and beryllium fumes are commonly present in non-ferrous foundries. Iron oxide is the major fume generated in iron and steel operations. 'Metal fume fever' may result from exposure to these contaminants. This is an acute illness of short duration which commences some hours after inhalation of the metallic fumes. The initial symptoms are flu- like: nausea, headache, dry throat and coughing, and muscular pains. Chills and sweating may occur later. Recovery is usual within 24 hours after removal from exposure. The lead hazard in furnace cleaning, dross disposal and the fettling of lead alloys deserves particular attention. Besides dusts & fumes in foundries are known to have carcinogenic properties.

(c) Occupational dermatitis:

Formaldehyde, isocyanates, various resin products associated with pattern making and coremaking processes can irritate the skin and may precipitate allergic skin reactions.

(d) Noise induced hearing loss and related effects:

Some fettling workers have been shown to be exposed to levels of noise over 100 dB; shakeout and knockout processes are typically associated with readings of 90 - 110 dB. Mechanical sand mixing processes and forced draught furnaces may produce noise levels of 90 - 100 dB. Extraction fans, diecasting machines, core-making and shell-making equipment may also be sources of excessive noise.

(e) Vibration:

Pneumatic grinding and chipping tools used in dressing the cooled castings may cause vibration induced health effects in operators. Hazardous vibration equipment may also be utilized in shakeout and core removal operations.

(f) Heat and heat stress:

Radiant heat is the major contributor to the heat load imposed on the worker by the environment. Convective heat transfer adds to this radiant heat. Protective clothing is worn for protection against the heat radiating from the heat sources and against contact with molten metal. Such clothing greatly restricts the potential for body heat loss via evaporation. The effects of heat range from decreased concentration to painful cramps, fainting, heat exhaustion and heatstroke. Heat stress can also aggravate the effects of exposure to other agents such as noise and carbon monoxide.

(g) Accidents:

Serious burns may result from splashes of molten metal in the melting and pouring areas of foundries. Frequent, unprotected viewing of white-hot metals in furnaces and pouring areas may cause eye cataracts. Eye injuries from molten metal or fragments of metal may occur in pouring and dressing areas. During continuous casting processes, non-ferrous molten metals, such as copper and aluminium, may explode violently if they contact water. Injuries related to the manual handling of materials, and injuries due to falls, may occur. Grinding wheels used for dressing small articles may result in hand injuries.

**Preventive Measures**

Monitoring & Evaluation of exposure

Monitoring of the work environment, Personal monitoring, Biological monitoring should be undertaken. In some cases, biological monitoring may be required to supplement static or personal monitoring. When developing a monitoring program in foundries, due consideration should be given to the hazards in the foundry. In the control of health hazards due to a specific contaminant, where it has been demonstrated that the exposure of the employee to the contaminant is approaching the relevant exposure standard, or where biological monitoring indicates that an unacceptable exposure is occurring, immediate action must be taken to reduce the health hazard and intensive monitoring should continue. Worker exposure to dusts, gases and vapours should be kept as low as workable. Exposures should be well below the exposure standards recommended in the Factories Act 1948.

Engineering control measures:

(a) Elimination/substitution and process modification viz quartz sand can be substituted by olivine sand in 'sand blasting' as it is less hazardous. Silica-based polishing pastes should not be used in metal cleaning operations

(b) Engineering controls like local exhaust ventilation should be provided at the mixing or mulling stage as the sand is dry. It is a means of controlling carbon monoxide emissions at their source. Total enclosure of abrasive and cleaning operations should be provided. Potentially irritant vapours or fumes generated in coremaking or moulding processes should be collected by exhaust ventilation at the point of emission.

(c) The reduction of noise at the source or in the transmission path should be achieved wherever workable

Preventing physical injuries:

(a) Mechanically propelled vehicles or machinery should be inspected regularly.

(b) Contact between molten metal and water must be avoided. All ladles and other equipment used for handling metal should be completely dry before contacting molten metal.

(c) Good housekeeping practices are to be followed.

(d) Floors around furnaces should be of slip-resistant, non-combustible material, kept free of obstructions and cleaned regularly.

(e) Persons should be prohibited from entering furnace areas when the temperature exceeds 50°C.

(f) Foundries should be equipped with safety blankets, automatic emergency showers or hoses to

extinguish burning clothing.

(g) Self-contained breathing apparatus must be used in emergencies when high carbon monoxide concentrations are suspected.

Minimising the risk of heat illness:

People who have any history of heat intolerance or a circulatory disorder, anyone recovering from a fever, and any dehydrated worker must be regarded as being in a high-risk category for heat illness. Unacclimatised persons must be given time to acclimatise to work in the heat. Planned job rotation can assist in reducing exposure to heat. Cool water should always be available in close proximity to hot working areas and encouragement given for the use of these facilities. The exposure of workers to radiant heat can be reduced by the strategic positioning of shields between workstations and heat sources. Clothing should be carefully selected so that a balance between protection and facilitation of heat loss through evaporation is achieved.

Personal protective equipment:

Personal protective equipment such as goggles, padded gloves, ear muffs must be used by the workers. If the mechanical ventilation in the foundry is not adequate in removing the dust at all points of contamination, the wearing of personal respiratory protective equipment, such as a face mask/respirator, is a complementary preventive measure together with local exhaust ventilation. If operators are required to work inside the enclosure, a continuous- flow, air- line respirator must be worn.

Education and training:

All employees working with foundry hazards must be informed of the hazards and the precautions necessary to prevent damage to their health. Employees exposed to contamination hazards should be educated in the need for, and proper use of, facilities, clothing and equipment and thereby maintain a high standard of personal cleanliness.

Health assessment:

Preplacement examination and periodic medical examination of all workers should be done annually for early identification of health effects and for documentation for compensation claims. (28)

## Noise

It has already been realised that noise is a great hazard to human health. The whole world is getting increasingly conscious of noise pollution. Excessive and unwanted noise is always disliked by people and more so, it adversely affects the safety & working efficiency of workers in industries. Noise is a discordant sound resulting from non-periodic vibrations of air.

### Sources

The common sources of noise are military operations, aviation, submarines, automobiles and factories like boiler factories, steel mills, textile plants, can factories, ship yards, aeroplane factories and various other workshops. Domestic exposure occurs due to TV, radio, record players, tape recorders, VCR,VCD and so on.

### Effects

The loudness of sound depends on intensity and frequency. Human ear perceives, sounds of 20 to 20000 cycles per second (Hz). Sensitivity of ear changes at different frequencies. Most sensitive frequencies are from 500 to 5000 Hz. Prolonged exposure to sound levels of 90 decibels (dBs) and above cause permanent deafness. Very high intensity sounds (160 dBs and above) may produce damage in a single exposure. Noise can produce auditory effects and non-auditory effects (16, 29).

(a) Auditory Effects

**(i) Masking Effects**

Excessive noise leads to masking effect, which makes it impossible to hear normal speech.

**(ii) Acute Severe Exposure**

Sound above 160 dBs may rupture the tympanic membrane and may cause bleeding through ear. This leads to temporary deafness, which recovers after the healing occurs. This deafness is in all frequencies and is present only in the affected ear.

**(iii)Auditory Fatigue**

Sound level exposures above 90 dBs and 4000 Hz over prolonged period led to an auditory fatigue which is associated with whistling and ringing in ears.

**(iv) Occupational Deafness**

This is the most serious effect of noise and can be temporary or permanent.

- Temporary Deafness(Temporary Threshold shift)

This occurs due to an exposure of noise at 4000 6000 Hz in initial period and it may recover if the worker is withdrawn from exposure for sufficient length of time.

- Permanent Deafness (Permanent Threshold shift)

This occurs due to prolonged exposure to sound levels of 90 dBs and above. The victim is usually unaware of the damage initially. The extent of damage depends on intensity, frequency, and duration of exposure and individual susceptibility to noise levels. Audiogram shows hearing loss at frequencies above 2000 Hz but there is a typical dip (c5 dip) at 4000 Hz. Hearing loss is gradual and progressive. Worker is unaware of his deafness until it is severe. First symptom is inability to converse in which many people take part followed by tinnitus, buzzing and ringing & whistling sounds in ears. This is bilateral, periodic and transitory. Vertigo and ear pain is rare. There is repetition of sounds heard at work place during night when away from work (acoustic after-images). Audiogram shows bilateral hearing loss with typical c 5 dip (30 32).

(b) Non-auditory Effects

Excessive noise reduces general efficiency and increases fatigue. Sudden noise increases BP and intracranial pressure. It leads to giddiness, nausea, insomnia, tachycardia and tachypnoea. Irritation, annoyance and neurosis may ensue (33, 34).

### Prevention

(a) Control at Source
   (i) Monitor sound levels in work environments for frequencies and intensities and take action to reduce sound levels.
   (ii) Segregation of noisy machines.
   (iii) Apply sound mufflers to machines.
   (iv) Enclose noisy processes.
   (v) Change their designs suitably.

(b) Control of Transmission
   (i) Improve architectural designs of noisy buildings.
   (ii) Sound proofing of walls, ceiling and floors.

(c) Protection of Workers
   (i) Use of ear defenders e.g. ear plugs and ear muffs
   (ii) Rapid turn over of workers.
   (iii) Preplacement and periodic medical examination.
   (iv) Health education of the management, staff and workers.
   (v) Legal protection of workers against noise induced deafness (35, 36).

## Occupational Cancer

It has the following sequences: -

(a) Exposure to carcinogenic agent or factor;
(b) Long latent period during which continuous or interrupted application of the carcinogenic agent continues;
(c) Manifestation of precancerous conditions;
(d) Appearance of a state of malignancy;
(e) Appearance of invasive and metastatic carcinoma.

### Carcinogenic Agents

These include many chemical groups, various physical factors and diverse groups of viruses. Each of these groups manifests particular features and basic characteristics. Many of these agents occur together in combinations and present the problem of assessing the relative value of each component. At present the following groups are mentioned: -

(a) Carcinogens acting by surface contact on the skin such as coal tar derivatives;
(b) Carcinogens acting via the respiratory tract such as the industrial fumes,asbestos.
(c) Carcinogens entering the body the mouth and acting on the gastrointestinal tract such as food additives, contaminants, pesticides etc.
(d) Carcinogens entering the body by various routes and acting systemically on the liver, haemopoietic and lymphatic systems, bladder etc. like aniline dyes, benzene, naphtha etc.
(e) Carcinogens causing tumor developments by hormonal imbalance either by assimilation of hormones or toxic agents which disturb the hormonal balance in the body.
(f) Various forms of radiation causing skin tumours,

Table 6 : Prevention Of Occupational Cancer

| Technical | | Personal | Medical | Legal |
|---|---|---|---|---|
| Engineering | Process control | Personal protective equipment | Preplacement Medical Examination | Notification |
| Building | Substitution | Barrier creams | Periodic examination | Cancer registry |
| General ventilation | Isolation of harmful process | Bathing & washing | Mass screening of vulnerable group | Acts and Rules |
| Local exhaust system | Maintenance of plant equipment | Limitation of exposure | Analysis of medical records | Forbidding use of harmful chemicals |
| Plant equipment design | Dust control | Personal health habits | Knowledge of plant processes & materials | Periodic checks by factory inspectors |
| Mechanization | Environmental | Avoidance of repeated trauma & tar burns | Health education | Licencing Certifying surgeons |
| Monitoring physical and chemical waste disposal | Good house keeping | Protection against ionizing radiations | Early diagnosis and treatment | Compensation |
| | | | Special cancer clinics | |

bone sarcoma, lung cancer, leukaemia etc.

(g) Viruses capable of inducing tumours;

(h) Carcinogens acting on connective tissues e.g. Plastics;

(j) Mixed

**Sites**

The most common sites of the body affected are skin, lungs, bladder and blood forming organs. The characteristics of occupational cancer are: -

(a) Appear after prolonged exposure;

(b) Period between exposure and affection may be 10 to 20 years;

(c) May develop even after cessation of exposure;

(d) Average age incidence is earlier than other cancers.

(e) Localisation of the tumours is remarkably constant in any one occupation.

**Prevention**

This involves the elimination or substitution of any carcinogenic factor including promulgation of legislation, protection of those exposed to risk by suitable engineering measures and education and training.

Owing to the complexities of industrial carcinogenesis, however, there are difficulties in the application of all these methods. It is unusual to accept evidence of carcinogenicity in animals alone as justifying legislative action, which requires a long connected evidence of carcinogenicity in man. When there is epidemiological evidence that an industrial substance is carcinogenic, combined with experimental proof of its carcinogenicity in animals, the manufacturers should be advised of its hazards and forced to stop its manufacture, eliminate or substitute the process or material with a safe one or institute measures necessary to prevent contact of the worker. The manufacture of b-napthylamine a proven bladder carcinogen was stopped in many countries through voluntary action by the dye manufacturers. Where a risk of such substances has been proved beyond doubt, the law places a basis of claiming compensation of the hands of the worker and gives a warning to the employer, and finally prohibits the use of such material, process, or manufacture of the product. The industrial materials, proved to be highly carcinogenic both in animal experimentation and epidemiological studies in man, include b-naphthylamine benzidine, 3-3-dichlorobenzidine, 4- aminobiphenyl (xenylamine), polycyclic hydrocarbons, dimethylnitrosamine, nitrosomethy-lurethane, b-propiolactone, diazomethane, trinitrotoluene, beryllium salts, oxides, mineral oil, pitch, tar, 3:4 benzpyrene, radioactive substances, nickel, arsenic and asbestos.

Besides elimination, substitution and engineering devices of safety, the principles which protect workers exposed to risk from industrial carcinogens are the segregation of processes, mechanical handling, enclosure of processes, exhaust removal, chemical monitoring, dust control, use of protective clothing, provision of washing facilities, medical surveillance and education of the worker. Workers require a clear exposition of the risks to which they are exposed and of the reasons why protective measures and codes of hygiene are so important, of how these measures are to be carried out, combined with a warning of the possible consequences if they do not adhere to; and with advice to report any health abnormality, however trivial, to the factory doctor. The various preventive measures have been shown schematically in table 6 (37-42).

## Protection of the Worker

The worker is the most important component of the industrial set up. It is imperative that the worker remains in an optimal state of physical, mental and social health. To achieve this, it is of prime importance to fit the worker's skill to the job and the job to his skill. Therefore, from the medical point of view, a judicious preplacement medical examination should be carried out taking into consideration the hazards which the factory life will impose on the individual. It should, however, be realised that every factory job does not require the highest physical standard of health. Even a disabled person could be accepted in certain jobs where the partial disability of the individual will not in any way interfere with the efficient performance of his duties in that particular job. In other words, a disabled person should be viewed not as to how much he cannot do, but how much he really and safely can do. In addition to assessing his disability his residual ability should also be assessed. For instance, a few totally blind ex-soldiers have been employed in an optical factory and it has been found that their output has been more than that of normal men. They work through the sense of touch which evidently they have developed in themselves to an extraordinary degree of proficiency and also perhaps the blindness in their case has actually helped greater concentration on work by excluding visual distraction. Having ensured basic fitness it would be important to watch, through periodic medical examinations, the progress of the worker under the impact of his occupational environment. After selection and placement it is the duty of the management to provide adequate safeguards to protect him from accidents, toxic and other occupational hazards, not only to fulfil the employer's obligations under the Factory Act, but also ensure maximum individual and collective protection. It is then necessary to train him in work-methods and self-protection against all possible occupational hazards. If in spite of all these precautions the person does become a victim, the management should offer the remedial measures, social security, alternative placement and rehabilitation.

**Occupational Psychology**

Occupational psychology enables the study of psychological fitness for employment and investigation into the causes of a psychological breakdown due to stress and strain in certain occupations. This includes the investigations into aptitude for different kinds of work and into the causes of industrial fatigue. This wider aspect

Table 7 : Personal Protective Equipments

| S.No | Hazards | Part of body protected | PPE Recommended | I.S.No |
|---|---|---|---|---|
| 1. | Chemicals | Chest/Abdomen | Apron Rubber Acid & Alkali Proof 30" wide x 40 long | IS-4501-1981 |
| 2. | Chemicals | Full body | Acid Protective suit with Coat, Pant, Hood, PVC welded | - |
| 3. | Falling objects | Head | PVC Helmet | IS-2925 |
| 4. | Welding rays | Eyes | Goggles blue | IS-5983-1980 |
| 5. | Gas cutting/ Welding rays | Eyes | Goggles green | IS-5983-1980 |
| 6. | Chemicals | Eyes | Goggles cup type | IS 5983 1980 |
| 7. | Flying particles (Grinding) | Eyes | Goggles impact | IS 5983 1980 |
| 8. | Flying particles (Grinding) | Face/Eyes | Face shield plastic transparent with adjustor head band | IS-8521 Type-I of 1977 |
| 9. | Hot metal | Hand | Gloves Mitten Gunny | - |
| 10. | Handling of material having sharp edges | Hand | Canvas Gloves 12" long | IS-994 Type -XV |
| 11. | Handling of material having sharp edges | Hand | Cotton drill Gunny pattern (blue) gloves | IS-6994 Type-XV |
| 12. | Thin gauge strip inspection | Hand | Shingler coloured hosiery hand gloves | - |
| 13. | Handling hot components | Hand | Asbestos hand gloves 16" long with cotton lining | - |
| 14. | Welding | Hand | Leather Gauntlets for welders 16" long | IS-2573 Type-I |
| 15. | Handling | Hand | Rubber Gauntlets Acid & Alkali proof 16" x 18" long (without internal lining) | - |
| 16. | Working on Electrical lines | Hand | Rubber gloves for Electrical purpose working voltage 4000V | IS-4770 Type-IV |
| 17. | Dust | Respiratory | Permacal face mask "Swasthya" | - |
| 18. | Fumes/Mist | Respiratory | Chemical Cartridge respirators | IS-18522 |
| 19. | Noise | Ear | Foam Ear plugs | IS-9167-1979 |
| 20. | Noise | Ear | Rubber Ear plugs | -do- |
| 21. | Fall from height | - | Safety belt | IS-3521 Type-2 |
| 22. | Toxic gas | Respiratory | Canister gas mask | IS-8523-1977 |
| 23. | Chemical | Foot | Industrial vulcanised rubber knee high boots | BS-5145 of 1984 |
| 24. | Fall of heavy objects | | Foot | Leather safety |
| shoes for heavy metal Industry | | | IS-1989 of 1978 | |
| | | | | |

of industrial psychology includes vocational guidance, personal supervision, management and the quality and nature of human relationship in industry. There are many psychological factors involved in occupational morbidity, work may be dull, monotonous, repetitive or otherwise un- suited to persons of certain temperament or character.

## Personal protective equipment (PPE)

Personal protective equipment generally provided in factories for protection against various hazards is given in table 7. The provision of PPEs does not enable an individual to take liberties against the hazard, as it is not foolproof. Hence, emphasis should be directed at prevention of hazards by making the system foolproof. At the same time, individuals who have been provided PPEs should use the same although there may be some difficulty and discomfort initially. Gradually the wearer shall get accustomed to the same and discomfort will vanish.

### Clothing

They should fit well; there should be no loose flap or string, even shoelaces should be tied tight. Persons exposed to inflammable, explosive or toxic dusts should not wear clothing having pockets, cuffs and turn-ups that might collect such dusts. Loose, torn or ragged garments, neckties, mufflers or head dresses and key or watch chains should not be worn near moving parts of a machine. Shirts with short sleeves should be worn in preference to rolled up sleeves, and pockets, if any, should be few and as small as practicable in all clothing. When the operation involves a danger of explosion or fire, wearing of articles such as, collars, eye shades, cap visors and spectacle frames made of celluloid or other inflammable materials should be prohibited during working hours. Sharp or pointed objects and explosive substances or Inflammable liquids should not be carried in pockets. The material and shape of special protective overalls should vary with the substances involved e.g. liquid proof or gas proof against corrosive and irritant liquids / gases; asbestos suits complete with a helmet, gloves and boots against risks of excessive heat and fire; against radio-active substances washable material so designed as to cover other clothing at the neck and wrists. Washing of working clothing is necessary at least once a week as prevention against contamination of other clothing.

### Head Gear

Well fitting helmets made of aluminium; fibreglass or steel should be worn as a protection against falling or flying objects and blow on the head. For protection of hair from overhead moving belt, well fitting caps of washable and non-inflammable material should be used.

### Eye and Ear Protection

Workers with errors of refraction should have the error corrected. Glasses or transparent plastic materials for goggles and windows of protectors should be free from striae and air bubbles. All goggles intended for mechanical protection should be splinter proof. Goggles and shields for workers engaged in welding, furnace work or any other operation where their eyes are exposed to glare should have filter lenses or windows of standard absorption value against ultraviolet and heat rays. Non-flammable, transparent visors, free of scratches should be provided for protection against glare and sparks. Goggles, when not in use should be kept in special closed containers protecting them from mechanical damage and should be inspected at regular intervals once a month and all defective parts should be replaced immediately. Earmuffs and earplugs should be used for protection against noise. These reduce the sound level exposure by about 20 dB each.

### Hand and Arm Protection

Gloves for workers handling sharp edged or abrasive objects should be made of tough material and where necessary provided with special reinforcements of leather pieces or even a metal piece over the palm. Gloves should also be made of steel mesh for use in cutting process. Gloves and sleeves for workers handling hot metals could be made of asbestos or other heat-resisting material. Gloves with sleeves made of rubber capable of withstanding voltage of 10000 or more should be used for electrical workers. Gauntlets made of natural synthetic rubber or pliable plastic material should be used when handling corrosive liquids. Close fitting gloves should be used for avoiding exposure to toxic fumes and infectious agents.

### Barrier Cream

It prevents penetration of irritant substance into the skin. Ideally a barrier cream should be non-irritating, non-sensitising, insoluble in substance against which being used, easily removable and cosmetically agreeable.

### Foot and Leg Protection

Leggings for workers handling molten metals should be made of asbestos or other suitable heat resisting material, extending to the knee. At the lower end they should also cover eyelets of footwear. Metal toe guards or safety boots or shoes should be worn in operations where heavy objects are handled. Footwear for workers handling corrosive liquids should be of rubber, specially treated leather, wood or other suitable corrosion resisting material. Footwear for electrical workers should have non-conductive soles.

### Respirators

The cardinal principles governing the choice of a respirator are the process and conditions that create the exposure; the chemical, physical, toxic or other hazardous properties of the substance from which protection is required; the nature of the duties performed by the persons wearing the equipment and the encumbrance or restriction of movement in the working area; and the facilities for maintenance, upkeep and supervision of use. Finally, all respiratory protective equipment should be capable of fitting various types of facial contours without leaking. The following are a few types of respirators used in various industrial processes and environments. These should all be inspected and

Table - 8 : Aetiology of industrial accidents

| Host factors | Agent Factors | Environmental Factors | | |
|---|---|---|---|---|
| | | **Physical Environments** | **Social Environments** | **Lack of safety policy** |
| Age<br>Sex<br>Experience and education<br>Physical defects<br>Concomitant disease<br><br>**Psychological factors**<br>Personality Traits<br>Emotional Stability<br>Accident proneness<br>Industrial fatigue<br>Accidental falls<br>Wearing unsuitable shoes<br>Carrying improper loads<br>Faulty stepping<br>Habits<br>Carelessness<br>Negligence<br>Not using personal protective measures | **Improper planning and construction of factories**<br>Machines<br>Faulty design<br>Lack of guards and fencing<br>Lack of maintenance<br>Entanglement of loose Clothes and hair<br>Transmission of Machinery<br>Speed of work<br>Processes<br>Faulty planning<br>Boiler explosion<br>Dust explosion<br>Corrosive materials<br>Molten metal and Hot Liquids<br>Flying solid particles<br>Metal grinding<br>Stone dressing<br>Riveting<br>Chipping metal<br>Electricity<br>Gassing<br>Hand Tools, Hammer, Chisel, Cutting instruments<br>Falling objects in maintained Roofs<br>Transport, Trolleys, Cranes, Locomotives,<br>Poor human engineering (Ergonomics). | Bad House keeping<br>Overcrowding<br>Defective lighting<br>Temperature<br>Ventilation<br>Humidity<br>Radiations from surroundings<br>Atmospheric pressure<br>Noise<br>Vibrations<br>Ionizing Radiations<br>Slippery Floors<br>Uncovered drains | At work place<br>Domestic Relationship<br>between workers and management | |

tested at regular intervals by responsible trained persons.

(a) Mechanical Filter Respirator

A mechanical filter respirator can only filter the suspended atmospheric impurities. A wide variety of impressive patterns and designs are available. None afford protection against solvent vapours, injurious gases or in atmospheres deficient in oxygen, and are essentially dust and fume filters in an otherwise healthy atmosphere. The simplest example of such type of respirator is the common surgical gauze mask. By introducing a thin layer of wet cotton wool in between the layers of gauze, it may be worn as a protection against coarse particles, such as fibres or sawdust. Their efficiency against fine particulate, such as those of silica dust, will depend upon the quality of the filtering medium. In course of time, these, filters become clogged and there is increased resistance to breathing. The filters should then be washed or changed. Everybody should be supplied with a personal mask.

(b) Chemical Cartridge Respirators and Canister Mask

Chemical cartridge respirators and canister masks ensure the purification of air, which passes through the canisters containing specific neutralisers against specific toxic gases. The canisters have a particular coloured design painted on them indicating the specific toxic gases against which they afford protection; e.g. an orange coloured canister indicates that it is meant to be used against nitrous fumes. The user has to depend upon the oxygen content of the atmosphere, therefore, such respirators should not be worn in confined or poorly ventilated places or where the concentration of the offending gases is high. The canister should be changed after each use, and if not in use, at an interval not exceeding one year or such other period as specified by the manufacturer. These should be properly maintained and all defective parts replaced.

(c) Breathing apparatus (supplied-air-respirators or hose masks)

The term 'supplied-air-respirators' means a respirator equipped with a hose line, through which fresh air is supplied under positive pressure whereas through hose masks the wearer can inhale air at atmospheric pressure. The length of hose in the former should not exceed 45 metres and in the latter it should not be more than 75 m. For hose mask the inside diameter of the hose should not be less than 2.5 cm and the hose should be of a non-collapsible type. These are also used when the canister for cartridge respirator cannot be used due to high concentration of dangerous gases or fumes. The body harness should be comfortable and should allow free movement of the wearer and also all component parts should withstand a pull of at least 115 kg.

(d) An oxygen breathing apparatus

An oxygen breathing apparatus consists of a face piece with a corrugated tube connecting it to an oxygen tank or cylinder. This is used by workers engaged in fire fighting, rescue or repair work in atmospheres containing high concentrations of gases or which is deficient in oxygen or sufficient pure air supply.

(e) A self-generated oxygen mask

A self-generated oxygen mask is a new type of oxygen breathing apparatus fitted with a small canister containing a chemical. Moisture from the inhaled air starts a chemical reaction, which liberates oxygen.

## Industrial Accidents

The most important industrial hazard due to machinery is the accidental injury. Accidents in industrial environments are due to various causes. Bad house keeping, faulty and unguarded machinery, faulty work methods, carelessness, ignorance, physical and mental illness, accident-proneness, and slackness in the maintenance of machinery or in the formation of an accident prevention organisation, are the important factors. The components of machinery are the main causes of accidents. Though the loss of productive capacity due to accidental disabilities major and minor, and even deaths cannot be measured definitely, it is obviously of same magnitude, as judged by the man-days or working time lost. Practical preventive measures are therefore essential to safeguard the workers against accidents. The safety officer must investigate all accidents with a view to ascertaining the cause, adopt safety measures against recurrence and to train personnel in accident prevention. Most of the accidents are preventable by the close collaboration of the factory engineer, safety officer, welfare officer, chemist, industrial hygienist and the medical officer. The worker plays an important role in the prevention of accidents. Some particular industries, occupations and processes cause particular types of injuries on particular parts of the body. Therefore, he must be educated and trained in various processes and handling of different type of machines. Tables 9(A) & 9(B) shows the general causes and give a broad outline of preventive measures against them.

The first step in any accident prevention programme is elimination of various hazards whilst designing the process. If this is not possible, the next best step would be to control the physical, mechanical and chemical hazards in work environment by suitable engineering design. But when this also is not possible or is not able to give full protection to workers the third line of defence has to be resorted i.e., the personal protective equipments. These protective equipments cannot eliminate hazard or stop an accident taking place. These equipments merely set up a barrier against the hazards thereby preventing or minimising an injury.

In selection of these equipments, the following points are to be borne in mind: -

(a) Type of hazard to be faced.

(b) Selection of right type of personal protective equipment.

(c) Availability of correct equipment in good condition at the work spot.

(d) Training of workers to use the equipment.

(e) Convincing the workers that the equipment if used will protect them from hazard.

(f) Making it a habit with the worker to use the equipment.

(g) Degree of protection needed.

(h) Ease & comfort with which it can be used and freedom of movement with equipment which should not hamper performance of the worker.

(j) Maintenance of these equipment.

(k) Periodical check up

(l) Good earthing

### Safety Audit

(a) Objectives of Safety Audit: -

(i) Critically evaluate the safety programme.

(ii) Evaluate the systems to identify and control hazards.

(iii) Check that the above system meets the statutory standards and codes of practice.

(b) Benefits of Safety Audit System: -

(i) Strengthening of the Organisation safety standard and programme.

(ii) Improve the skill and performance of employee and managers.

(iii) Helps to create group and self awareness and provides motivation.

(iv) Identifies specific deficiencies in the safety programme.

(v) Provides timely information before any injury producing incident occurs.

(c) Corporate Safety Audit System

Safety audit shall be carried out at three levels in the Ordnance Factories.

(i) Level-I

Internal Audit Inspection by Safety Officers from within the factory once in every three months.

(ii) Level-II

Audit Inspection by a group comprising of 3 officers of the factories in the concerned group, once in a period of six months.

(iii) Level-III

Annual Audit Inspection by the Regional Controller of Safety/O.F. Board.

Table - 9 (A) : Prevention of Industrial Accidents

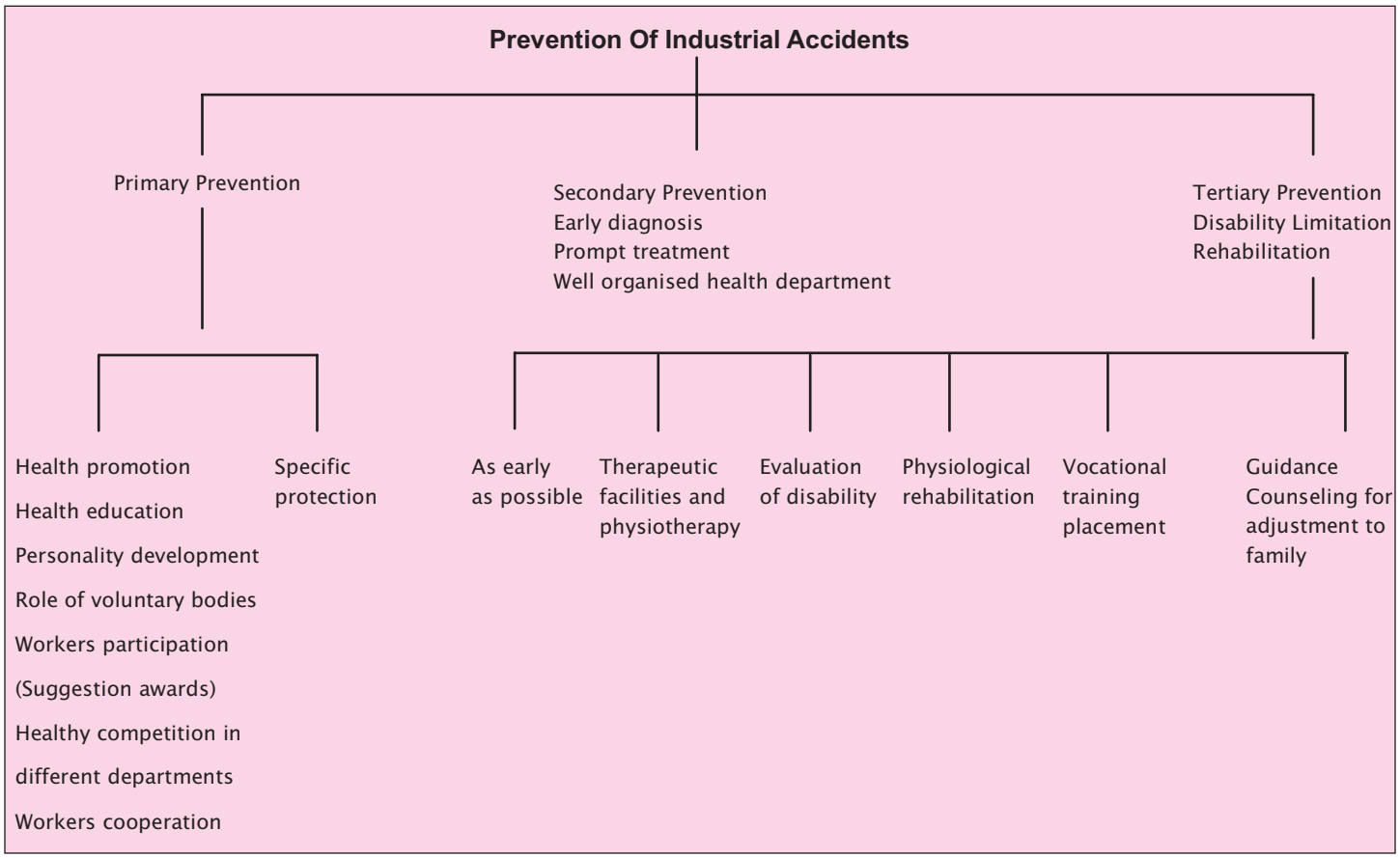
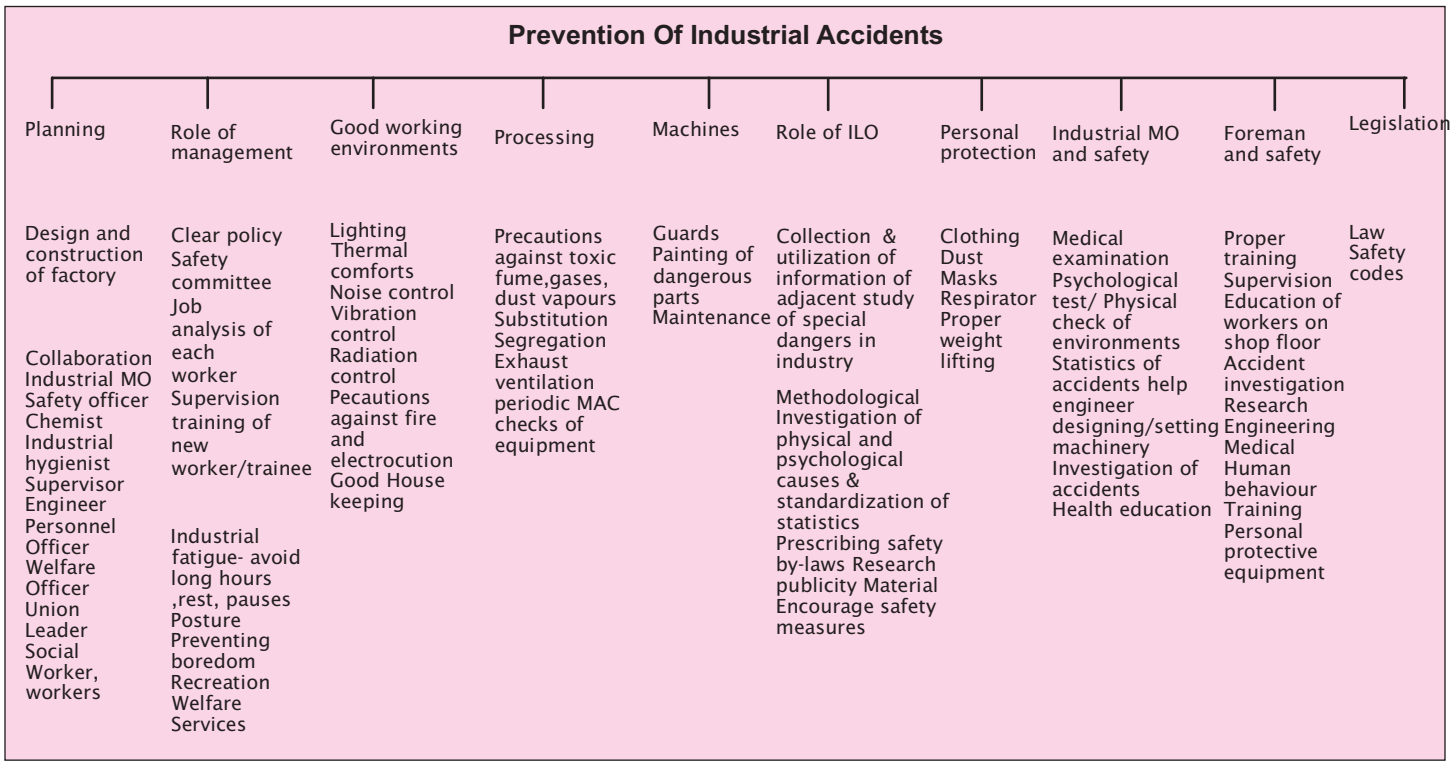



Table - 9 (B) : Prevention of Industrial Accidents



(d) Scope of Safety Audit: -

The Audit is necessarily very wide ranging in scope and covers all aspects of a company's operations. Some of the broad areas to be covered for Safety Audit are appended below: -

(i) Safety Policy - Involvement of Top Management, assignment of responsibility and accountability, workers participation through involvement.

(ii) Process Safety - Identification and control of hazards.

(iii) Fire Safety - Fire prevention and protection.

(iv) hazards and their control - Covering ventilation and exhaust system, work environment monitoring, personal protective equipment, emergency showers.

(v) Pollution control- Air, Water, Noise.

(vi) Review of Procedure - Operating, Maintenance, Start up & shut down, permits to workers etc.

(vii) Machine guarding.

(viii) Housekeeping.

(ix) Material Handling system.

(x) Safety.

(xi) Training of workers/Supervisory staff and Management personnel.

(xii) Accident reporting, investigation & Analysis.

(xiii) Emergency preparedness.

(xiv) Health, First Aid, Periodical Medical Examination.

### Accident Investigation

All accidents shall be investigated by the concerned Heads of Sections and an unambiguous report sent in Form No 14.Safety Section shall investigate selected accidents involving plants/ machineries/chemicals where accidents are due to unsafe conditions. In case of all serious accidents, a Board of Enquiry to investigate into the accident shall start investigation immediately on receipt of intimation by visiting the accident spot so that the evidence is not tampered. Photographs may be taken if necessary. The investigation should be towards fact finding and not fault finding. The concerned sections shall not disturb the site until it is cleared by the Board of Enquiry or Safety Officer.

### Accident Returns

The accident statistics indicating details of accidents, man-days lost, man-hours worked are compiled quarterly. A monthly report on the accidents taking place during the preceding month is also compiled.

### Accident Analysis

The accidents taking place in the factory shall be analysed by Safety Section, Department-wise and as per IS-3786-1983 as follows :-

(a) Unsafe mechanical or physical condition.

(b) Unsafe act

(c) Type of Accident.

(d) Agency of Injury.

(e) Nature of Injury.

(f) Location of Injury.

## Medical Examinations

### Preplacement Medical Examination

(a) All workers should undergo a medical examination before entering industrial employment for the first time (engagement or preplacement examination) or within I5 days of employment.

(b) Those under 14 years of age should not be employed except in technical schools, special training shops or apprenticeship courses.

(c) Section 34 of Factories Act states that: No woman or young person unaided by another person, lift, carry or move by hand or on the head, any material, article, tool or appliance exceeding the following limits :

Adult female -29. 5 kg.

Adolescent male -29. 5 kg.

Adolescent female -20 kg.

Male child -16 kg.

Female child -13. 5 kg.

(d) Medical services should collaborate closely with the technical services of industrial establishments to ensure as perfect a selection of workers as possible from the standpoint of physical, physiological and psychological suitability and also from that of the worker's skill.

(e) The pre-placement medical examination should consist of a general clinical examination and special investigation, where indicated. Diagnosis made on these medical examinations should be strictly confidential. Persons suffering from unsafe traits, such as, 'accident-proneness' should not be employed.

(f) Proper job analysis should be done for all the jobs and each person should be placed in such a way that he fits in the job and the job fits him.

### Periodical Medical Examination

(a) Periodical medical examination should be carried out at regular intervals (monthly, quarterly, yearly) depending upon the hazard to which a worker is exposed.

(b) In addition medical examination of workers should be carried out on their returning from sick leave and those seeking change of employment.

(c) The clinical examination should be supplemented by special investigations where indicated.

(d) Date and results of such examination should be recorded in special registers maintained for this purpose.

**Medical Records**

Meticulous attention should be paid to the maintenance of all statistical records/documents. These should be carefully studied and analysed for correct evaluation. These records will help in planning, development and efficient operation of the occupational health service. Graphs should represent ratios per 1000 and not actual figures. The latter are fallacious and of no comparative

| | |
|---|---|
| Average days lost per worker | $\frac{\text{Total Number of days lost in a period}}{\text{Total Number of effective full time employees (EFT)}}$ |

value. Amongst other documents/ records, and 'Absentee register' is of special importance and gives an indication for taking appropriate measures for the improvement of industrial safety and hygiene in the factories.

**(a) Analysis of sickness or morbidity**

Total sickness absence expressed as the average number of days lost per worker employed during the period and is calculated as: -

NOTE : With a view to obtain more accuracy with regard to low figures of small factories, cases of 'sickness absence' may be divided into 'long term' and 'short term' absence (over or under 7 days respectively).

(b) Analysis of Accidents

The higher risk of accidents is greater in certain occupations than in others. In order to compare the frequency and the severity of accidents in a given period, the International Labour office has standardised the following ratios for each million man-hours worked: -

(i) Frequency rate : $\frac{E \times 1{,}000{,}000}{C}$

(ii) Severity rate : $\frac{F \times 1{,}000{,}000}{C}$

NOTE : E = Number of accidents causing loss of working time in the given period.

C = Total man-hours worked in the given period.

F = Total hours loss through accidents occurring in the given period.

## Air Pollution

In recent years, air pollution by smoke and noxious gases, dusts and fumes has become an important public health problem. Turbulence in the air usually ensures that the pollutants put into it are rapidly removed. This process, however, may not be adequate to deal with the exorbitant amount of pollutants. Moreover, due to temperature inversion in still weather, cold air near the ground comes to underlie the warm air, and the pollutants accumulate near the earth's surface. The most important air pollutant is smoke resulting from incomplete combustion of solid, liquid and gaseous fuels. Use of fuel is associated with all aspects of our life but industrial uses are the most important sources of smoke in the atmosphere. Besides industry, the shipyards, rail and road transport, thermal power stations and household activities also pollute the atmosphere with smoke. Smoke is often mixed with dense fog, which has come to be termed as 'smog'.

Most coals, cokes and heavier oils contain sulphur compounds, which on burning emit sulphur dioxide. Combustion of gasoline yields carbon monoxide and the irritating hydrocarbon known as olefin. Other volatile organic compounds present in polluted air in big cities are cresol, phenol, toluene, xylene, 3:4 benzpyrene, aldehydes, soot and tar compounds. Industrial contaminants specific to some industries are, sulphur dioxide from smelting operations, chemical plants and oil refineries; sulphuric acid mist from acid producing plants; fluoride compounds emitted by aluminium plants, phosphate from fertilizer plants and refinery processes; radio-active wastes from atomic reactors; suspended matter from pulp and paper mills, steel plants and tanneries, and so on. Dust is a special hazard from industries like Portland cement manufacturing (43 46).

**Ill Effects on Health**

Air polluted with sulphur dioxide and sulphuric acid can produce acute respiratory irritation and distress. This may prove to be a final burden for the persons suffering from respiratory or/and cardiac disease and allergic disorders of the respiratory tracts, the aged, and for premature infants. The other ill effect attributed to air pollution is the increased incidence of lung cancer. Unpleasant odours of polluted air may cause perpetual anorexia and gastric troubles. Interference with visibility may be a contributory factor towards increasing the frequency of road accidents. Eye troubles also increase in a smoky atmosphere. In any case it is very depressing to work and move in smoky and smogy environments. Silicosis and pneumoconiosis occur due to pollution with dusts.

## Trade Effluents

Indiscriminate discharge of untreated liquid wastes into a stream makes the water unpotable, destroys fish and renders it unfit for bathing and recreation purposes. Livestock and dairy cattle may get poisoned by drinking water contaminated with industrial wastes like insecticides and mineral oil etc., or give an unpleasant flavour to milk. Anthrax is known to be transmitted by using water polluted with slaughterhouse or tanneries wastes. Wastewater from chemical and ammunition factories contain untreated compounds like arsenic, cyanides etc., which are toxic to plant, animal and human life. Untreated trade effluents discharged into a sewer make the final disposal of sewage unsatisfactory. Trade effluents from gas works give an offensive taste and smell to water. The indiscriminate discharge of wastewater on land may cause water logging, infertility of soil and even destruction of standing crops.

**Control Measures**

(a) Effective legal provisions for control of water and

soil pollution by proper disposal of trade effluents should be provided. A technical organisation to assess nature and magnitude of water pollution is required. Water (prevention and control of pollution) Act, 1974 & Environmental Protection Act 1986 refers.

(b) Similarly, legislative procedures for the control of smoke nuisance coupled with regular monitoring of air pollutants, and rigid enforcement of these provisions are the chief measures for controlling smoke pollution of the atmosphere. Standards for the sulphur content of coal and smoke in the air must be laid down. Air pollution control Act 1981& Environmental Protection Act 1986 refers.

(c) A technical organisation to monitor the water, soil and air pollution, and advice on methods of treatment and to determine suitable standards for disposal should be established.

(d) Administrative machinery to enforce legal provisions with representatives from the state health department, factory inspectorate and public health engineering should ensure that these essential requirements are fulfilled.

(e) The proper siting of residential and industrial areas by sound town planning is important to reduce the hazards from air pollution.

(f) Smoke nuisance from railway locomotives, ships and also the industry can be eliminated by a change over to diesel fuel or electric power.

(g) The active cooperation of industrialists who must recognise their responsibility in this matter plays a vital role in control of air pollution and disposal of effluents.

(h) The education of legislators, industrialist and workmen is important to make them appreciate the problem and their respective role in minimising the hazards.

## Social security and welfare of industrial worker

### The Factories Act 1948

#### Introduction

Society has an obligation to protect the health of the workers engaged in diverse occupations. Factory laws have thus been framed in every country to govern the conditions in industry and to safeguard the health and welfare of the workers. The factories Act was enacted by the parliament of India in 1948, and since then it has been revised and amended from time to time (47), the latest being the Factories (Amendment) Act, 1987. The amendment in 1987 was elaborate following the Bhopal Gas Tragedy. Prior to 1987, the owner of the Factory could wash his hands off the responsibility for Safety and Health aspects by entrusting the day to day affairs to a managing agent. However, after the Bhopal Gas Tragedy the Government realised how hollow the definition of "occupier" under the Factories Act was. Accordingly, the Factories (Amendment) Act was passed in 1987 to amend the definition of "occupier". This landmark amendment in the Factories Act, 1948 in effect means that the affair of the Company cannot be entrusted to a managing agent, and the owners or directors of the factories will be deemed to be the 'occupier' of the factory. This makes the factory owners directly responsible for ensuring Safe and Healthy working conditions in their factory.

#### Scope of the Act

The Act defines "factory" as an establishment employing 10 or more workers where power is used, and 20 or more workers where power is not used. The term "Worker" includes within its meaning contract labour employed in the manufacturing process. The Act applies to the whole of India except the State of Jammu and Kashmir. Under the provisions of the Act, the State Governments are authorised to appoint besides the Chief Inspector of Factories as many Additional Chief Inspector of Factories, Joint Chief Inspectors, Deputy Chief Inspectors and Inspectors as they think fit to enforce the provisions of the law. The system of enforcement of Factories Act, 1948 is established on two tier basis. At the Central level, the Director General Factory Advisory Services & Labour Institutes (DGFASLI) has an advisory role. It coordinates the activities of the Factory Inspectorates and provides training and advisory services to the Inspectors. In addition it also assists the Ministry in drafting amendments to the Act and the Model Rules. The latter are recommended to the State Governments for adoption with necessary modifications to suit local conditions. The Factory Inspectorates under the State Governments and Union Territories carry out the enforcement functions (48).

#### General Duties of Employer

The Act specifically directs the employer to ensure the Health, Safety and Welfare of all workers while they are at work in the factory. His duties include ensuring:

(a) Proper maintenance of plant and systems of work in the factory

(b) Ensuring safety in connection with the use, handling, storage and transport of articles and substances

(c) Provision of information, instruction, training and supervision necessary to ensure the health and safety of all workers at work

(d) Provision and maintenance of risk free and safe means of access, and egress from, all places in the factory

(e) Provision, maintenance and monitoring of working environment in the factory so that the same is risk free and safe

In addition, the Act casts a duty on the manufacturers who design articles and substances for use in factories to ensure the following:

(a) Ensure that the article is so designed and constructed as to be safe and without risks to the health of the workers

(b) Carry out such tests and examination and provide information necessary for effective

implementation of Safety and Health provisions

**The Inspecting Staff**

The State Government is empowered to appoint Inspectors/ Additional Chief Inspector of Factories and as many officers, it thinks fit to ensure that provisions of the Act are complied with (49). These Inspectors are empowered to:

Enter any factory or any place which he believes is being used as a factory, make examination of the premises, plant, machinery, article or substance, inquire into any accident or dangerous occurrence, inspect registers or any other document relating to the factory, seize, any register, or other document, in respect of any offence under this Act, direct the occupier to leave undisturbed any part of the factory for the purpose of an enquiry into violation of the Factories Act, take measurements and photographs necessary for inquiry into violations of the Factories Act.

**Certifying Surgeons**

The State Government is empowered to appoint qualified medical practitioners to be certifying surgeons for the purposes of the Factories Act. The duties of the Certifying Surgeon are:

(a) The examination and certification of young persons under this Act,

(b) The examination of persons engaged in dangerous occupations or processes,

(c) The exercising of medical supervision for any factory where-

  (i) Cases of illness have occurred due to the nature of the manufacturing process carried on, or other conditions of work prevailing therein

  (ii) By reason of any change in the manufacturing process carried on (or in the substances used therein), there is likelihood of injury to the health of workers employed

  (iii) Young persons are employed in any work which is likely to cause injury to their health

**Health and Safety**

Elaborate provisions have been made in the Act under Chapter III, IV and IV A with regard to health and safety of workers. These chapters deal with laws pertaining to such matters as cleanliness, lighting, ventilation, treatment of workers, effluents and their disposal, elimination of dusts and fumes in the workplace, provision of spittoons, control of temperature, supply of cool drinking water and for the employment of cleaner to keep the water closets clean. A minimum of 350 cu feet of space for each worker for factories installed before 1948 and 500 cu feet for factories installed after 1948 has been prescribed by the govt not taking into account space more than 14 feet above ground level. The Act also prescribes in detail provisions relating to the safety of workers. Section 40B provides for the appointment of "Safety Officers" in every factory wherein 1000 or more workers are ordinarily employed. The State Government is empowered to prescribe maximum weights, which may be lifted or carried by men, women and children. Some of the other safety provisions relate to caring of machinery, devices for cutting off power, hoists and lifts, protections of eyes and precautions against dangerous fumes, explosive and inflammable materials.

**Welfare**

Chapter V of the Act relates to welfare measures for the worker. The Act specifies that wherein more than 250 workers are ordinarily employed, a canteen shall be provided. In every factory, wherein 30 or more women workers are ordinarily employed, a creche should be provided. Provisions have been made under the Act to ensure adequate washing facilities, facilities for storing and drying clothes, sitting, first aid appliances, shelters, rest rooms and lunchrooms. There should be a welfare officer for every factory employing more than 500 workers.

**Employment in Hazardous Processes**

Chapter IV A, incorporated by the Factories (Amendment) Act, 1987 relates to hazardous processes. A Site Appraisal Committee consisting of Chief Inspector and other members, not more than 14 in number, is to be constituted to submit recommendations on the siting of factories using hazardous processes. Provisions have been made for workers, participation in safety management in industries involving hazardous processes.

**Hours of Work**

The Act has prescribed a maximum of 56 hrs of work (60 hrs including overtime) per week with maximum spread over of work upto 12 hrs per day (including rest interval of 1/2 hr after every 5 hrs of work). For adolescents, the maximum hours of work per day have been restricted to 4 1/2 hours.

**Employment of Young Persons and Women**

The Act prohibits employment of children below 14 years of age. Persons between the ages of 15 and 18 years are to be duly certified as adolescents by "Certifying Surgeons" and also deemed thus fit to work. Adolescent employees and women are restricted from employment in certain dangerous occupations and hazardous processes and are allowed to work between 6 A.M. and 7 P.M.

**Leave with Wages**

The Act lays down that besides weekly holidays, every worker will be entitled to leave with wages after 12 months of continuous work at the rate of one day for every 20 days of work for adults and one day for every 15 days of work for adolescents.

**Notifiable Occupational Diseases**

The Act gives a schedule of Notifiable diseases (see 3rd schedule of the Act). It is obligatory on the part of the factory management to give information regarding specified accidents, which cause death or serious bodily

**Social security schemes in India**

- Central Government Health Scheme (CGHS)
- Central Maternity Benefit Act 1961
- Workmen's Compensation Act 1923
- Employees State Insurance Act 1948
- The Family Pension Scheme 1971
- Employees Provident Fund Organisation
- Various Insurance Schemes of LIC, private insurers
- Armed Forces Personnel Provident Fund (AFPP Fund)
- Defence Services Officers Provident Fund (DSOP Fund)

injury and regarding occupational disease. Provisions have also been made for safety and occupational health surveys in the factories.

### Social Security Schemes

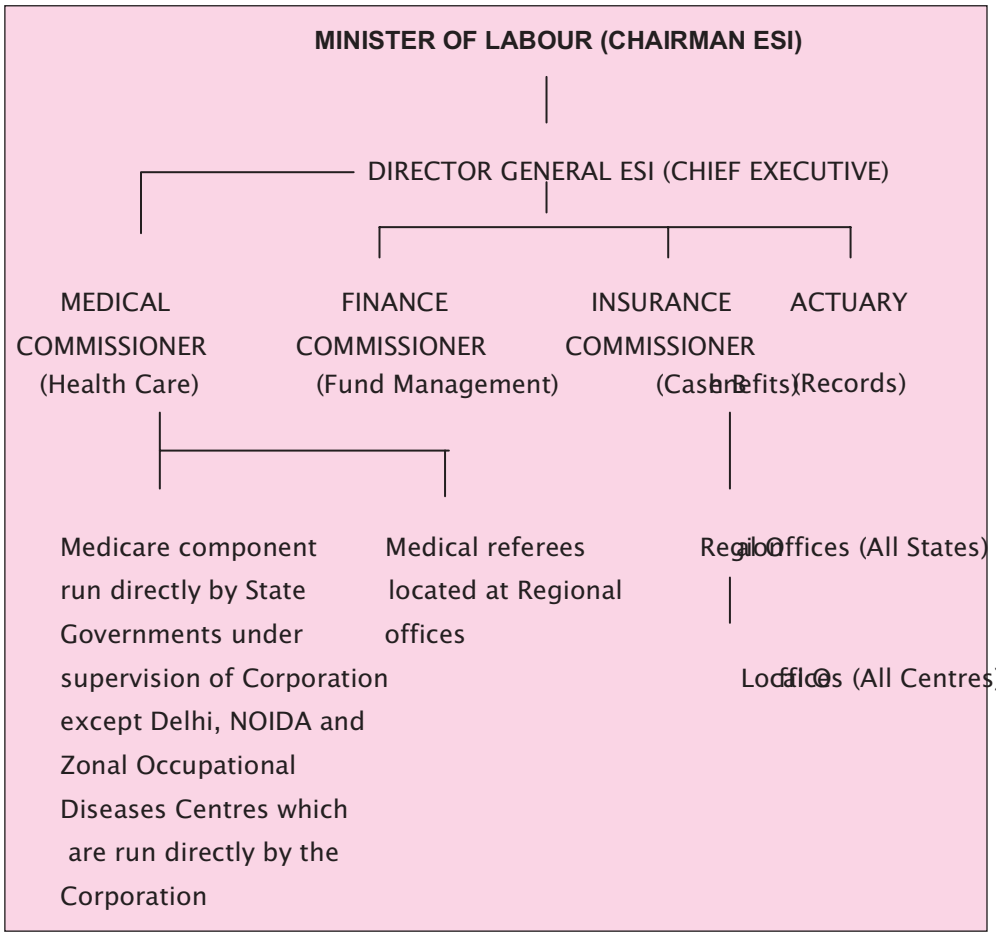
Social Security is a wide term and it is difficult to have a standard uniform definition of the term. The International Labour Organization (ILO) defines it as "the security that society furnishes through appropriate organization against certain risks to which its members are exposed". It is Social because it represents a collective effort by society. The security is provided in an organized form and therefore is not haphazard. However this definition does not identify the risks against which social security protects an individual. Beveridge has tried to identify some of the risks against which this security provides protection. He states "Social Security is an attack on five giants - Want, Disease, Ignorance, Squalor and Idleness". Friedlander defines it as "a programme provided by society against those contingencies of modern life, like sickness, unemployment, old age, dependency, industrial accidents and invalidism against which the individual cannot be expected to protect himself and his family by his own ability or foresight". The Social Security legislation is a part of Social Welfare legislation, which emerged and was evolved during the world wide depression of 1929 when laissez faire did not work well. Due to the late industrialization of the country such legislation also came into being very late in India.

### The Employees State Insurance Act 1948

The ESI Scheme is hailed as the largest Social Security Scheme of its kind in Asia. The ESI Act 1948 was enacted to "provide for certain benefits to employees in case of sickness and employment injury and to make provision for certain other matters in relation thereto". It has undergone amendments several times. The ESI Act, at present, applies in the first instance to non- seasonal factories using power in the manufacturing process and employing 10 or more persons and non power using factories employing 20 or more persons for wages. A factory or an establishment to which this Act applies shall continue to be governed by this Act notwithstanding that the number of persons employed therein at any time falls below the limit specified by or under this Act or the manufacturing process therein ceases to be carried on with the aid of power.

The Act contains an enabling provision under which the "appropriate government" is empowered to extend the provisions of the Act to other classes of establishments. Under these provisions most of the State Governments have extended provisions of the Act to the following classes of establishments: (50)

Table 10 : National setup of The ESI Corporation



(a) Shops, hotels, restaurants, cinemas including preview theatres, road motor transport agencies, newspaper establishments, employing 20 or more persons;

(b) Beedi manufacturing establishments employing 10 or more persons in the implemented area;

(c) State pencil manufacturing establishments employing one or more persons.

All factories or establishments to which the Act applies are required to register themselves in the Local Office of the ESI Corporation. The Act empowers the Central Government, the State Government and the Corporation to frame rules for the running of the Scheme. For carrying out its functions a statutory body called the ESI Corporation has been set up with the Minister of Labour as its Chairman. It has representatives of the Central and State Governments, employers, employees, medical professionals and members of Parliament. The Chief Executive of the Corporation is the Director General ESI who is assisted by an Insurance Commissioner, a Medical Commissioner, a Finance Commissioner and an Actuary. The DGESI and the Finance Commissioner are appointed by the Central Government. The other executives get promoted through ESI departmental channels. The Corporation has one Regional office each, in all the States who have Local offices under them in all areas covered by the Act (Table 10). There is a Medical Benefit Council, which decides medical care policies, headed by the DGHS who is assisted by the Medical Commissioner.

The other members of the Medical Benefit Council include Dy DGHS, State ESI medical heads, and representatives of employers, employees and medical professionals. The latter are nominated by the Indian Medical Association. The duties of Medical Benefit Council are:

(a) Advise the Corporation and the Standing Committee on matters relating to the administration of medical benefit, the certification for purposes of the grant of benefits and other connected matters;

(b) Have such powers and duties of investigation as may be prescribed in relation to complaints against medical practitioners in connection with medical treatment and attendance; and

(c) Perform such other duties in connection with medical treatment and attendance as may be specified in the regulations.

The Medical Care component called the Kingpin of the scheme is to provide full preventive, curative and occupational health services to its beneficiaries (51,52,53). Through it the Scheme provides:

(a) Out-patient treatment

(b) Domiciliary treatment

(c) Specialist Consultation

(d) In-patient treatment

(e) Free supply of drugs, dressings, artificial limbs, aids and appliances

(f) X-ray and laboratory investigations

(g) Vaccination and preventive inoculations

(h) Antenatal care, confinement and postnatal care

(j) Ambulance service or conveyance charges for going to hospitals, diagnostic Centres, etc. where admissible

(k) Family welfare services and other national health programme services

(l) Medical certification

(m) Special provisions including super-specialist services

(n) Early detection and diagnosis of occupational diseases (50)

Initially the medical care was provided only to workers in active employment. It has subsequently been extended to families of workers. In 1989, the Act was amended to include provision of medical care to an IP who ceases to be in insurable employment on account of permanent disablement, subject to payment of contribution, till the date on which he would have been superannuated had he not sustained such permanent disablement. It also brought under the 'medical care umbrella' retired workers and their spouses subject to payment of nominal contribution of Rs 10 only by a subsequent amendment. This Scheme is run by the State Governments under the guidance of the Corporation except in Delhi and NOIDA where it is run directly by the Corporation (50). The State Government bears 1/8th of the cost of medical care and the balance is met by the Corporation. For budgetary calculations the ceiling for the total cost on medical care benefit has been fixed at Rs 500 per IP annually. These benefits are provided free of cost including hospitalization in case of sickness, employment injury and maternity related causes. Medical Care is provided either directly through the exclusive ESI Hospitals and Dispensaries or indirectly through a panel of private medical practitioners (Panel System). All industrial Centres having large concentration of Insured Persons have the direct pattern of medical care, and the indirect pattern is restricted to areas having less concentration of Insured Persons where providing exclusive ESI services is not considered cost effective. It has its own referral chain and patients requiring super specialty treatment can be referred to the Zonal level ESI hospitals cum occupational Centres. In addition patients can be sent to specialised non ESI hospitals also at the expense of the ESI Corporation.

Besides, the ESI Scheme provides the following major benefits (50):

Sickness Benefit

This consists of periodical cash payment to an insured person if his sickness is duly certified by an ESI / Insurance Medical Practitioner. The benefit is payable for a variable period of time depending on the type of illness and

subject to the individual remaining under medical treatment provided under the Act. The insured person is protected from dismissal or discharge from service by the employer during the period of sickness.

### Maternity Benefit

The benefit is payable in cash to an insured Woman for confinement/ miscarriage or sickness arising out of pregnancy/confinement or premature birth of child or miscarriage. For confinement the duration of benefit is 12 weeks, for miscarriage 6 weeks and for sickness arising out of confinement 30 days. The Benefit is allowed at about full wages.

### Disablement Benefit

The Act provides for periodic cash payment, besides free medical treatment, in the event of a temporary or permanent disablement as a result of employment injury as well as occupational diseases.

### Dependent benefit

In case of death, as a result of employment injury, the dependents of an insured person are eligible for periodical payments.

### Funeral benefit

Funeral expenses are in the nature of lump sum payment upto a maximum of Rs 1500 made to defray the expenditure on the funeral of a deceased insured person. This payment is to be made to the eldest surviving member of the family of the deceased.

### Unemployment Allowance

This benefit has been introduced from 01 Apr 2005 & provides for an unemployment allowance to an individual for a maximum period of 6 months on account of closure of a factory or establishment, retrenchment or permanent invalidity arising out of non employment injury, after being in insurable employment for five or more years.

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# Bio-Medical Sciences

## Communicable Diseases : General Principles


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## General Prevention and Control Measures

The fields of preventive medicine and public health share the goals of promoting general health, preventing specific diseases, and applying the concepts and techniques of epidemiology to attain these goals. Preventive medicine seeks to enhance the lives of individuals by helping them improve their own health, whereas public health attempts to promote health in populations through the application of organized community efforts.

### Classification of Diseases

Diseases can broadly be classified as communicable and non-communicable as under :

(a) Communicable Diseases

These are illnesses caused due to invasion by specific microorganisms or their toxic products. The transmission of the agent or its products occurs from a source reservoir by direct or indirect means.

(b) Non-communicable Diseases

These are diseases, which are not caused by specific microorganisms and are not spread from one person to the other. These diseases may be metabolic, degenerative, neoplastic, mental, allergic, constitutional or accidental.

### Principles of Prevention and Control

The practical application and aim of epidemiological investigation and intelligence are to prevent and control the entry and spread of diseases in communities. The amenability of a disease to prevention and control depends upon the knowledge of its aetiology, epidemiology, mode of contraction, route and mode of transmission of the aetiological agent, the natural history or course of the disease and the incubation period. The better the knowledge of these factors, the greater is the amenability of the disease to prevention and control. The principles of prevention and control are applicable to non-communicable diseases as well as communicable diseases. However, a better knowledge of the specific aetiological agent and epidemiology makes it easier to apply the principles of prevention and control to most communicable diseases. The ever increasing knowledge of the aetiological and epidemiological factors involved in the causation of non communicable diseases has now made the control and prevention of many non communicable diseases possible as well.

### Natural History of Disease

The disease process is a dynamic one and is initiated by a disturbance of the balance between man and environment. The term 'natural history of disease' is applied to its course in man. Disease as seen in the hospital is but an episode in the natural history. The natural history of disease can be seen as having three stages: the pre disease stage, the latent (asymptomatic) disease stage, and the symptomatic disease stage. Another classification of the natural history is the pre pathogenesis phase (pre disease phase), the pathogenesis phase (the latent and symptomatic disease stage) and the post pathogenesis phase. In the pre disease stage the individual possess various factors that promote or resist disease, these include genetic make up, demographic characteristics (especially age), environmental exposures, nutritional history, social environment, immunologic capability and behavioral patterns. Over time, these and other factors may cause a disease process to begin. Thus potentially man is always in the midst of disease but only when the agent, host and environmental factors, the three components of the epidemiological triad, interact that the disease process is initiated. The pathogenic period begins with the entry of disease agent in the human host as a result of the disease provoking stimuli. If the disease producing process is underway but no symptoms of disease are apparent, the disease is said to be in the latent stage. This stage represents a window of opportunity during which detection followed by treatment provides a better chance of cure or at least of effective treatment. Once the agent becomes established and multiplies, there are tissues or physiologic changes in the host and the disease process is advanced enough to produce clinical manifestations, it is said to be in the symptomatic stage. The end result of the disease process may be complete recovery, chronicity, disability or death. (1 – 3).

### Levels of Prevention and Control

The modern concept of health as 'the state of complete physical, mental and social well being and not merely the absence of disease or infirmity' warrants the application of preventive and control measures in the three phases in the natural history of disease discussed above. Prevention of disease means barring or preventing its initial entry into man or a community while 'control' means arresting the further progress and propagation after its entry in an individual host or a community at large. Prevention entails anticipatory action to remove the possibility that a disease will ever occur. Control entails action to prevent invasion of the non-affected but exposed individuals in the affected community. As far as the non-communicable diseases are concerned, some are amenable to simple means of protection e. g. ill effects of cold and heat, while others require more intricate and elaborate preventive and control measures. The natural history and epidemiology of the non-communicable diseases such as cancer, cardiovascular diseases, accidental injuries and occupational diseases, have to be studied in detail to detect vulnerable points or links where preventive or control measures can be applied (1 - 3).

The objective in the pre-pathogenic phase is to achieve primary prevention, firstly through health promotion by socio-economic improvement and providing healthful housing, adequate nutrition, clothing, healthy living & working environments, and secondly by giving specific protection through immunization, environmental sanitation, use of specific nutrients, protection against occupational hazards, accidents, protection from carcinogens or allergens and so on.

In the pathogenic phase, secondary prevention aims at early case detection & treatment as well as uncovering the vulnerable community in the submerged part of the iceberg. It limits dissemination of infection and prevents occurrence of secondary cases in the community by reducing the infectious pool. The methods employed in early case detection are

(a) Case finding measures-individual or mass or by contact tracing.
(b) Screening surveys.
(c) Surveillance techniques and
(d) Selective examination of high risk groups.

In the post-pathogenic phase, disability limitation helps early rehabilitation of the patients. The objective is to halt the further progress of the disease process by instituting adequate therapy to limit the disability, prevent further complications through physiotherapy and other techniques of physical medicine. A rapid rehabilitation prevents the recovered individual from lapsing back into ill health, both physical and mental and protects the community from social disruption and diseases. Rehabilitation aims at restoring and retraining a patient to live and work within the limits of his disability but to the maximum of his residual capacity. This is termed as the tertiary prevention.

The various levels and stages of prevention in relation to the periods in the natural history of disease are shown in Table - 1.

Communicable diseases can be classified according to the aetiological agent or as per the route and mode of transmission. Usually both methods are employed. However, as they have a definite chain of transmission from the reservoir or source through a route upto the susceptible host or recipient, it is more convenient from the point of view of prevention and control, to classify them according to their mode of transmission. The latter, which also indicates the portal of entry & venue of exit of the infecting organism is as follows :

(a) Contact transmission - direct and indirect.
(b) Vehicle transmission - water, food, milk etc.
(c) Vector transmission - by arthropods.
(d) Air-borne transmission - droplet, droplet nuclei andinfected dust.
(e) Animal-borne transmission - zoonoses
(f) Trans placental transmission

**Control Measures**

These aim at exterminating the causative agent in its reservoir at the source of its production, its destruction soon after exit and before it starts its spread by interrupting its path of transmission. Action at these levels requires knowledge of the multifarious factors concerned with the inanimate or animate reservoir or source, various links in the chain of transmission and different approaches to the recipient susceptible host.

The practical measure of control broadly fall under three main heads. One or all of these measures may be applied according to the circumstances of the case (1, 4 - 6)

(a) Control of Reservoir and Source of Infection

The first link in the chain of causation is the existence of infected persons, cases (clinical or subclinical) or carriers, who constitute the primary source of infection. The general measures of control of the reservoir of infection are :

(i) Early detection of cases.
(ii) Notification
(iii) Isolation
(iv) Treatment.
(v) Quarantine.
(vi) Surveillance.
(vii) Disinfection.

(b) Block the channels of Transmission

This may be achieved by general environmental control, specific control measures such as safe water supply, sanitary disposal of sewage & other waste products, high standard of food hygiene, vector control, personal hygiene, proper ventilation, prevention of overcrowding and dust control.

Table -1 : Levels of prevention

| Levels of prevention | Appropriate response | Period in the natural history where applied |
|---|---|---|
| Primary prevention | ✎ Health promotion (eg. Encourage healthy lifestyle changes, balanced nutrition and clean environment)<br>✎ Specific Protection (eg., immunizations Occupational and automobile safety measures) | Pre-pathogenesis |
| Secondary prevention | ✎ Early Diagnosis & treatment | Pathogenesis |
| Tertiary prevention | ✎ Disability limitation (i.e., institute medical or surgical treatment to limit damage from the disease)<br>✎ Rehabilitation (i.e. identify and teach Methods to reduce physical and social disability) | Pathogenesis and Post-pathogenesis |

(c) Protection of Susceptible Population

This is carried out by immunization, chemoprophylaxis, good nutrition, health education and personal protection.

**Control Measures on the Occurrence of an Infectious Disease**

In public health practice, the action to control the communicable diseases has to be crystallized into the form of a 'drill' which should involve no elaborate thought or preparation because the aetiological agents travel fast and gain momentum and invasive force as they proceed from person to person. The usual sequence of action to control the spread of an infectious disease is as follows :

(a) Early detection of case.
(b) Isolation of the case for the entire period of infectivity.
(c) Prompt and effective treatment of case.
(d) Disinfection of discharges and fomites.
(e) Notification.
(f) Surveillance of contacts.
(g) Mass immunization of the vulnerable community.
(h) Investigation of the current outbreak.
(j) Survey to assess endemicity.

**Legislative Control**

Statutory legislation have been made at the central, state and district levels or at the municipal cantonment / peripheral rural levels for imposing legal obligations on people to facilitate control actions. In the Armed Forces, notification to higher authorities and other actions in connection with communicable diseases are to be carried out in accordance with RMSAF Chapter XIII and under the provisions of the Cantonment Act, 1924, in so far as it pertains to the civil population in the cantonments. Similar action has been evolved and enforced by statutes to prevent and control occupational diseases, effects of ionizing radiations, use of agricultural fertilizers or insecticides. More and more are being included in national and international surveillance procedures with a view to prevent and control them. The list of notifiable communicable diseases in the Armed forces is given here under. The notification form (AFMSF-73) is used for reporting the infectious case.

Notifiable Diseases

Diseases which are notifiable in the Armed Forces are arranged in groups according to the procedures to be adopted. These are shown in Table - 2.

Table - 2 : Notifiable diseases in the armed forces

| | |
|---|---|
| Group 'A'<br>Cholera, Yellow Fever | By telegram/signal to ADMS, reported to DDMS and DGMS (and equivalent officers in the case of IN and IAF) and Director of Health services of the state. In addition, the notification form AFMSF-73 will be forwarded to MO in charge unit, and ADMS, with a copy to DDMS (and equivalent officers in the case of IN and IAF). The following information will be given in the telegram/signal :-<br>(a) Disease<br>(b) Date of occurrence<br>(c) Rank/Rating and unit/ ship of patient.<br>(d) Probable source of infection<br>(e) Preventable precautions taken.<br>(f) No. of death since last report<br>(g) Whether the disease is prevalent in local civil population, town or district. (The code laid down in RMSAF will be used). |
| Group 'B'<br>Acute poliomyelitis<br>Anthrax<br>Cerebrospinal fever<br>Diphtheria<br>Encephalitis<br>Enteric gp of fevers<br>Epidemic influenza<br>Epidemic pneumonia<br>Outbreak of food poisoning<br>Plague<br>Relapsing fever<br>Typhus and other rickettsial diseases | On the notification form in quadruplicate; one copy each to MO in charge unit, ADMS, DDMS and DGMS (and equivalent Officers in the case of IN and IAF. |
| Group 'C'<br>Chickenpox<br>Dysentery<br>Malaria<br>Measles<br>Mumps<br>Pulmonary tuberculosis<br>Scarlet fever | On the notification form in triplicate; one copy each to MO in charge unit, ADMS, SMO or administrative authority in the case of IN; and in the case of IAF, DGMS(Air) and PMO concerned (where applicable) DDMS if made notifiable by DDMS and DGMS (Navy) for IN personnel |

Notification Procedure

Copies of the notification form should be prepared in respect of all ranks including families and civilians by the medical officer in charge of the case in consultation with the medical officer in charge of the unit and submitted to the OC hospital who should distribute them as above and retain one copy for record. When a case has been received as a transfer from another station, a note should be made in the general remarks column stating the station from which the case was transferred. Only information of

interest or practical value regarding the source of infection, preventive measures etc. will be entered on the form. It is always desirable to inform the medical officer in charge of the unit by telephone as soon as a case of notifiable disease is diagnosed. In the event of an outbreak of any of the above diseases attaining epidemic proportions, it will suffice if the number of cases by units or sub-units is submitted, whereas names of individuals may be omitted. A detailed special report of the outbreak should be submitted by the ADMS/ SMO/ PMO to the DDMS for onward transmission to the DGMS. The occurrence of the following diseases amongst personnel of the armed forces should be notified by the officer commanding service hospital without delay to the local civil health authority concerned e. g. district or municipal officer of health.

(a) Anthrax
(b) Plague
(c) Cholera
(d) Relapsing Fever
(e) Diphtheria
(f) Fevers of the typhus gp
(g) Typhoid fever only)
(h) Influenza (if epidemic

**Note:** Details of rank, name and number etc, such as are required for notification form, need not be given in the reports, to be submitted to local Civil health authority.

Alteration in Diagnosis

In the event of an alteration of diagnosis becoming necessary, all those originally notified should be informed accordingly. A new notification form should be rendered if the new diagnosis is that of a notifiable disease.

Other Infectious Diseases

Infectious diseases other than those enumerated above should, if occurring in epidemic form, be reported in manuscript to the ADMS/ SMO/ administrative authority in case of IN and in case of IAF, DGMS (Air) and PMO concerned where applicable by the ADMS/ SMO (IN)/ PMO (IAF)). The ADMS should keep the DDMS Command and through him the DGMS informed of the progress of such epidemics. Should the above mentioned infectious diseases or other infectious diseases occur in epidemic form among the civil population in localities adjacent to those occupied by the troops and be considered likely to spread to the troops, manuscript reports should be made to the ADMS/ SMO (IN)/ PMO (IAF)/ DGMS.

## Disinfection

### General consideration (4)

Definitions

**(a) Disinfection**

This means destruction outside the body, of specific microorganisms, which cause communicable diseases.

**(b) Disinfectants**

These are the agents used for disinfection.

**(c) Antiseptics**

These are the chemical agents, which inhibit the growth and multiplication of microorganisms, but are not strong enough to destroy them completely. A sufficiently diluted or weakened disinfectant becomes an antiseptic.

**(d) Disinfestation**

This means destruction of undesirable animal forms, especially arthropod ectoparasites present upon the persons or on domestic animals. The term also includes destruction or avoidance of endoparasites like helminths, and rodent destruction. However, in practice this term mainly refers to the destruction of ectoparasites like lice, sarcoptes, bugs and fleas and their ova and eggs.

**(e) Disinfestants**

These are the agents used for disinfestation. Disinfestants which are specially used against arthopods are called 'insecticides' and 'acaricides' depending on their special values in practice. A number of disinfectants are disinfestants if used in adequate strength, but all disinfestants or insecticides are not disinfectants.

**(f) Detergents**

These are surface cleansers and degreasers. They dissolve grease and oily matter and thereby help removal of dirt etc. , from any material when rinsed or washed with water consequently removing the micro-organisms sheltered by grease and dirt.

**(g) Deodorants**

These are substances, which mask the unpleasant odours without having disinfecting or antiseptic powers. Many disinfectants and antiseptics mask putrefactive odours also.

Objective

The object of these processes is to cut the links in the chain of the spread of communicable diseases and reduce nuisance. They can, therefore, be considered as supplementary to environmental sanitation. The main objective can be achieved with minimum effort and maximum success if the aetiology and mode of transmission of each disease is clearly understood, ecology and bionomics of their agents are known, procedures are rational and specifically directed against the paths of its spread and not employed merely as placebos to appease the ignorant mind. Much time, energy and money are wasted on disinfection of places which only require ventilation and cleansing. Some situations may need only the disinfection and other may need only disinfestation while a few may need both. Agents and procedures adopted will, therefore, depend upon the situation as well as nature of the problem. Disinfection is discussed hereunder.

### Disinfection Procedures

(a) Concurrent Disinfection

It means the disinfection of the patient himself, of his excreta and discharges and of all articles used by him or likely to have been contaminated during the course of his illness, including the hands and clothing of attendants.

(b) Terminal Disinfection

It means the disinfection of the room or premises and their contents after the patient has recovered, died or has been removed elsewhere. This includes the vehicle or

ambulance, the wheel chairs and stretcher used by the patient. This is either 'local or 'complete'.

(i) **Local** : It is the disinfection of the bedding and the bedsheet occupied by the patient, the walls, floor, furniture including the kit box, shelf, lockers and their contents and all other surfaces or articles within 2 meters all round the bed.

(ii) **Complete** : It is the disinfection of the whole room and all its contents.

Prophylactic Disinfection

It means chemical treatment or boiling of water, pasteurization of milk, washing of hands and so on.

Concurrent disinfection destroys maximum number of pathogenic organisms while their virulence and infectivity are maximum. Terminal disinfection exterminates the residual infection likely to have been left behind by the patient. Although the virulence of the pathogenic organisms is at its height just when they leave the host, some organisms retain it at a high level for a long time after their exit from the host, under favourable conditions. Thus all spores and some bacteria, like tuberculosis, survive and retain their virulence for a long time outside the host; some intestinal pathogens have a long saprophytic life; and some viruses are markedly tenacious extra corporeally. Therefore, while greater reduction in dissemination of infection is achieved by immediate concurrent disinfection, terminal disinfection is definitely complementary. However, as the infective propensity for non-sporing bacteria rapidly diminishes in their extra corporeal existence, properly carried out concurrent disinfection should relegate terminal disinfection to a subordinate position.

### Classification of Disinfecting Agents

Disinfecting agents can be classified as follows :

**(a) Natural Agents**

(i) Fresh air

(ii) Sunlight

**(b) Physical Agents**

(i) Dry Heat

- Burning
- Hot dry air
- Contact heat-ironing

(ii) Moist Heat

- Boiling (with or without chemical agent).
- Steaming-current steam and steam under
- Pressure.

(iii) Radiation

- Lonising radiation
- Ultraviolet rays.

**(c) Chemical Agents**

(i) Solids.

(ii) Liquids.

(iii) Gases.

(iv) Aerosols.

It will not, however, be correct to suppose that the action of any agent is circumscribed in or confined to its particular group only. Many disinfectants act both by physical action and chemical action e. g. soap acts by physically removing the grease and dirt which shelter the organisms as well as by its chemical action. Often, in practice, disinfection by chemical agents can be complemented or supplemented by physical agents. Thus clothing can first be soaked in a chemical agent, then steamed and finally washed, dried in the sun and ironed. Similarly disinfection by boiling can be accelerated or aided by the addition of a chemical or soap.

Natural Agents

Fresh air dilutes the bacterial content in enclosed places and desiccates micro-organisms by dehumidification. Sunlight disinfects due to the desiccating effect of its heat rays and the action of its ultraviolet rays. Indeed, this disinfecting power of the sun has made life possible in the insanitary tropical and subtropical environments. Although these agents are slow in action and frequently unreliable owing to the resistance of certain organisms, they are valuable adjuncts to artificial methods. In their absence the saprophytic life of all germs is prolonged. Thus, during epidemics, cinema theatres act as foci for the dissemination of infection since they usually admit no direct sunlight and little fresh air, whilst respiratory moisture delays desiccation.

Physical Agents

Heat kills ectoparasites and micro-organisms by coagulating their protoplasm. It may be employed in a dry or moist form. To ensure perfect sterility, the former demands a higher temperature and / or longer exposure than the latter. Heat, especially in the moist form, is the only physical agent that is reliably used for artificial disinfection and disinfestation in preventive medical practice.

**(a) Dry Heat**

Burning is a certain and rapid method of disinfecting and disinfestation but has only a limited scope. It may, however, be the only available method on active service. For example, clothing contaminated by excreta of cholera patients may be burnt, or the ground which has been contaminated by an anthrax carcass may be disinfected by burning straw or oil on the top of it. Contact heat applied by pressing irons over clothing may be used to disinfest louse and mites. Hot air ovens are used to disinfect glass ware such as petridishes, sharp instruments, swabs, dressing, chalk, Vaseline etc. The temperature of the air in the oven should be maintained at 160°C for at least one hour.

**(b) Moist Heat**

Boiling is quite effective in killing all non-sporing organisms, Spores being very resistant require boiling for an hour and a half. Boiling is largely used for sterilizing instruments and is useful for disinfecting bed clothing, underwear and similar articles. Blood stains become fixed by boiling owing to the coagulation of protein; these

should, therefore, be first removed by soaking in cold soapy water. Another disadvantage of boiling is that it is unsuitable for thick bedding of woolens. The effect of boiling can be enhanced by adding soap or washing soda to water. Steaming is the most efficient procedure of disinfection and disinfestation. The usual method is to expose the infected articles to 'saturated steam' in 'current steam' or 'under pressure'.

**(c) Radiation**

(i) **Ionizing Radiation** : Gamma radiation or electron beams have the advantage of combining great penetrative power with little or no effect on the object to be sterilized. Bandages, catgut, dressing and surgical instruments may be sterilized by ionizing radiation. These methods are used commercially. The isotope used is Cobalt 60.

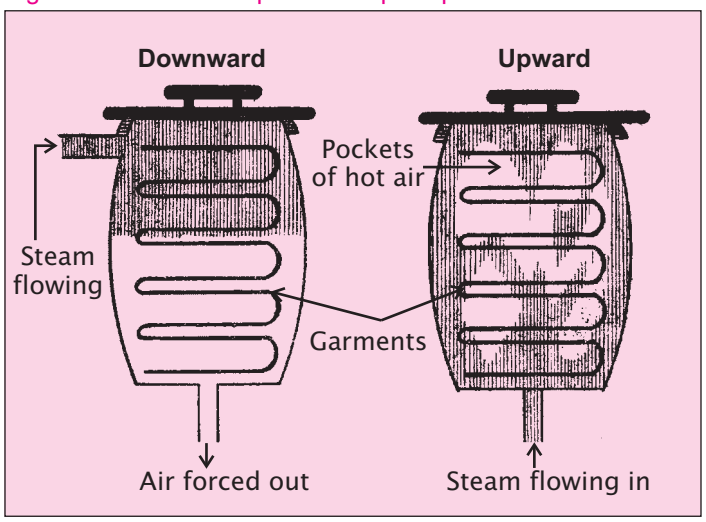
(ii) **Ultraviolet Rays** : Ultraviolet rays delivered from an apparatus hung in the ceiling at the entrance of special purpose rooms like the one in which premature infants are kept or in operation theatres, temporarily disinfect the objects and air entering inside.

**Steam Disinfection**

Steam in contact with boiling water from which it is generated has the temperature of 100°C and is called as 'saturated steam'. When it comes in contact with colder objects it immediately condenses and every gramme of it transfers a latent heat of 537 calories to that object and it contracts to about 0. 0015th of its volume and creates a partial vacuum. To fill the empty space more steam immediately rushes, condenses, releases the latent heat and again creates a partial vacuum. Continued repetition of this process achieves penetration of steam throughout the mass of, the fabric. Heat is thus transferred to the exposed articles until its temperature is raised to 100°C. Intimate contact with saturated steam is instantly fatal to all non-sporing organisms. Steam, however, gets mixed with the air contained in the clothing. Air absorbs heat, impedes intimate contact of steam with the fabric and being a bad conductor of heat, insulates clothing and reduces penetration, and thus disinfects much less efficiently than pure steam. This difficulty can be overcome by extracting air from the disinfection chamber before introducing steam into it, or by a downward displacement of air by steam introduced at the top of the chamber.

Steam being lighter than air when introduced from below into a chamber, it naturally ascends taking the line of least resistance between the layers of the clothing instead of through their texture, without displacing the air contained in it. If admitted at the top of the container it forms a supernatant layer, and if it cannot escape from above, descends gradually layer by layer through the fabric. If steam continues to enter from the top, all the air is pressed out of the fabric and the container through an escape hole provided at the bottom of the chamber. Finally, the steam completely penetrating throughout the mass of textiles rapidly raises the temperature of

Fig - 1 : Downward displacement principle




everything in the container to 100°C. The 'Serbian barrel' shown in Fig – 1 demonstrates this 'downward displacement of air' principle with clarity and simplicity.

Steam introduced at atmospheric pressure is known as 'current' or 'unconfined' steam; and at pressure in excess of that is called 'pressure' or 'confined steam'. The penetration of the pressure steam is no better than the current steam unless the chamber is vacuumised. By increasing pressure after creating vacuum much higher temperatures can be attained than the 100°C obtained with current steam. This renders 'pressure steam' disinfection more effective. This temperature of steam with a 0. 33 kg per square cm rise of pressure above the atmosphere is 109°C, at 0. 66 kg it is 115°C, at 1 kg 121°C, at 1. 33 kg 126°C, and at 2.66 kg per square cm it goes upto 141°C and so on.

Pressure Steam Disinfectors

A typical pressure steam disinfector consists of a double-jacketed wrought-iron cylinder, loaded at one end and unloaded at the other, each end having a hinged iron door. The clothing is placed in a cradle which is run on rails in the cylinder and the doors are clamped. Steam is first admitted in the outer jacket for heating the cylinder. The cylinder is then vacuumised and steam is introduced in it at 133 kg/ cm2 pressure for 10 min. After this, it is revacuumised and recharged with steam at the same pressure for further ten minutes, followed by aspiration of hot air through the clothing. Finally the clothing is taken out in a dry state from the other end. The whole operation takes about 35 min. Pressure-steam disinfectors of various types, but operated on the same principle are seen in large military hospitals.

Current-steam Disinfector

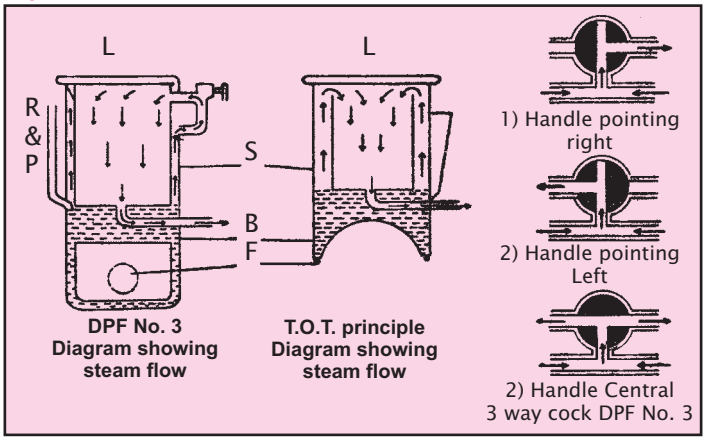
Pressure-steam requires apparatus with considerable extra strength and weight. Therefore, its use is practicable only in garrison stations and large hospitals. The current-steam apparatus, operated on the 'principle of downward displacement of air' being lighter and portable, is ideal for use on active service and in temporary camps. The

current-steam disinfectors at present in use are the TOT Disinfector (Fig -2) and Disinfector portable field (Fig - 3)

**The 'TOT' Disinfector**

This is a portable 'downward-air-displacement' current-steam disinfector named after its designer, T. O. Thompson. It is a rectangular metal box, the bottom of which has the fire chamber (F) with a built in 20 l capacity boiler (B) over it, and the upper part is a double jacketted steam chamber (S). The lid (L) is well fitting, air tight and asbestos/ hemp or felt lined. Heating is done by a burner, firewood or coal, for which a simple trench-fire-place (T) is required. Clothing is placed in the steam chamber and the lid is clamped so as to fit firmly. Steam generated in the boiler travels up between the two jackets of the steam chamber and, being stopped by the clamped lid, is forced down into it. It can not escape until all air is displaced downwards and forced out of the spaces between the interstices of the fabrics. It finally reaches the escape pipe through the hole (H) in the bottom of the container. This entire process takes about 10 min when steam will be seen spurting from the steam escape pipe (P) with a whistling noise. A definite continuous spout, and not the intermittent wisps of steam, indicates that the chamber is filled with steam without any air left in it. Steam is allowed to spout for 5 min and then the lid is opened, clothing is taken out and aired for drying. The process is repeated until all clothing is disinfected. At each loading about 9 to10 blankets or one man's full kit can be treated, provided the blankets are not brand new and are neatly folded and pressed well down into the chamber, corners up most to allow easy removal. About 5 1 of water should be added at each reloading.

Fig - 2 : TOT Disinfector

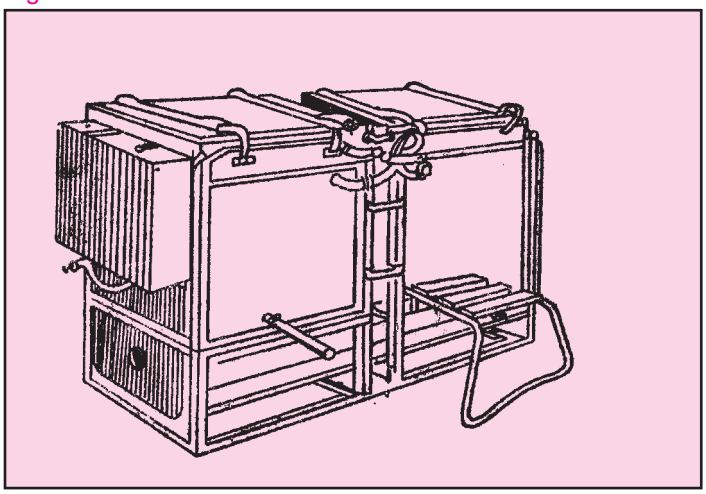



**Disinfector Portable Field**

The disinfector is also of the 'downward air displacement' type. It has two halves of identical construction bolted together (Fig - 3).

The front burner half carries a detachable 180 l capacity water reservoir with a water level gauge. The back flue-box half carries the detachable flue box and a pipe which is immersed in boiler water and is open to atmosphere, and therefore serves as low water alarm and also as a pressure limiting device. Through the detachable boiler section at the bottom, runs the fire tube with 5 cm space

Fig - 3 : Disinfector Portable field



around it. The boiler holds 80 l of water. The top chamber section carries the disinfecting chamber. Between this and the outer sheet is a 3 cm steam space surrounding the chamber. The front and back halves are interconnected by a loose fire tube connector, a water-pipe assembly which equalizes the water level and drains the water space, and steam pipe assembly which collects the steam generated in both halves and passes it to either of the disinfecting chambers separately or to both simultaneously. The water and steam pipe assemblies are joined to the disinfector body by unions with ground faces. When union nuts are taken off, the entire assembly comes away. Procedure of its working is briefly as follows :

(a) The boiler is filled via the water reservoir till the gauge shows 1. 5 cm and then the water reservoir itself is filled. There will then be about 260 l of water in the boiler and the reservoir, enough for two hours steaming. The burner is started and pushed into the opening of the fire tube with the burner plate abutting against its porch way. The flame should be kept steady.

(b) Articles for disinfection are collected on a ground sheet on the 'dirty side'. These may be tied in blankets to make bundles of the size of the chamber or loaded directly in layers. Blankets are folded to make neat bundles on the slings supplied. Steam from the boiler rises up in the steam space from where it is drawn off by tubes and admitted at the top of the disinfection chambers, at a pressure slightly above the atmosphere. Steam continuously entering from the top displaces all the air in the chamber and fabrics downwards and finally, completely filling the chamber, escapes through the bottom exhaust pipe in a continuous 'full bore' steam of vapour.

(c) To start with, the first chamber is loaded while the steam is diverted by the three-way valve to the other chamber. After loading, the lid is clamped down and the three-way valve is turned over to admit all steam into it. The second chamber is then loaded and the three-way valve is turned midway

to admit steam to both chambers simultaneously. After12 min, steam will issue forth 'full bore' from the exhaust pipe of the first chamber. After 5 min of the 'full bore' exhaust, disinfection of that chamber is complete and the three way valve is set to pass all steam to the second chamber, while the first is emptied and reloaded. By this time the second chamber may have completed its 5 min of 'full bore' exhaust and all steam is passed to the new load in the first chamber while the second is recharged. These cycles are repeated till all clothes are disinfected. The water level is always maintained showing 1. 5 cm up in the gauge-glass by replenishing at short intervals.

(d) Operating and working party as follows will be needed. 3 men to hand over the dirty clothing; 3 men to take over the disinfected clothing; and 3 men to operate the disinfector, No. 1 to attend to the boiler and burner, No. 2 to load the disinfector on the dirty side, and No. 3 on the clean side to operate the three way valve, unload the disinfector and pass the disinfected clothing to men who air them and hand them over to the loading party. There should be no passage of persons between dirty and clean sides, and the only passage of articles should be via the disinfection chambers. The output is about 200 blankets per hour. After the work is over the water should be drained out of the disinfector.

(e) The 'Disinfection centre' should have two apartments, the 'infected' or 'dirty' apartment and the 'disinfected' or 'clean' apartment. The disinfector should be built in between the two rooms, without communication between the two sides except through the disinfector, so that the receiving end opens into the 'infected' side and the other into the 'disinfected' side. After the work is over the water should be drained out of the disinfector.

### Chemical Agents

Chemical disinfectants and disinfectants may be solid, liquids, gases or aerosols. Solids act as disinfectants only in solution. A few disinfectants as powders, act better when dissolved. Gases like sulphur dioxide and formaldehyde also act as better disinfectants in the presence of adequate moisture. The disinfecting power of a chemical depends upon its basic toxicity, concentration, penetrating power, the medium in which it is to act, the resistance of organism required to be killed, the extent to which the organism is protected by organic matter like pus or faeces, and the period of contact allowed. The ideal chemical disinfectant should be capable of destroying all micro-organisms in all probable media within half an hour; it should be harmless to man and higher animals; it should not spoil metals, clothing and other household goods in the concentration usually employed; for convenience of transportation it should be obtainable in a highly concentrated form; it should be capable of forming a solution or stable emulsion in water (even in hard water); and finally it should be cheap. The main problem with any disinfectant, however, is the ability of its particles to gain contact with bacteriae. Capsulated organisms resist penetration to a marked degree; the organisms locked up even in microscopic masses of pus, mucus, faeces etc. are protected against most disinfectants unless the time of contact is long and the concentration high. Disinfection by chemicals is thus a complex process and the estimation of the true disinfecting power of any chemical agent is difficult (7, 8).

#### Estimation of Germicidal Power

The best known test for assessing germicidal power is the 'Rideal- Walker phenol coefficient test' (R. W. ). In this test the bactericidal power of any chemical is compared with that of phenol under identical conditions. This is done by observing the comparative sterilizing effects of a series of dilutions of the particular chemical and those of phenol against a standard dose of a standard culture of the Lister strain of B. typhosum, in a standard time, at a standard temperature. The RW coefficient is obtained by dividing the highest sterilizing dilution of the agent under test by the highest dilution of phenol sterilizing in the same time. For example, if cresol diluted 1:1200 and phenol diluted 1:100 both produce sterility, say, in 15 min, the RW coefficient of cresol would be 12 i. e. cresol has 12 times the disinfecting power of phenol. The test, however, does not indicate the disinfecting powers of disinfectants under natural conditions. For example, the mercurial salts show a high RW coefficient but their disinfecting action is arrested by albuminous materials. Chlorine and potassium permanganate lose a great deal of potency in the presence of organic matter, while others like cresol are only slightly handicapped. Various modified tests, like Chick-Martins test, take into account the effects of extraneous material. However, the unmodified Rideal-Walker test is useful for comparing the germicidal power of different batches of the same disinfectant.

#### Solids

**(a) Quicklime**

It is used in the burial of animals dead of anthrax; for disinfecting byres and stables after the occurrence of a case of anthrax; and as 25 per cent lime wash for walls, ceiling and floors of barns, sheds, stables, kitchen, stores and so on. Slaked lime is used as a deodorant in and around urinals, soakage pits, greases traps; to promote bacterial growth by retarding acidity in deep trench latrines; and as a final spread over shallow trenches.

**(b) Chlorine Compounds**

Bleaching powder, water sterilizing powder, sodium hypochlorite and many other kindred substances containing chlorine are used to sterilize water and vegetables. Bleaching powder in combination with boric acid has been used as eusol in surgery. The practice of sprinkling bleaching powder in drains, gutters, latrine pails etc. is wasteful and useless.

#### Liquids

**(a) Coal Tar Derivatives**

These are obtained by its fractional distillation and are most widely used of all the liquid disinfectants. This group includes the aniline dyes, the phenols and the cresols.

(i) **Cresol** : It is a dark brown, oily, readily emulsifiable liquid. Liquor cresoli fortis, known in the Armed Forces as 'disinfecting fluid black' or simply as cresol, is the most convenient and the most useful general disinfectant. It turns white on dilution with water and is extremely stable. Liquor cresoli fortis has a RW coefficient of 12, but cresol commercially supplied may have a 10 RW. All containers are marked with the RW of the contained cresol so that, by increasing or decreasing the amount of dilution with water a final disinfectant liquid of known strength can be made. For general use, like scrubbing bedsteads the dilution of 1 per cent of RW 10 cresol is enough. In this dilution it is not dangerously toxic if swallowed, is only mildly irritating to the skin, and possesses high germicidal power. For disinfecting bedpans, sputum or excreta a dilution of 2. 5% of RW 10 cresol is needed. Even in this dilution cresol does not destroy fabrics. Although it is rapidly fatal to micro-organisms when it comes in contact with them, its penetration into a mass of sputum or faeces is not good. Therefore, as a measure of greater safety, a 5 per cent emulsion is used for disinfecting sputum of tuberculosis cases and faeces of some excremental disease cases. Cresol is of great value in the disinfection of the receptacle after the contained infective material has been disposed of.

(ii) **Izal** : This is saponified cresol, officially known as 'disinfecting fluid white (Izal)'. This correct nomenclature should always be used. It is used in 3 per cent strength for disinfecting mouthpieces of telephones and microphones, of RT sets and PA sets and the face pieces of respirators. It should not be used for any other purpose.

**(b) Dettol**

This is chloroxylenol. It is non-irritating but inactivated by organic matter. It is active against streptococci but has no effect on some gram-negative bacteria.

**(c) Commercial Formalin**

This is a 40 percent aqueous solution of formaldehyde. It is a powerful disinfectant, but since it is very irritating to the hands, eyes and respiratory passages, it is not used as a general disinfectant. It can be used in a 5 per cent dilution for disinfecting rooms, tents, huts, or vehicles and for spraying fur-coats, leather, rubber, metal and similar articles which are destroyed by steam. It is used for disinfecting valuable like jewellery, gold and ornaments and watches. It is used for preserving tissues required to be sent to the laboratory for examination.

Gases

**(a) Sulphur Dioxide**

This gas has been used for fumigation against rats in ships and warehouses by the Clayton apparatus in which a forced draft from a blower ensures complete combustion of sulphur. By means of pipes led from the generator, a concentration of 15 per cent sulphur dioxide is attained in the air in enclosed places. Sulphur dioxide is not dangerous to human life, but tarnishes metals, discolours paints, destroys pictures, spoils grain and entails a risk of fire.

**(b) Formaldehyde**

The gas is generated popularly by pouring liquid formalin over crystals of potassium permanganate placed in a deep pan. About 300 ml of formalin and 150 gm of potassium permanganate are required for 1000 cft of space. The room is to be kept closed for 6 to 12 hours to allow disinfection.

Aerosols

Aerosols are mists released into the air by a special atomizer to disinfect the air in enclosed places. Their action is believed to be either due to collision with and absorption by organisms or condensation of vapour on bacteria-carrying particles, quickly destroying their bacterial content. The ideal aerosol should be non-irritating to the mucosa, non-toxic even after prolonged exposure, invisible, inodorous, non-corrosive, non-inflammable, highly bactericidal in low concentrations, and capable of penetrating organisms in dried secretions such as saliva. The most effective and irritating particles have a diameter of less than 1 micron and act at dilution ranging 1 in 100 million to 500 million volume of air. Aerosol has an advantage over ultra violet rays in the disinfection of air in enclosed places due to their penetration to the remote corners of rooms. Aerosols so far tried for killing bacteriae suspended in the air, fall into three groups viz. hypochlorites, resorcinols and glycols. Insecticide aerosols are effective against insects only. They contain Freon gas, Pyrethrum and DDT in solutions.

**Practice in the Armed Forces**

On the occurrence of a case of communicable disease in the Armed Forces barracks, and married quarters or treatment of a case in hospital, both concurrent and terminal disinfection are required to be carried out vide RMSAF paras 710 to 714. Concurrent disinfection of the patient himself, of his infective body-discharges immediately on voidance, of all articles used by him, nursing appliances immediately after use and clothing and linen when soiled or change is carried out during the course of an infectious illness. Terminal disinfection is carried out after the patient is dead or discharged or transferred. While only the 'local' terminal disinfection is necessary in all cases of infections, 'complete' disinfection is carried out for cholera, pulmonary tuberculosis, puerperal sepsis and pneumonic plague after the diagnosis. Chemical disinfectants like cresol and formalin are usually used for treating walls, floors, bedstead, furniture, fixtures, nursing appliances and articles of personal use. Blankets used by all patients and

complete clothing used by infectious patient are disinfected by steam and then washed, dried in the sun and ironed. If a steam disinfector is not available they are soaked in 2. 5 per cent cresol for half an hour. To summarize, disinfection of the following must always be considered in all cases of infectious illness :

(a) The patient's excreta and discharges, linen, utensils and other articles used by the patient.

(b) The quarters occupied by the patient before removal to hospital and their contents.

(c) The vehicle in which the patient is conveyed to hospital.

(d) On recovery of the patient, the ward/ room in which the patient was treated and its contents.

(e) In the case of carriers or contacts disinfection should be carried out at the discretion of the officer in medical charge.

In the Armed Forces, as practically all cases of infectious diseases are treated in hospitals, the disinfection is always carried out by trained persons. Occasionally when an infectious case has to be treated in quarters, full instructions in writing should be given. Disinfection and disinfestation should be carried out under the direction of medical authorities. Working parties are to be provided by the COs of units. In the Army, the scale of authorized disinfectants are given in SRS; in the Navy and Air Force these are to be drawn as per scales authorized from time to time through administrative orders/ instructions.

Details of Procedures to be followed

**(a) Concurrent Disinfection**

It should always be considered as extremely important. Concurrent disinfection of various infective materials in appropriate cases should be carried out as follows :

(i) Sputum should be received directly into sputum cups containing 2. 5 per cent cresol and afterwards burnt.

(ii) Nasal, aural and eye discharges should be received directly into small pieces of linen, cotton or cotton wool, and immediately burnt. Vaginal or urethral discharges and those from open sores should also be similarly received on pads left in situ under dressings and burnt after removal at frequent intervals. Handkerchiefs should be soaked in 2. 5 percent cresol solution before washing with soap and ironing.

(iii) Contents of bed pans and urine bottles used by patients suffering from gastro-intestinal diseases as well as their vomits should be thoroughly mixed with an equal quantity of 2. 5 per cent cresol and allowed to stand for 2 hours before throwing down the sluice or water closet or incinerated. Bed pans and bottles should subsequently be steeped in 2. 5 per cent cresol for15 min to half an hour and then washed.

(iv) Bed linen, blankets etc. which have been soiled with infectious discharges, exudates or excreta should be steeped in 2. 5 percent cresol for half an hour before removal from the ward. Special bedding and clothing marked with 'I' are reserved for use of patients suffering from infectious diseases.

**(b) Terminal Disinfection**

It is complementary to the concurrent disinfection. All clothing, mattresses, bedding, linen, personal wear and similar articles within the specified areas for local or complete disinfection as indicated are packed in sacks, or sheets soaked in 2. 5 per cent cresol and removed to the disinfection center for steam disinfection. After disinfecting, the articles of clothing and linen are washed with soap, dried in the sun and ironed. The floor, the walls, the tent-walls and wall-skirting, bedsteads, shelves, kit boxes and any other metal or wooden article, other than those which are removed for steam disinfection, are disinfected in situ by scrubbing or spraying with 2. 5 per cent cresol. After a suitable period of contact with the disinfectant, these may be washed.

**(c) Some Special Disinfections**

(i) **Vehicle or Aircraft** : Spray or swab with 5 per cent formalin or 2. 5 per cent cresol followed by washing in hot water with soda.

(ii) **Crockery and Cutlery** : Steep for half an hour in 2. 5 per cent cresol followed by washing in hot water with soda.

(iii) **Toys, Book and Papers** : If of small value, they may be burnt. If valuable, spray or swab with 5 per cent formalin followed by exposure to the air for two to three days.

(iv) **Shaving Brushes** : Thoroughly wash in 5 per cent soap solution containing one per cent soda ash at 50˚C. Allow to stand in one per cent soda ash at 50˚C for half an hour. Soak for half an hour in 10 percent formalin solution at 50˚C. Allow to dry in the shade, bristles downwards.

(v) **Latrine Seats** : Scrub with 2. 5 per cent cresol, which should then be allowed to dry on the seat.

Routine Disinfection of Personal Clothing

Disinfection / disinfestation of personal clothing in units obviates the possibility of any inadvertent transmission of contagious infection or louse infestation or bed bugs from person to person. Formerly routine steam disinfection of winter clothing used to be carried out after the clothing was withdrawn at the termination of the winter season, before stowing away for the summer. The present practice is to wash such clothing with soap and hot water at 60˚C, and afterwards expose them to the sun for 24 hours. After drying and ironing, it is stowed away in rat proof boxes or racks, after interposing naphthalene mothballs in between layers. Coloured clothing is fumigated with carbon tetrachloride by laundry units. Cotton clothing is boiled in soap solution, dried and ironed.

The common disinfectant in use and their dosage is shown in Table - 3 and Table - 4

Table - 3 : Recommended dilution of Chlorine releasing compounds

| Available Chlorine | "Clean" condition | "Dirty" Condition |
|---|---|---|
| Required chlorine | 0.1% 1gm/litre | 0.5%, 5 gm/litre |
| Sodium hypochlorite solution 5% available chlorine | 20 ml/litre | 100 ml/litre |
| Calcium hypochlorite 70% available chlorine | 1.4 gm/litre | 7.0 gm/litre |
| (NaOCl Powder) Sodium dischlorosocyanurate | 1.7 gm/litre | 8.5 gm/litre |
| (NaOCl Tablets Sodium dischlorosocyanurate | 1 tablet/litre | 4 tablets/litre |
| Chloramine (25% available chlorine) | 20 gm/litre | 20 gm/litre |

Table - 4 : Non-chlorine releasing compounds (used for disinfection of items which are adversely affected upon by chlorine).

| Name of Disinfectant | Required concentration | Contact period | Used for disinfection of |
|---|---|---|---|
| Ethanol | 70% | 3-5 min | Smooth metal surfaces, table tops, incubators, thermometers |
| Alkaline Glutaraldehyde | 2% | 30 min | Ambu bags, suction tubes/bottles, laryngoscopes, endotracheal tubes, catheters etc. |
| Formaldehyde / Formalin | 3 - 4% | 30 min | Furniture, rooms, walls, blankets, beds, books etc. |
| Savlon | 1% | 30 min | Cheatle forceps. |
| Dettol (chloroxylenol) | 5% | 15 min | Instruments & plastic equipment |

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# Immunization

## Introduction

The concept of immunity has intrigued mankind for thousands of years. The prehistoric view of disease was that it was caused by supernatural forces, and that illness was a form of theurgic punishment for "bad deeds" or "evil thoughts" visited upon the soul by the gods or by one's enemies(1). The first written descriptions of the concept of immunity may have been made by the Athenian Thucydides who, in 430 BC, described that when the plague hit Athens "the sick and the dying were tended by the pitying care of those who had recovered, because they knew the course of the disease and were themselves free from apprehensions. For no one was ever attacked a second time, or not with a fatal result(2) The term "immunes", is also found in the epic poem "Pharsalia" written around 60 B. C. by the poet Marcus Annaeus Lucanus to describe a North African tribe's resistance to snake venom (3). The first clinical description of immunity which arose from a specific disease causing organism is probably *Kitab fi al-jadari wa-al-hasbah* (4) written by the physician in the 9th century. However, it was with Louis Pasteur's Germ theory of disease that the fledgling science of immunology began to explain how bacteria caused disease, and how, following infection, the human body gained the ability to resist further insults (3).

Burnet and Medawar, Nobel Prize winners in 1960 put forth the concept that Man had learnt to tolerate his own tissues (self) and was intolerant to foreign tissues (i. e. not self). The concept of 'self' and 'not self', therefore, means that under normal conditions the body tolerates its own tissues (immunological tolerance), and recognizes and destroys foreign tissues. In the modern sense, therefore, immunity has been defined as the ability of the body to recognize, destroy and eliminate antigenic material foreign to its own. It is imperative to have updated knowledge regarding the immunologic basis of diseases and immunization, when dealing with the issue of immunization (5, 6).

## Basics of Immunology

The immune system is a collection of mechanisms within an organism that protects against infection by identifying and killing pathogens and tumor cells.

### Structure and function of Immune system

Tissues and Organs Important for Immune function include :

(a) Cells derived from stem cells: liver, bone marrow

(b) Cells that are stored, multiply, interact, and mature in: thymus, spleen, lymph nodes, blood

(c) Transport: lymphatic vessels

(d) Accessory Organs : Appendix, tonsils, intestines

The immune system detects a wide variety of pathogens, such as viruses and parasitic worms and distinguishes them from the organism's normal cells and tissues. The immune system protects organisms from infection with layered defenses of increasing specificity. Most simply, physical barriers prevent pathogens such as bacteria and viruses from entering the body. If a pathogen breaches these barriers, the innate immune system provides an immediate, but non-specific response. Innate immune systems are found in all plants and animals. However, if pathogens successfully evade the innate response, vertebrates possess a third layer of protection, the adaptive immune system. Here, the immune system adapts its response during an infection to improve its recognition of the pathogen. This improved response is then retained after the pathogen has been eliminated, in the form of an immunological memory, and allows the adaptive immune system to mount faster and stronger attacks each time this pathogen is encountered (7,8).

### Antigens

An antigen is defined as a substance which when introduced into the tissues stimulates the production of specific antibodies and combines specifically with the antibody so produced(3). By far the best antigens are proteins (eg diphtheria toxin, tetanus toxin); others are poly-saccharides (eg. blood group antigens), lipids and nucleic acids. There are also incomplete antigens called 'haptens' which by themselves are not antigenic but can provoke an immune response by combining with one of the body's proteins in such a way that the protein becomes 'foreign' to the body. Penicillin is an example of 'hapten'. On contact with an antigen the host can respond in three different ways :

(a) Circulating antibody is formed.

(b) A delayed-type cell mediated hypersensitivity reaction may result on second contact with the antigen.

(c) Tolerance, which means that on second contact with the same antigen no response will be provoked.

The type of response in a particular case will depend largely on the antigen itself, the dosage, and the route of application and possibly on other lesser-known factors (9).

### Antibodies

An antibody is a protein substance that appears in the body as a result of invasion by an antigen. It is capable of reacting specifically with the same antigen, which provokes its production. The sites of maximum antibody formation are the lymph nodes and spleen. Smaller collections of antibody producing cells are widely scattered in various tissues throughout the body. Plasma cells also produce antibodies. Antibodies may be antitoxic such as diphtheria and tetanus, antibacterial like typhoid or antiviral such as polio.

### Immunoglobulins

These comprise of families of closely related globulin molecules, which are synthesized by cells of reticulo-endothelial system. The human immunoglobulin system is divided into five major classes IgG, IgA, IgM, IgD and

IgE. The molecule of each immunoglobulin is understood to consist of K (Kappa) and L (Lambda) polypeptide chain. It is still an open question whether all immunoglobulins are antibodies that have arisen as a result of antigenic stimulation(10)).

**(a) IgG**

Repeated exposure to antigen leads to its accumulation in serum and it comprises about 80 per cent of serum antibodies in an adult. Antibodies to gram positive pyogenic bacteria, antiviral and antitoxic antibodies are found exclusively among IgG globulins. Further, this is the immunoglobulin, which is transported across the placenta. Maternally derived IgG is slowly replaced by actively synthesized IgG which appears at 1-3 months of age and then rapidly rises. Adult levels are reached by the age of one to two years. Normal adult serum level of IgG is 600-1800 mg/100 ml.

**(b) IgA**

This fraction has been found to contain isohaemagglutinins, antibrucella, antidiphtheria antibodies and comprises about 10 per cent of the serum antibodies. Saliva, colostrum and tears are relatively rich in this fraction. Nasal and bronchial secretions, bile, intestinal juices and prostatic fluid also contain IgA. It seems to play a decisive role in local immunity. IgA synthesis begins two weeks after birth. Normal adult serum level is 70-380 mg/100 ml.

**(c) IgM**

This fraction is found to have high agglutinating and complement fixation ability. Wasserman antibodies and bactericidal antibodies against Gram negative organisms (endotoxins) are almost exclusively found in IgM. It accounts for 5 to 10 per cent of serum antibodies. It cannot pass through placenta. Normal adult serum level is 20-130 mg/100 ml.

**(d) IgD**

Normal adult serum level is 4-40 mg/100 ml.

**(e) IgE**

The antibodies in this fraction have the ability to fix themselves firmly to tissues and remain so fixed. They are likely to play an important role in allergic reactions.

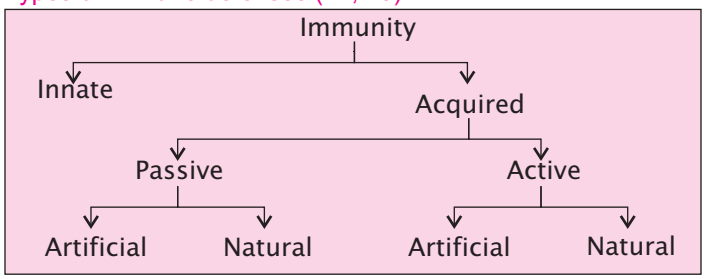
Immunity

Table - 1

| Nonspecific defense mechanisms | | Specific defense mechanisms (immune system) |
|---|---|---|
| **First line of defense** | **Second line of defense** | **Third line of defense** |
| Skin<br>Mucous membranes<br>Secretions of skin & mucous membranes | Phagocytic White blood cells<br>Antimicrobial proteins<br>The | Lymphocytes<br>Antibodies |

The modern word "immunity" derives from the latin *immunis*, meaning exemption from military service, tax payments or other public services and is defined as

Types of immune defenses (12, 13)




"Ability of an organism to recognize and defend itself against specific pathogens or antigens" (11).

**Innate and Adaptive Immunity**

The normal individual has two levels of defence against foreign agents. The first type is present in neonatal animals and in invertebrates namely natural or innate immunity. This type of immunity is sometimes referred to as non-specific but broadly specific would be a better description. The second type of immunity is adaptive or acquired immunity and is confined to vertebrates.

**Innate (or natural) immunity**

This is made up of several components.

(a) Physical barriers are the first line of defense against infection. The skin and mucous membranes provide a continuous surface which must be breached and back this up with mechanical protection through cilia and mucous.

(b) Physiological factors such as pH, temperature and oxygen tension limit microbial growth. The acid environment of the stomach combined with microbial competition from the commensal flora inhibits gut infection.

(c) Protein secretions into external body fluids such as lysozyme also help resist invasion. Soluble factors within the body such as complement, interferons and collectins and other "broadly specific" molecules such as C-reactive protein are of considerable importance in protection against infection.

(c) Phagocytic cells are critical in the defense against bacterial and simple eukaryotic pathogens. Macrophages and Polymorphonuclear leucocytes (PMN) can recognise bacterial and yeast cell walls through broadly specific receptors (usually for carbohydrate structures) and this recognition is greatly enhanced by activated complement (opsonin) (7).

**Acquired immunity**

Acquired immunity is also called adaptive immunity and develops only after exposure to inducing agents such as microbes, toxins, or other foreign substances.

Table - 2 : Comparison between active & passive immunity

| Active Immunity | Passive Immunity |
|---|---|
| 1. Usually produced in response to bacteria viruses, . toxins or toxoids | 1. Produced by serum containing already prepared antibodies |
| 2. Body cells take an active part in the production of immunity | 2. Cells of body do not take part in the production of antibodies. |
| 3. It takes sometime to develop the antibody in the system. | 3. No time is lapsed in getting the antibodies circulating in the system. |
| 4. Immunity lasts long | 4. Immunity lasts for a short period, usually 10-14 days. |
| 5. Used for prepathogenic prophylaxis and treatment of subacute or chronic infections in order to increase resistance of the body | 5. Used for treatment of acute infection and for tiding over the crisis or incubation period |

**Active immunity**

(a) Naturally acquired active immunity occurs when a person is exposed to a live pathogen, and develops a primary immune response, which leads to immunological memory. This type of immunity is "natural" because it is not induced by man.

(b) Artificially acquired active immunity can be induced by a vaccine, a substance that contains antigen. A vaccine stimulates a primary response against the antigen without causing symptoms of the disease.

**Passive immunity**

Passive immunity is the transfer of active immunity, in the form of readymade antibodies, from one individual to another.

**Naturally acquired passive immunity**

Passive immunity can occur naturally, when maternal antibodies are transferred to the fetus through the placenta or through breast milk(14, 15).

**Artificially acquired passive immunity**

Artificially acquired passive immunity is a short-term immunization induced by the transfer of antibodies, which can be administered in several forms; as human or animal Plasma or serum or pooled human immunoglobulin (16).

**Active versus Passive Immunity**

Some differentiating points between active and passive immunity are given in Table -2.

Host defenses

There are two different types of Host defenses that the body exhibits as a result of exposure to antigen. They are:

(a) The humoral immune response involves the activation and clonal selection of B cells, resulting in the production of antibodies.

(b) The cell-mediated immune response involves the activation and clonal selection of cytotoxic T cells.

Humoral immunity is active when the organism generates its own antibodies, and passive when antibodies are transferred between individuals. Similarly, cell mediated immunity is active when the organisms' own T-cells are stimulated and passive when T cells come from another organism (17).

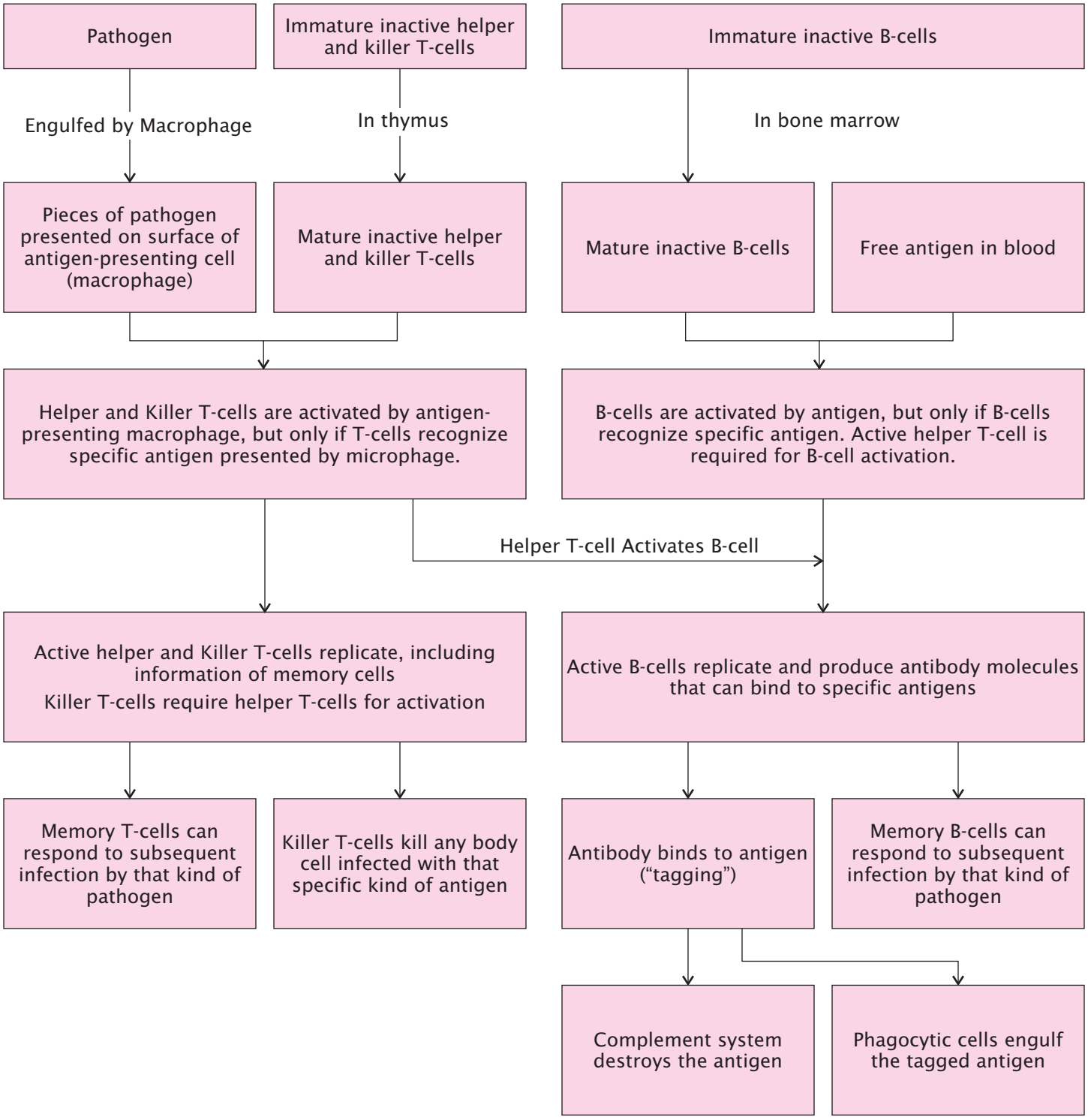
**Humoral immunity**

An immunocompetent but as yet immature B-lymphocyte is stimulated to maturity when an antigen binds to its surface receptors and there is a T helper cell nearby (to release a cytokine). This sensitizes or primes the B cell and it undergoes clonal selection, which means it reproduces asexually by mitosis. Most of the family of clones become plasma cells. These cells, after an initial lag, produce highly specific antibodies at a rate of as many as 2000 molecules per second for four to five days. The other B cells become long-lived memory(18).

**Cell-mediated immunity**

Macrophages engulf antigens and process them internally. This sensitizes the T cells to recognize these antigens. T cells are primed in the thymus, where they undergo two selection processes. The first positive selection process weeds out only those T cells with the correct set of receptors that can recognize the MHC molecules responsible for self-recognition. Then a negative selection process begins whereby T cells that can recognize MHC molecules complexed with foreign peptides are allowed to pass out of the thymus. Cytotoxic or killer T cells (CD8+) do their work by releasing lymphotoxins, which cause cell lysis. Helper T cells (CD4+) serve as managers, directing the immune response. They secrete chemicals called lymphokines that stimulate cytotoxic T cells and B cells to grow and divide, attract neutrophils, and enhance the ability of macrophages to engulf and destroy microbes. The process by which T cells and B cells interact with antigens is summarized in the diagram (Fig - 1)

Fig - 1


Pathogen
Immature inactive helper and killer T-cells
Immature inactive B-cells
Engulfed by Macrophage
In thymus
In bone marrow
Pieces of pathogen presented on surface of antigen-presenting cell (macrophage)
Mature inactive helper and killer T-cells
Mature inactive B-cells
Free antigen in blood
Helper and Killer T-cells are activated by antigen-presenting macrophage, but only if T-cells recognize specific antigen presented by microphage.
B-cells are activated by antigen, but only if B-cells recognize specific antigen. Active helper T-cell is required for B-cell activation.
Helper T-cell Activates B-cell
Active helper and Killer T-cells replicate, including information of memory cells
Killer T-cells require helper T-cells for activation
Active B-cells replicate and produce antibody molecules that can bind to specific antigens
Memory T-cells can respond to subsequent infection by that kind of pathogen
Killer T-cells kill any body cell infected with that specific kind of antigen
Antibody binds to antigen ("tagging")
Memory B-cells can respond to subsequent infection by that kind of pathogen
Complement system destroys the antigen
Phagocytic cells engulf the tagged antigen

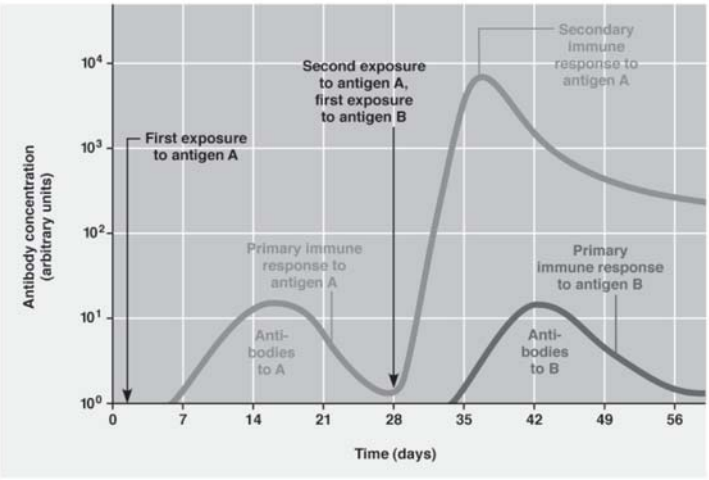
Local Immunity

The cells of the tissue attacked are as much concerned in offering resistance to the infecting agent as the antibodies or phagocytes; this is the local immunity. Besredka, who first evolved the primary importance of local immunity in prophylaxis against diseases, suggested that if the particular tissues attacked by a particular infective agent (e. g. in typhoid and dysentery the intestines and in anthrax the skin) are previously unsusceptible, the person would behave as if completely immune. Local immunity is believed to be produced by fixation of various specific humoral antibodies in tissues, cells; or it may be nonspecific response of local tissues, induced by a local application of antigen, against a subsequent infection threatening systemic disease. This principle is now employed for producing immunity against poliomyelitis by giving Sabin's oral poliomyelitis vaccine.

Herd Immunity

Herd Immunity is the immunity of a group of people or a community taken as a whole. In the epidemiology of infectious diseases, consideration of herd immunity is of greater importance than that of individual immunity. Epidemics disappear from a community long before 100 per cent of its members become immune, either naturally through epidemics or artificially through mass immunization. Epidemiological immunity is usually established even when, say only 80 to 85 % people in the community become immune. The other 20 % people enjoy freedom from infection by virtue of their belonging to the 'herd'. Herd immunity can also develop through the process of natural selection by weeding out of the susceptible successive generations due to death from disease. The level of herd immunity at a given time depends on the herd structure which is constantly changing. Influx of susceptible people and occurrence of new births lower the herd immunity. The herd structure includes the hosts (population) belonging to the herd species, and also the presence and distribution of alternative animal hosts and possible insect vectors as well as those environmental and social factors that favour or inhibit the spread of infection from host to host. The herd structure plays a decisive role in the immunity status of the herd (19) .

Fig - 2 : Immune response




**Types of Immune Response**

The first encounter with an antigen is known as the primary response. Re-encounter with the same antigen causes a secondary response that is more rapid and powerful (20) .

**Immune responses depends on**

(a) Nature and dose of antigen
(b) Route of administration
(c) Type of adjuvants used
(d) Nutritional status of the recipient

## Immunisation

Immunisation is the process by which an individual is exposed to an agent that is designed to fortify his or her immune system against that agent. The material is known as an immunogen. Immunization is the same as inoculation and vaccination in that inoculation and vaccination use a viable infecting agent like immunization does.

**History of immunization**

While Dr. Jenner (1749-1823) has been recognized as the first doctor to give sophisticated immunization, it was British dairy farmer Benjamin Jestey who noticed that "milkmaids" did not become infected with small pox or displayed a milder form. Jestey took the pus from an infected cow's udder and inoculated his wife and children with cowpox, thereby making them immune to smallpox. By injecting a human with the cowpox virus (which was harmless to humans) , Jenner swiftly found that the immunized human was then also immune to smallpox. The process spread quickly, and the use of cowpox immunization has led to the eradication of smallpox in modern human society. After successful vaccination campaigns throughout the 19th and 20th centuries, the

Table - 3 : Milestones in vaccination

| | |
|---|---|
| 1798 | Smallpox |
| 1885 | Rabies |
| 1897 | Plague |
| 1923 | Diphtheria |
| 1926 | Pertussis |
| 1927 | Tuberculosis (BCG) |
| 1927 | Tetanus |
| 1935 | Yellow Fever |
| **After World War II** | |
| 1955 | Injectable Polio Vaccine (IPV) |
| 1962 | Oral Polio Vaccine (OPV) |
| 1964 | Measles |
| 1967 | Mumps |
| 1970 | Rubella |
| 1981 | Hepatitis B |

World Health Organization (WHO) certified the eradication of smallpox in 1979.

### Vaccines

These are immunobiological substances designed to produce specific protection against diseases by stimulating production of protective anti body or other immune mechanisms. A number of agents can be used to provide protection against diseases. This protection can be active where antibodies are produced by our own bodies in response to vaccines or passive where antibodies are received in ready made form of Immunoglobulins or Non Human Antisera

### Immune response to vaccination

The Vaccine mimics the infection with the respective pathogen, but without risk of the disease. The consequent immune response may be manifested through antibody (humoral immunity) or cell mediated immunity (CMI) , or both. If the antigen stimulates Th1 series of T helper lymphocytes, then stronger cytotoxic lymphocytic response is obtained; if Th2 series is stimulated, the ultimate expression of immunity is predominantly humoral. Carbohydrate antigens are T cell independent; hence they stimulate B cells directly without T helper cell modulation. The result is predominantly IgM response without IgG production or induction of immunological memory. BCG elicit CMI.

Maternal CMI is not transferred to the foetus. Therefore BCG can be given at birth. OPV is given by mouth; it establishes local infection in a proportion of children. Maternal antibody in the infant's circulation is a very weak inhibitory factor; hence OPV also can be given at birth. Hepatitis B surface antigen is an excellent immunogen, overcoming, to a large extent, the inhibiting effect of maternal antibody; hence that too can be given at birth. On the other hand, live Measles vaccine may be completely inhibited in the presence of detectable maternal antibody in the infant's circulation. Therefore Measles vaccine is given after a delay of 9 months from birth and MMR only after 12 months (8) .

The goal of all vaccines is to promote a primary immune reaction so that when the organism is again exposed to the antigen, a much stronger secondary immune response will be elicited. Any subsequent immune response to an antigen is called a secondary response and it has

(a) A shorter lag time,
(b) More rapid buildup,
(c) A higher overall level of response,
(d) A more specific or better "fit" to the invading antigen,
(e) Utilizes IgG instead of the large multipurpose antibody IgM.

### There are four types of traditional vaccines

(a) Live (attenuated)
(b) Inactivated (killed)
(c) Toxoids
(d) Subunit and recombinant

### Live Vaccines

Are prepared from live attenuated organisms. They are very potent immunizing agents because:

(a) Live organisms multiply in the host
(b) All major and minor antigenic components are present
(c) Target organs may be colonized
(d) May replace wild strains in the community

However, live vaccines also suffer from some drawbacks. Safety is an issue because mutation may take place resulting in disease. Live vaccines can not be used for immunodeficient patients and they can not be used during pregnancy.

Two important precautions have to be observed while using live vaccines. Two live vaccines are usually not used together. They are to be given at different sites or three weeks apart. The other important aspect that must be kept in mind is that live vaccines have exacting storage requirements.

Live vaccines have been developed for all kinds of organisms. Examples off live vaccines for different kinds of organisms include

Bacterial

(a) BCG
(b) Typhoid oral

Viral

(a) Measles, Mumps, Rubella
(b) Oral Polio
(c) Yellow fever, influenza

Rickettsial

(a) Epidemic typhus

### Inactivated (Killed) Vaccines

These are prepared from organisms killed by heat or chemicals.

Killed vaccines are very safe but less efficacious than live vaccines. They require multiple doses which may be administered as a series of primary doses followed by regular booster doses. The only absolute contraindication is hypersensitivity

Examples of inactivated vaccines of different kinds of organisms include

**Bacterial**

(a) Typhoid
(b) Pertusis
(c) Cholera

Viral

(a) Rabies
(b) Hepatitis B
(c) Japanese encephalitis

### Toxoids

These are produced from detoxicated toxins. The body produces antibodies against the toxin in response to

toxoids. They offer no protection against infection. Toxoids are very safe and highly effective

**Examples:** Diphtheria, Tetanus

**Passive Immunisation**

Passive immunization may be administered using human or animal products. Conventionally human products are called immunoglobulins and animal products are called anti sera. Animal products are cheaper but suffer from the disadvantage of greater chances of immediate or delayed hypersensitivity.

Human Immunoglobulins

Non specific or generalized protection is offered by normal immunoglobulins while protection against specific diseases is given by using hyperimmune immunoglobulins

**Normal immunoglobulins**

Normal immunoglobulins provide non specific immediate ready made protection for upto three weeks. No live vaccine should be given for 12 weeks following administration of immunoglobulins. They should be administered at least two weeks after a live vaccine

**Examples:** Measles, Hepatitis A

**Specific hyperimmune immunoglobulins**

Specific hyperimmune immunoglobulins are made from plasma of recently recovered patients. They are to be given immediately after exposure. Peak blood levels are usually achieved in two days. They have a half life of three to five weeks

**Examples:** HBIG, VZIG, Rabies, Tetanus

Animal Anti-sera or anti toxin

Animal anti-sera are generally equine in origin. Their biggest draw back is that they may cause anaphylactic reactions or serum sickness

**Examples:** Diphtheria, Tetanus, Rabies, Botulism, Gas gangrene, Snake Bite.

Table - 4 : Immunizing agents

| | | |
|---|---|---|
| Live attenuated vaccines | BCG | Bacterial |
| | Typhoid, oral | |
| | Plague | |
| | Oral polio (Sabin) | Viral |
| | Yellow fever | |
| | Measles | |
| | Rubella | |
| | Mumps | |
| | Influenza | |
| | Chickenpox | |
| | Epidemic Typhus | Rickettsial |
| Inactivated or killed vaccines | Typhoid | Bacterial |
| | Cholera | |
| | Pertusis | |
| | C.S. meningitis | |
| | Plague | |
| | Hepatitis A | |
| | Hepatitis B | Viral |
| | Rabies | |
| | Salk (polio) | |
| | Influenza | |
| | Japanese Encephalitis | |
| | KFD | |
| Toxoids | Diphtheria | Bacterial |
| | Tetanus | |
| Human Immunoglobulins | Hepatitis A | Human normal |
| | Measles | |
| Immunoglobulin | | |
| | Rabies | |
| | Tetanus | |
| | Mumps | |
| | Hepatitis B | |
| | Varicella | Human specific |
| | Diphtheria | |
| Immunoglobulin | | |
| Non-human (Antisera) | Diphtheria | |
| | Tetanus | |
| | Gas gangrene | Bacterial |
| | Botulism | |
| | Rabies | Viral |

## National Immunization Schedule

Any immunization schedule is drawn up keeping two important factors in mind. Firstly the vaccines need to be administered in doses and schedules which produce an adequate immunological response in the recipient. Secondly the schedule should be administratively the most convenient and one which is likely to be most acceptable to the target population.

The National Immunization schedule drawn up for India factors in both these aspects (21). Only a quarter of all deliveries in India take place in some kind of a health care facility. Therefore, most infants are not available at birth for immunization. The schedule aims at minimizing the number of visits required to be made by the mother and child. The schedule also aims at minimizing the number of injections required to be given keeping in mind the risks that each injections poses for the infants. The schedule also keeps the time gap between visits as easy to remember as possible so that illiterate women also do not

Table - 5 : National immunisation schedule

| | |
|---|---|
| **Infants** | |
| At Birth | BCG, OPV – 0 (Institutional delivery) |
| 6 weeks | BCG (If not given at birth) |
| | DPT – 1, OPV – 1 |
| 10 Weeks | DPT – 2, OPV – 2 |
| 14 Weeks | DPT – 3, OPV – 3 |
| 09 months | Measles |
| **Children** | |
| 16 – 24 mths | DPT and OPV |
| 5 – 6 yrs | DT* |
| 10 yrs | TT* |
| 16 yrs | TT * |
| (If there is no clear evidence of previous immunization two doses one month apart to be given) | |
| **Pregnant Women** | |
| Early pregnancy | TT – 1 |
| One month later | TT – 2 |
| (In case of clear evidence of primary immunization or two doses during previous pregnancy, only single dose to be given) | |

have any problem in following the schedule. At the same time care has been taken to ensure that the schedule does not compromise the immunological efficacy of the vaccines.

## Immunization in Armed Forces

Immunization of troops against the enteric group of fevers and tetanus has proved efficacious to reduce the incidence of this disease and prevent outbreak in units, though stationed amidst epidemic or endemic localities. All ranks and their families and civilian employees, including private servants are therefore immunized. Those who refuse or neglect to be immunised run a personal risk and endanger the health of the community as a whole. The immunization against quarantinable disease under the International Health Regulations, 1971 viz, yellow fever, is carried out in the designated centers. Immunizations specially offered for infants and children are DPT, DT, polio, measles and BCG.

Commanders are responsible for maintaining the immunization state of units under their command at 100 % level at all times against the diseases notified, provide facilities for carrying out immunization recommended, maintain a unit vaccination register, ensure that personnel proceeding on leave or temporary duty or permanent transfer to another unit are fully protected prior to their departure and will not fall due for immunization during transit or soon after arrival at their destination, and ensure that all the families in the unit/station are fully protected. All personnel whose families are residing in places where there are no military establishments should be advised to get themselves protected from civil health authorities. Medical Officers are responsible for maintaining facilities for carrying out immunization and administering the same to all individuals who present themselves. They are also required to keep necessary records in the personal book (AB-64) of the individuals immunised and render such returns as may be called for by higher authorities after checking the unit immunization state. Medical officers should periodically check the protection state of the units under their medical care and ensure 100 per cent protection level at all times.

### Immunization Records

A register in which the details of immunizations are recorded for all ranks of the units is maintained by every unit/sub-unit commander as shown in Table - 6. The date of administration of Typhoid and TT should be recorded immediately in ink. The column which shows the 'date next due' should always be filled in pencil. Three or four lines should be allotted to each individual in these registers. A similar register should be maintained for families of all ranks living in the station. The unit administrative officer should ensure that the registers are maintained up-to-date, checked on the first day of every month and a list of individuals who are due for immunization sent to the MI Room/RAP. Personnel should then be sent in batches once a week, usually on a Saturday before the actual date on which due with a nominal roll and their personal books (AB-64) and Health Record Card. Entries in respect of officers and JCOs should be made in the Health Record Card and unit copy of the medical history AFMSF-1. The medical officer should ensure that all immunization carried out are at the same time entered in AB-64/AFMSF-1 and Health Record Card, dated and signed and the MO's name is entered in block capitals below his signature. From this nominal roll, the unit immunization register is brought upto-date.

The immunization schedule recommended for families and children of the Armed Forces personnel is as under :

(a) Schedule of routine immunization for children will be as per Table-5

(b) Schedule of Immunization for Women.

Table - 6 : Register of vaccination and inoculation

| Personal No. | Rank/Rate | Name | Typhoid Inolculation | | Antitetanus (TT) | | Special Immunisatio, If any | |
|---|---|---|---|---|---|---|---|---|
| | | | Date done | Date next due ( in pencil | Date done | Date next due ( in pencil | Date done | Date next due ( in pencil |

(i) It is desirable that women are also immunised against Tetanus with Tetanus toxoid. The procedure to be followed is the same as that for service personnel.

(ii) For protection of the neonates against Tetanus, the pregnant women should be adequately protected with Tetanus toxoid. Booster dose should be given to the women every time she becomes pregnant. The last dose of Tetanus toxoid should be given at least eight weeks before the expected date of delivery.

(iii) In case of pregnant women not protected against Tetanus earlier, the following schedule of Tetanus toxoid will be followed :

16 - 20 weeks - 1st dose

20 - 24 weeks - 2nd dose

**Immunization against Typhoid**

A typhoid vaccine is used for the pre-exposure active immunization. The vaccine used in the Armed Forces is a heat killed and phenol-preserved vaccine containing 1000 million S typhi. Routine immunization of all categories of entrants to the Armed Forces is to be carried out as soon as they join their training centers by giving vaccine as mentioned in Table 7. Families of service personnel are immunised under the same schedule. The dose will be reduced for the elderly and physically weak persons.

Reactions due to this vaccination vary in intensity from individual to individual but an overwhelming majority do not suffer for more than 48 hours, most of them showing only malaise after 24 hours. The most commonly occurring manifestation of reactions are local pain, swelling and redness, fever up to 39ºC, headache and body ache. Very few persons, particularly those in whom the interval after the previous injection had been much longer than one year or those in indifferent health, suffer from a severe reaction, which can be ameliorated by 0. 5 g of aspirin. The immunization does not abort the disease if the person is already incubating the infection, but it will do him no harm and probably reduces the severity and cut short the course of clinical illness.

**Immunization Against Tetanus**

This is an obligatory immunization in the Armed Forces. Pre-exposure active immunization is carried out by tetanus toxoid (TT) . For post-exposure passive immunization antitetanus serum may be administered.

Active Immunization

Tetanus Toxoid (TT) is used in the Armed Forces for pre-exposure immunization against Tetanus. It confers long lasting, active immunity. All ranks are immunised as soon as they enter the Armed forces and subsequently reimmunised with the procedure described below. The RMO should scrutinize the records of all newly posted personnel for this requirement and always ensure that the Immunization State of the personnel under his medical care is at 100 percent level. On recruitment, Armed Forces personnel should be immunized as per Table 8. A high degree of immunity is conferred only when the third dose of toxoid is administered. Therefore, it should be considered as part of the basic course of immunization. A 'booster' dose of 0. 5 ml given every five years maintains the immunity at a high level. The booster dose should be annually repeated when a greater liability to injuries is expected e.g. when a greater risk of contamination of wounds is expected e.g. while working in proximity with animals in AT Coy or dairy farms. In the event of a wound or injury with high risk of tetanus in a person who is adequately immunized, a booster dose of 0. 5 ml of TT should be given provided the last dose was given more than a year back. Injections are given deep intramuscularly. Rarely individuals with a history of asthma or hay fever may develop an allergic reaction, otherwise in normal individuals there is no particular reaction. Children who have received the full course of

Table - 7 : Dosage of typhoid vaccine

| Category | Initial Vaccination | | Re-vaccination | |
|---|---|---|---|---|
| | First dose (ml) | Interval | Second dose (ml) | Booster dose (ml) |
| Adult males/ Women/ | 0.5 | 4-6 weeks | 0.5 | 0.5 after 3 years |
| Children above 10 years | | | | |
| Children below 10 years | 0.25 | 4-6 weeks | 0.25 | 0.25 after 3 years |

Table - 8 : Dosage of tetanus immunisation

| Categories | Initial vaccination | | | Revaccination |
|---|---|---|---|---|
| | Ist dose | 2nd dose after 4-6 weeks | 3rd dose after 6 -12 months | every 5 yrs |
| Adult male/female/ children above 10 yrs | 0.5ml | 0.5ml | 0.5ml | 0.5ml |

triple antigen should get 5 yearly booster doses of TT.

**Col n**

All es are sensitive to heat to some extent, but some are sensitive than others. The commonly used EPI vac may be ranked according to their sensitivity to hea llows:

**M itive**

OPV
Measles
DTP, Yellow Fever
BCG
Hib, DT
Td, TT, Hepatitis B

**Least Sensitive**

(Note however, that all freeze-dried vaccines become much more heat-sensitive after they have been reconstituted, and it is then even more important that they are not exposed to heat.

**Sensitivity to cold**

Some vaccines are also sensitive to being too cold. For these vaccines, freezing or exposure to temperatures below zero degrees centigrade (0°C) can also cause loss of potency, and again, the ine will become useless. For these vac it is therefore essential to protect them not from heat, but also from freezing. The vac sensitive to freezing (as well as to heat) are

**Mo sitive**

Hep B
Hib (Liquid)
DTP
DT
Td
TT

**Least Sensitive**

**Sensitivity to light**

Some vaccines are also very sensitive to strong light. For these vaccines, exposure to ultraviolet light will also cause loss of potency, so they must always be protected against sunlight or fluorescent (neon) light. BCG, measles, MR, MMR and rubella vaccines are sensitive to light (as well as to heat) . Normally, these vaccines are supplied in vials made from dark brown glass, which gives them some protection against light damage, but care must still be taken to keep them covered and protected from strong light at all times (22, 23) .

**Recommended storage temperatures for vaccines**

The recommended conditions for storing vaccines are shown in Fig - 3. This diagram indicates the maximum times and temperatures in each case. At the higher levels of the cold chain, i. e. , at national (central) , and regional or province level, OPV must be kept frozen between minus 15 and minus 25 degrees centigrade (-15°C to -25°C) . Freeze-dried vaccines (i.e., BCG, measles, MMR and yellow fever) may also be kept frozen at –15°C to –25°C if cold chain space permits, but this is neither essential nor recommended. At other levels of the cold chain, these vaccines should be stored between plus 2 and plus 8 degrees centigrade (+2°C and +8°C) . All other EPI vaccines should be stored at between +2°C and +8°C at all levels of the cold chain (24) .

If a vaccine is damaged by heat and loses some of its potency, this loss can never be restored, and the damage is permanent. Each time heat damage occurs, the loss of potency accumulates, and eventually, if the cold chain is not correctly maintained, all potency will be lost, and the vaccine becomes useless.

Fig - 3

<table>
<tr><th rowspan="2">WHO recommended vaccine storage conditions</th><th rowspan="2">Primary</th><th colspan="2">Intermediate</th><th rowspan="2">Health Centre</th><th rowspan="2">Health Post</th></tr>
<tr><th>Region</th><th>District</th></tr>
<tr><td></td><td>6 months[a]</td><td>3 months</td><td>1 month</td><td>1 month</td><td>Daily use</td></tr>
<tr><td>OPV</td><td colspan="3">-15˚C to -25˚C</td><td colspan="2" rowspan="12">+2˚C to +8˚C</td></tr>
<tr><td>BCG</td><td colspan="3" rowspan="6">WHO no longer recommends that freeze-dried vaccines be stored at –20˚C. Storing them at –20˚C is not harmful but it is unnecessary. Instead, these vaccines should be kept in refrigeration and transported at</td></tr>
<tr><td>Measles</td></tr>
<tr><td>MMR</td></tr>
<tr><td>MR</td></tr>
<tr><td>Yellow Fever</td></tr>
<tr><td>Hib freeze-dried</td></tr>
<tr><td>HepB</td><td colspan="3" rowspan="6"></td></tr>
<tr><td>DTP-HepB</td></tr>
<tr><td>Hib liquid</td></tr>
<tr><td>DTP</td></tr>
<tr><td>DT</td></tr>
<tr><td>TT</td></tr>
<tr><td>Td</td></tr>
<tr><td colspan="6">Diluent vials must NEVER be frozen. When the manufacturer supplies a freeze-dried vaccine packed together with its diluent, ALWAYS store the product at between +2°C and +8°C. Where space permits, diluents supplied separately from the vaccine may safely be stored in the cold chain at between +2°C to +8°C<br>Note a. 6 months is the maximum recommended storage time at primary level. This includes the period required to obtain clearance from the National Regulatory Authority.</td></tr>
</table>

**Expiry date**

Even when stored at the correct temperature, vaccines do not retain their potency for ever, and all vaccines have an expiry date. This is the date by which the vaccine must be used, and will be printed on all vials and packets during

manufacture. The expiry date shown on each vaccine vial and on each packet assumes the vaccine has been properly stored and transported at all times, in accordance with the guidelines shown in the above Figure. If the vaccine has been damaged by heat or other causes however, its potency will be reduced even before the expiry date shown on the vial or packet is reached.

Only vaccine stocks which are fit for use should be kept in the vaccine cold chain. Any expired vials, heat damaged vials or vials with VVMs beyond the discard point should not be kept in the cold store, refrigerator or freezer, as they may be confused with good quality vaccines. If unusable vaccines need to be kept for a period before disposal, for example, until accounting or auditing procedures have been completed, such vials should be kept outside the cold chain, separated from all usable stocks and carefully labeled to avoid mistaken use (24) .

**Correct conditions for storing diluents for vaccines**

Diluents for vaccines are less sensitive to storage temperatures than the vaccines with which they are used, but may be kept in the cold chain between +2°C to +8°C if space permits. When vaccines are reconstituted, the diluent should be at same temperature as the vaccine, so sufficient diluent for daily needs should be kept in the cold chain at the point of vaccine use (health centre or vaccination post) . At other levels of the cold chain (central, provincial or district stores) it is not necessary to keep any diluent in the cold chain unless it is planned to use it for reconstituting vaccine within the next 24 hours. However, diluent vials must never be frozen. This will risk cracking the glass and allowing contamination of the contents, so diluent vials must never be kept in a freezer, or allowed to be in contact with any frozen surface (25) .

Freeze-dried vaccines and their diluents should always be distributed together in matching quantities. The vaccines must be kept in the cold chain between +2°C and +8°C at all times, or optionally, at –15°C to –25°C if cold chain space permits. For each distribution link, the cold chain will normally comprise cold boxes or vaccine carriers with ice packs. The diluents do not need to be kept in the cold chain unless they will be used for within the next 24 hours. However, diluents must travel with the vaccine at all times, and the diluent must always be of the correct type, and from the same manufacturer as the vaccine which it is accompanying. This is essential to ensure that the health worker always has equal numbers of vaccine vials and diluent vials for reconstituting them, and that he/she has the correct type of diluent for the vaccine being used.

Diluents may appear to be simple water, but in fact usually contain a variety of salts, chemicals and additives required to stabilize a specific vaccine after reconstitution. Each vaccine requires a specific diluent and therefore, diluents are not interchangeable. Therefore, diluent made for measles vaccine, for example, must not be used for reconstituting BCG, yellow fever or any other type of vaccine. Likewise, diluent made by one manufacturer for use with a certain vaccine cannot be used for reconstituting the same type of vaccine produced by another manufacturer. This means that diluent for measles vaccine made by company 'A' cannot be used for reconstituting measles vaccine made by company 'B'.

Some combination vaccines comprise a freeze-dried component (such as Hib) which is designed to be reconstituted by a liquid vaccine (such as DTP or DTP-HepB liquid vaccine) instead of a normal diluent. For such combination vaccines, it is again vital that ONLY vaccines manufactured and licensed for this purpose are combined. Note also that for combination vaccines where the diluent is itself a vaccine, ALL components must now be kept in the cold chain between +2°C and +8°C at all times. As for all other freeze dried vaccines, it is also essential that the 'diluent' travels with the vaccine at all times.

**Cold Chain**

Cold chain is a system of transporting and storing vaccines at recommended temperature from manufacturer to the point of use. All the vaccines can be stored at temperatures between +2 °C to +8°C. However for long term storage of OPV and Measles call be stored at sub zero temperatures in deep freezers. DPT, DT and TT should never be frozen. BCG and diluent ampoules should not be frozen, as ampoules are likely to crack. Diluents required for measles and BCG should be stored at +2 °C to +8 °C in the refrigerator.

**Cold Chain includes**

(a) Walk in cold rooms (WICs)
(b) Deep freezers
(c) Ice - lined refrigerators (ILRs)
(d) Refrigerators
(e) Cold box
(f) Vaccine carrier
(g) Day carrier
(h) Ice packs

Walk in cold rooms

These are used for the storage of large quantities of vaccines. They require constant electric supply. Vaccines can be stored up to 3 months. They serve a region of 4-5 districts.

Deep freezers and ILRs

These are provided at the district and CHC level and can store upto 1 month supply of vaccines. Capacity is 300/240 L. they can be used for storing OPV and measles. Ice packs are also prepared.

Small Deep Freezers and ILRs

These are provided at the PHC and can store upto 1 month supply of vaccines. Capacity is 140 L. They do not have a freezer compartment.

Refrigerators

While using a refrigerator for the purpose of keeping vaccines, certain Do's and Don'ts to be followed are given in Table - 9.

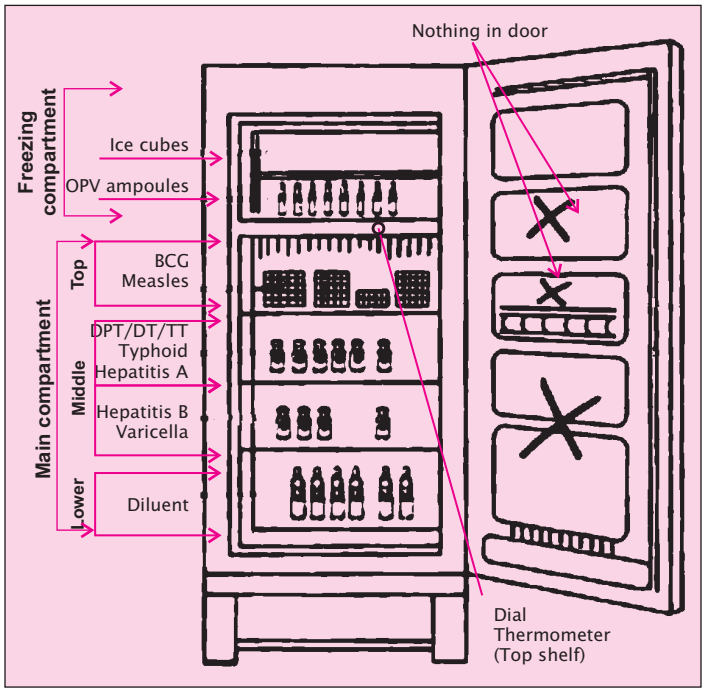
Vaccine Carriers

Used for transporting small quantity of vaccines to sub center. These are made of insulating material. Each carries

Table - 9

| Do's |
|---|
| Keep in cool room away from sunlight |
| At least 10 cm away from the wall |
| Keep ice pack in freezer |
| Defrost periodically |
| Check temp. and maintain record |
| **Dont's** |
| Open unless necessary |
| Keep vaccine in the door |
| Keep food inside |
| Keep more than one month's requirement |
| Keep expired vaccines |

Fig - 4 : Refrigerator showing vaccines stored correctly in clinic setup




four ice packs. The vaccines should be used on the same day. They should be kept away from direct sunlight.

Day Carriers

These are also made of insulating material and carry two ice packs. They can keep few vials for 6 to 8 hrs at a time.

Ice Packs

These are flat plastic water bottles filled with water. They are available in three capacities: 400ml, 500ml and 600ml. they are prepared by keeping in freezer. Water is filled upto the mark on the bottle. They should be kept frozen and ready for use. Cracked bottles should be discarded.

Quality of Cold Chain

The quality of the cold chain is monitored by the National Quality Control Lab. Located at Kasauli. The quality check is done before release of the vaccines. Reverse Cold Chain is also maintained to check vaccines for their potency.

### Vaccine stock management

**Vaccine stock management is done at three points**

(a) When vaccine consignments arrive at the storage point
(b) While vaccines and diluents remain in storage
(c) When vaccine and diluent stocks leave a storage point

When vaccine consignments arrive at the storage point

**The information to be recorded is**

(a) The type of vaccine
(b) The quantity received (in doses)
(c) The vaccine manufacturer
(d) The manufacturing batch or lot number (s) - (note there may be more than one batch or lot in a consignment)
(e) The expiry date (s) for each batch or lot
(f) The status of the Vaccine Vial Monitors (VVMs) on arrival of the consignment
(g) The status of the Cold Chain Monitor card (CCM) on arrival of the consignment

While vaccines and diluents remain in storage it is necessary to note the following details:

(a) All stocks must be distributed well before their expiry date
(b) Regularly check the expiry dates of the stock
(c) The principle of "earliest expiry first out (EEFO) " should be followed

When vaccine and diluent stocks leave a storage point, that is, at the time of distribution the information to be recoreded is:

(a) The quantity distributed (in doses)
(b) Batch numbers and expiry dates
(c) The destination for the consignment (i. e. , name of the region, province, district, etc)
(d) The balance remaining (in doses) of that batch or lot number after subtracting the amount distributed (26).

## UIP Vaccines

### BCG Vaccine

The BCG vaccine was first used to immunize humans in 1921. Following its introduction into the WHO Expanded Programme on Immunization in 1974, the vaccine soon reached global coverage rates exceeding 80% in countries endemic for TB. At present, about 100 million children receive BCG vaccine each year. Although the oldest of currently used vaccines, BCG is still controversial in that there are conflicting data on its protective efficacy. Most high-burden countries practice BCG vaccination of infants as part of the national childhood immunization

programme, but in industrialized countries, where the disease has become rare, vaccination of defined high-risk groups is increasingly becoming the preferred strategy(27).

A number of BCG vaccine strains are available, although the French Pasteur strain 1173 P2, the Danish strain 1331, the Glaxo strain 1077 and the Tokyo strain 172 account for about 90% of BCG vaccinations worldwide. In terms of efficacy, no BCG strain is demonstrably better than another, and there is no global consensus as to which strain of BCG is optimal for general use.

Administration of the vaccine

WHO recommends intradermal application of the vaccine, preferably on the deltoid region of the arm using special syringe as early as possible after birth. Newborn accines should receive half the dose given to older children. Within a few months of vaccination, the local reaction is replaced by a small scar. Presence of a typical scar is used as a marker of previous BCG vaccination but is not a marker of protection against TB. In the absence of a scar in children in endemic countries, BCG vaccination should be repeated.

Vaccine efficacy

Vaccine efficacy ranges from 0 to 80 percent. The Copenhagen vaccine strain showed 77% protection following vaccination of schoolchildren in England and 0% protection when used in the general population of southern India. BCG vaccine has protective effect against meningitis and disseminated TB in children Meta-analysis of 10 randomized and controlled studies showed that the average protection against TB meningitis and disseminated disease was 86%; the corresponding result of case-control studies was 75%(28,29,30)..

Duration of protection

The duration of protection after neonatal BCG vaccination is not well known but commonly believed to decline gradually to non-significant levels after 10-20 years. BCG vaccination does not prevent reactivation of latent TB, the main source of bacillary dissemination in the community. Hence, BCG vaccination has essentially no impact on TB transmission.

Adverse events

Complications following BCG vaccination are rare: Significant local reactions, such as extensive local ulceration and regional lymphadenitis occur in <1:1000 persons(31).

Indications and Contraindications as recommended by WHO

**Indications**

(a) For all infants living in areas where TB is highly endemic

(b) For infants and children at particular risk of TB exposure in otherwise low-endemic areas

(c) For persons exposed to multidrug-resistant MTB

**contraindications**

(a) For persons with impaired immunity (symptomatic HIV infection, known or suspected congenital immunodeficiency, leukaemia, lymphoma or generalized malignant disease);

(b) For patients under immunosupressive treatment (corticosteroids, alkylating agents, antimetabolites, radiation)

(c) In pregnancy.

New vaccines against TB

In recent years, there has been a dramatic increase in the number of candidate TB vaccines evaluated in research laboratories. Better understanding of the immunological deficits of BCG and impressive progress in knowledge of mycobacterial genomics have paved the way for promising new products. The main vaccine targets are prevention of infection in naive individuals, prevention of reactivation of latent infection and therapeutic vaccines to prevent relapses in TB patients. Currently, the most favoured research strategies include recombinant modified BCG vaccines, attenuated strains of MTB, subunit vaccines and DNA vaccines.

**Summary : BCG Vaccine**

- Attenuated M. tuberculosis var bovis developed in 1921.
- Protects against TB Meningitis, Miliary TB especially in Children
- Maternal antibodies do not interfere with BCG vaccine as CMI is not transferred transplacentally, hence should be given as early as possible after birth
- Vaccine efficacy ranges from 0 to 80 percent. Neonatal immunization induces long term protection
- Supplied freeze dried, store frozen or refrigerated
- Use reconstituted BCG within 4-6 hours
- Inject intradermally over left shoulder at the insertion of Deltoid.
- Local lesion due to bacterial multiplication; Heals leaving scars; If no scar, repeat BCG

**Polio Vaccine**

Poliomyelitis is an acute communicable disease caused by poliovirus types 1, 2 and 3, transmitted through person-to person contact. In the pre-vaccine era, virtually all children were exposed to poliovirus, and on average 1 out of 200 susceptible children infected by poliovirus developed paralytic poliomyelitis.

An effective IPV(Salk vaccine), comprising all three serotypes, was licensed after large-scale field trials in 1955. Extensive use of this vaccine decreased poliomyelitis incidence in many industrialized countries and interrupted wild poliovirus transmission. Starting in 1963, trivalent OPV (Sabin vaccine) replaced IPV as the primary means of prevention of poliomyelitis in most countries, because of the ease of administration, enhanced mucosal immunity providing a more effective barrier to transmission and community wide circulation of wild poliovirus, secondary spread of Sabin-derived

vaccine virus from vaccinees to close contacts thus immunizing some unvaccinated contacts and lower cost(32).

Oral Polio Vaccine

The oral polio vaccine is a suspension of over 1 million particles of polioviruses type 1, 2 and 3 together. It is supplied with a stabilizing agent, namely magnesium chloride. Therefore the potency is quite stable under refrigeration or freezing. The virus survives the acidity of the stomach and confers local immunity. However, for reasons not clearly understood, the 'take' rate is relatively low in our children. For the above reason, multiple doses of OPV are necessary before 90 – 95% of children develop immune responses to all 3 poliovirus types. In addition to the "Routine OPV doses", "Pulse OPV doses every year on National Immunization days (NID's) till the age of 5 years are also mandatory. The risks due to OPV comprise cases of vaccine-associated paralytic poliomyelitis (VAPP), outbreaks of circulating vaccine-derived polioviruses (cVDPVs) and long-term carriers of VDPVs identified among immunodeficient persons (iVDPVs)(33).

Eradication is defined as no case of paralytic poliomyelitis by wild polio virus in last 3 calendar years along with absence of wild polio virus in the community, where excellent clinical and virological surveillance exists and the coverage of routine OPV is more than 80%.

Polio elimination is defined as Zero cases of paralytic poliomyelitis by the wild polio virus in one calendar year with other criteria same as in eradication.

(a) Adequate immunization is the method of eradication

(b) Clinical surveillance is the method to identify AFP status

(c) Virological investigations are necessary to document confirmation of polio virus.

**Summary: Oral Polio Vaccine**

- Live attenuated Poliovirus types 1, 2 and 3 developed by SABIN, 1961
- Temperature sensitive, store frozen or refrigerated
- Can be given simultaneously with any other vaccine
- Multiple doses necessary to ensure vaccine virus take and antibody response to all 3 types of polioviruses
- First dose is recommended in the newborn period or as early as possible
- IAP recommends additional doses of OPV as a part of Pulse Polio programme every year till the age of 5 years.

**Summary: Injectable (Killed) Oral Polio Vaccine**

- Formaldehyde Killed Polio Virus grown in monkey kidney / human Diploid cell
- Contains 20, 8 and 32 D antigen units against type 1, 2 and 3 Polio Viruses respectively
- Seroconversion 90-95% after 2 doses and 99% after 3 doses
- Thermostable and is indicated in Immuniocompromised individuals, HIV infection and

Pulse Polio Immunization

On National Immunization Days (NID's), pulse doses of oral polio vaccine has to be administered, simultaneously to all susceptible infants and children, would produce immunity to all and prevent wild poliovirus to multiply in the gut.

Injectable Killed Polio Vaccine (IPV)

IPV is formaldehyde killed poliovirus grown in monkey kidney cell/human diploid cells containing 20, 8 & 32 D antigen against type 1, 2 and 3 poliovirus respectively. It is highly immunogenic. Seroconversion is 90-95%, after 2 doses and 99% after 3 doses. It produces excellent humoral immunity as well as local pharyngeal and possible intestinal immunity. The vaccine is very safe. However, it is not available at present in the Indian market for routine use and is licensed only for use in immunocompromised children.

**DPT Vaccine**

Diphtheria is a potentially acute disease caused by exotoxin producing Corynebacterium diphtheriae.

The combination of diphtheria toxoid, whole cell killed pertussis vaccine and tetanus toxoid is popularly known as the triple antigen. While the two toxoids are highly immunogenic and antibodies to them are almost completely protective, the pertussis vaccine, given in 3 doses, has a protective efficacy of about 70-80% only.

Administration of the vaccine

The DPT must be injected intramuscularly and the preferred site is the anterolateral aspect of the thigh. The immunization should begin by six weeks of life and completed before the ninth month at the latest, although it can be given at any period before 5 years of age. Initially three doses at monthly intervals are injected intramuscularly. Booster doses are given during the second year and just before the child starts going to school(34).

Adverse events and Contraindications

**Summary: DPT Vaccine**

- Diphtheria toxoid (Ramon & Glenny, 1923)
- Killed Bordetella pertussis (Madsen, 1923)
- Tetanus toxoid (Ramon & Zoeller, 1927)
- Toxoids adjuvanted (Aluminium hydroxide/phosphate)
- DPT vaccine supplied as liquid, store refrigerated
- Aluminium adjuvanted vaccines should not be frozen
- Inject intramuscularly, anterolateral thigh
- Alert parents about local reaction and fever; Paracetamol to be given to reduce pain/fever
- Progressive neurological disease or serious adverse reaction to earlier dose are contraindications for DPT; replace with DT Vaccine

Local pain and redness and fever after DPT are almost entirely due to the pertussis component. Convulsions following DPT vaccine are rare, and when occur, they may be the earliest signs of some incipient neurological disease in the infant. For these reasons, progressive neurological diseases are the only contraindication to first dose of DPT immunization. Severe adverse reactions in the form of anaphylaxis and encephalopathy occurring within 7 days to the earlier dose are contraindications for subsequent doses of DPT(35-39).

### Tetanus Toxoid

Indian Academy of pediatrics recommend TT at 10 and 16 years. After completing the full course of 7 doses, there is no need for additional doses during pregnancy, at least for the next 10 years. Thereafter a single booster would be sufficient to extend immunity for another 10 years. For pregnant women who have not had previous immunization, at least 2 doses should be given during pregnancy so that protective antibody would be transferred to the infant in order to prevent neonatal tetanus. Td is the preferred preparation for active tetanus immunization in wound management of patients greater than or equal to 7 years of age. Because a large proportion of adults are susceptible, this plan enhances diphtheria protection. For inadequately vaccinated patients of all ages, complete primary vaccination should be ensured

### Tetanus Immunoglobulin (TIG)

It is a liquid or freeze-dried preparation containing immunoglobulins, mainly IgG obtained from plasma or serum containing specific antibodies against the toxin of Clostridium tetani.

#### Indications

Burns, injuries, open and compound fractures. Unimmunised or inadequately immunised mothers.

#### Contraindications

Subjects already sensitized with serums of animal origin, existence of prior or present allergic manifestations (asthma, eczema, etc).

#### Adverse Effects

Local pain, fever, flushing, headache and chills may occur.

#### Dosage

Prophylaxis 250 – 500 I.U. Intramuscular.

Therapeutic : Tetanus neonatorum 500 – 1000 I.U. intramuscular or 250 I.U. intrathecal.

In adults and children 500 – 1000 I.U. intramuscular and / or 250 – 500 I.U. intrathecally.

### Measles Vaccine

Measles is an extremely contagious viral disease that, before the widespread use of measles vaccine, affected almost every child in the world. High-risk groups for measles complications include infants and persons suffering from chronic diseases and impaired immunity, or from severe malnutrition, including vitamin A deficiency.

The Measles vaccine consists of live attenuated Measles virus, developed by Enders, in 1960. The original virus strain was isolated from a child by the name Edmonston; therefore the virus strain was also named Edmonston. In liquid suspension the vaccine virus is very heat-labile; in the freeze-dried state the shelf life of the vaccine is one to two years. The vaccine may be stored frozen or refrigerated. But, after reconstitution, the vaccine should be injected within 4-6 hours. During such interval the liquid vaccine should be kept cold, either in the refrigerator or vaccine carrier.

#### Administration of the vaccine

The vaccine should be injected subcutaneously. The preferred site is right upper arm; this is only for uniformity. It can also be injected over the anterolateral thigh, but subcutaneously. The vaccine induces both humoral and cellular immune responses comparable to those following natural infection.

#### Vaccination schedule and vaccine efficacy

The optimum age for measles vaccination depends on the local epidemiological situation and on programmatic considerations. Given the immaturity of the immune system as well as the presence of neutralizing maternal antibodies, vaccination of infants before or at 6 months of age may often fail to induce immunity. In most developing countries, children are vaccinated against measles at 9 months of age, when seroconversion rates of 80–85% may be expected. In case of an outbreak (or impending outbreak) infants completed 180 days (6 months) may be given the vaccine, provided such infants (given vaccine below 9 months) are revaccinated after at least 3 months of interval. A single dose of live, attenuated measles vaccine is generally felt to provide lifelong protection(40,41).

#### Adverse reactions

Adverse reactions following measles vaccination, alone or in fixed combinations, are generally mild and transient. Slight pain and tenderness at the site of injection may occur within 24 hours, sometimes followed by mild fever and local Lymphadenopathy. Thrombocytopenia purpura occurs in approximately 1 in 30 000 vaccinated

**Summary: Measles Vaccine**

- Live attenuated Measles virus vaccine developed by Enders, 1960
- Vaccine further attenuated (Eg. Schwarz, Edmonston-Zagreb)
- MV supplied freeze dried, Store frozen or refrigerated
- Use reconstituted vaccine within 4-6 hours (Refrigerate, do not freeze)
- Inject subcutaneously, preferably right upper arm
- Recommended age 9 months (270 days ) plus
- During Measles outbreak, may be given at 6 months Plus
- If given at < 9 months, repeat dose after interval of at least 3 months
- Alert parents of fever 5-10 days later; Paracetamol may be given

individuals

## NON UIP VACCINES

### Mumps Vaccine

Mumps (or parotitis epidemica) is a viral infection primarily affecting the salivary glands mostly causing a mild childhood disease but it may also affect adults, among whom complications such as meningitis and orchitis are relatively common.

Mumps Vaccine can be prevented by vaccination given either as a monovalent vaccine or as part of MMR vaccine. A live attenuated monovalent Mumps vaccine was first developed by Hilleman in 1966. The mumps component in MMR vaccine contains live attenuated Mumps virus. Mumps vaccines are recommended for use in a 1-dose schedule, given at age 12-18 months(42)

Adverse reactions

In general, adverse reactions to mumps vaccination are rare and mild. The most common adverse reactions following mumps vaccination are parotitis and low-grade fever.

### Rubella Vaccine

Rubella occurs worldwide and is normally a mild childhood disease. However, infection during early pregnancy may cause fetal death or congenital rubella syndrome characterized by multiple defects, particularly to the brain, heart, eyes and ears(43,44).

A live attenuated Rubella vaccine was developed by Waller in 1962. The current rubella vaccine available commercially is derived from RA 27/3 vaccine strain grown in human diploid cell cultures. It is available either as a monovalent vaccine or as a part of combination vaccine – MMR. It contains live attenuated virus not less than 1000 TCID50. It is a highly immunogenic vaccine with positive antibody response in 95% of susceptible vaccinees. It provides long term and probably life long protection(45,46).

The primary purpose of rubella vaccination is to prevent the occurrence of congenital rubella infection including CRS. Two approaches are recommended by WHO:

(a) Prevention of CRS only, through immunization of adolescent girls and/or women of childbearing age

(b) Elimination of rubella as well as CRS through universal vaccination of infants and young children (with/ without mass campaigns), surveillance, and assuring immunity in women of childbearing age.

### MMR Vaccine

MMR Vaccine is available as single as well as multidose (5 dose) vial. The diluent for injection is available separately. The dose of the reconstituted vaccine is 0.5 ml per dose, to be administered subcutaneously in the upper arm. The vaccine should be stored between +2 to +8°C in the ordinary compartment of the fridge. Reconstituted vaccine should be used within 6 hours.

IAP recommends a dose of MMR vaccine to all children. For infants given Measles vaccine at 9 months, MMR vaccine may be given between 12-15 months of age. If Measles vaccine is given later, a 3 months gap is advisable. If Measles vaccine was missed altogether, one MMR dose should be given at or after 12 months. The vaccine can be given along with any other vaccine like DPT, OPV but at different sites using different syringes and needles(47).

### Hepatitis B Vaccine

The main objective of hepatitis B immunization strategies is to prevent chronic hepatitis B virus (HBV) infection and its serious consequences, including liver cirrhosis and hepatocellular cancer (HCC) (49).. Routine vaccination of all infants against HBV infection should become an integral part of national immunization schedules worldwide

In India, 3-7% of individuals, from school age upwards, are found to be chronic carriers of Hepatitis B Virus (HBV). The younger the age of infection, the higher the chance of becoming chronically infected as carrier. The World Health Organization recommends universal Hepatitis B Vaccination.

Administration of the vaccine

Two types of hepatitis B vaccines are available: plasma derived vaccines and recombinant vaccines. The two vaccines show no differences in terms of reactogenicity, efficacy or duration of protection. The complete vaccine series induces protective antibody levels in >95% of infants, children and young adults.

Hepatitis B vaccine should be given IM at antero-lateral thigh in infants. In older children/adults it should be administered at deltoid region. The minimum recommended interval between the doses is four weeks. Longer dose intervals may increase the final anti-HBs titres but not the seroconversion rates(49).

Using the principles described, the IAP recommends the commencement of HB immunization at birth. Two alternate schedules are available:-

(a) Infants
  (i) Birth, 6 and 14 weeks
  (ii) 6, 10 and 14 weeks. (Combined DTPw/Hepatitis B vaccine can be preferred)

(b) For older children, adolescents and adults the recommended schedule is elected date, 1 month and 6 months Booster dose is not recommended as of date.

As an adjuvanated vaccine, it should not be frozen. If frozen accidentally, the vaccine should be discarded.

Adverse Events

In placebo-controlled studies, with the exception of local pain, reported events such as myalgia and transient fever have not been more frequent than in the placebo group. Reports of severe anaphylactic reactions are also very rare.

Contraindications and Precautions

Hepatitis B vaccination is contraindicated for persons with a history of hypersensitivity to yeast or to any vaccine component. Pregnancy is not a contraindication to vaccination. Limited data indicate no apparent risk for adverse events to developing fetuses when hepatitis B vaccine is administered to pregnant women (50).

Passive immunization against hepatitis B

Temporary immunity may be obtained using hepatitis B immune globulin (HBIG) for post-exposure prophylaxis.

HBIG prophylaxis may be indicated

(a) For newborn infants whose mothers are HBsAg-positive

(b) Following percutaneous or mucous membrane exposure to HBsAg-positive blood or body fluids

(c) Following sexual exposure to an HBsAg-positive person

(d) To protect patients from recurrent HBV infection following liver transplantation.

HBIG does not interfere with generation of antibody response to hepatitis B vaccine. As a rule, HBIG should be used as an adjunct to hepatitis B vaccine. However, in full-term newborns, the protection against perinatally acquired infection achieved by immediate (<24 hours) hepatitis B vaccination is not significantly improved by the addition of HBIG.

**Summary HB Vaccine - *Development of Vaccines***

- Safe, immunogenic, effective HB vaccine available since 1982
- Highly purified preparation of HBsAg
- HBsAg is a glycoprotein that makes up outer envelope of HBV
- Two type of vaccine : plasma derived and Recombinant DNA
- To be shipped and stored at 2° C - 8° C
- IM Injection at deltoid in adult, adolescent and children and anterolateral thigh in neonates and infants upto 2 years
- Immunogenicity is > 95% in a variety of vaccination schedules
- No booster dose recommended

**Dosage:** Following exposure to HBsAg.

**Adults:** 1000 – 2000 I.U., I.M.

**Children:** 32-48 I.U.,/kg body wt. This should be administered within 7 days (preferably within 48 hrs) after exposure to HBsAg.

**Neonates:** Initial dose is 100 – 200 I.U. The first dose should be administered within 5 days after birth. The booster dose should be 32 – 48 I.U./kg of body wt., between 2 & 3 months after initial dose.

### Typhoid Vaccine

Typhoid fever is a serious systemic infection caused by the enteric pathogen Salmonella typhi. The infection is spread by the faecal-oral route and closely associated with poor food hygiene and inadequate sanitation. Typhoid fever is widely prevalent in India and three different types of vaccines are available. The choice of vaccine depends upon the age of commencement of the vaccine and the availability.

The Whole Cell Typhoid Vaccine

The heat-killed, phenol-preserved, and the acetone killed lyophilized whole cell Salmonella typhi vaccine was developed one century ago. This typhoid vaccine is extremely safe from serious reactions and is reasonably effective .

Primary course include 2 doses, 4 or more weeks apart and a single booster dose is recommended every 3 years. In field trials the vaccine has been associated with fever and systemic reactions in 9%-34% of the recipients, and with short absences from work or school in 2%-17% of cases This vaccine is extremely cheap and well suited for giving to children of families who cannot afford more expensive vaccines(51).

The Vi Polysaccharide Vaccine:

The Vi polysaccharide, purified and adjuvanted is another satisfactory typhoid vaccine with reasonable efficacy & low reactogenicity. As polysaccharide antigens are T cell independent, this vaccine is

(a) Non-immunogenic below 2 years of age

(b) Induces IgM response without IgG response

(c) Not able to induce immunological memory; hence not able to induce booster effect.

When a dose is repeated 3-5 years later, it induces response similar to the first dose. Adverse reactions seem limited to fever (0%-1%), headache (1.5%-3%) and erythema or induration >1 cm at the site of injection (7%)(52).

Oral Ty21a Vaccine:

This is a live attenuated strain of S. typhi Ty21a that was developed in the early 1970s by chemical mutagenesis. This live attenuated strain of S.typhi, namely Ty21a, is genetically stable, and does not revert to virulence. Indeed it does not induce a true "infection" as only very limited multiplication occurs in the gastrointestinal tract after oral feeding. It is not excreted in large numbers and is non-transmissible under natural conditions. Very large number of bacteria are necessary as oral doses in order to achieve sufficient degree of local immunity, which is the main basis of protection afforded by this vaccine. The bacteria are acid-labile. Hence the stomach acidity has to be either neutralised or bypassed when Ty21a is fed orally. The vaccine is administrated orally as enteric coated capsules and is registered for use from 6 years of age. The vaccine is to be given in three sittings, on alternate days. The protective efficacy is as good as other available typhoid vaccines. Immunization needs to be repeated every 3-5 years(53,54).

### Hib Conjugate Vaccine

Haemophilus influenzae type b (Hib) is estimated to cause at least 3 million cases of serious disease every year and 3,86,000 deaths. Although cases occur worldwide, the

**Summary: Typhoid Vaccine**

**1. Whole Cell**

- Killed S. typhi, often with S. paratyphi A (TA)
- Developed by Wright, 1896
- Liquid, store refrigerated, inject subcutaneously
- Primary course: 2 doses 4 weeks
- Boosters: Once in 3-5 years
- Dose: 0.5 ml SC

**2. Vi polysaccharide**

- Vi polysaccharide, developed by Robbins, 1984
- Liquid, adjuvanted, store refrigerated
- Inject IM; give at or after 2 years of age
- Dose 0.5 ml
- To be repeated 3 years later

**3. Oral**

- Live attenuated S.typhi, developed by Germanier, 1975
- Strain name: Ty 21 a
- Enteric coated capsules: store refrigerated administrative orally on alternate days, 3 doses
- To be repeated 3-5 years later

burden of Hib disease is most significant in developing countries.

Haemophilus influenzae type b vaccine is a very effective and safe vaccine. Both PRP-T and PRP - CRM 197 conjugate Hib vaccine are now available in India. All Hib-containing vaccines should be stored at between +2 ˚C and +8 ˚C. Liquid Hib vaccine should never be frozen (55).

Vaccine Administration

As Hib disease is age dependant and Hib immunization

**Summary: HIB Vaccine**

- H. influenzae b capsular polysaccharide
- Conjugated to protein antigens to improve immunogenicity
- Monovalent or DPT / Hib conjugate
- 3 doses 1-2 months apart
- Booster at 15-18 months
- Beyond 18 month a single dose up to 5 years

involves boosting of natural immunity, 3 doses when initiated below 6 months, 2 doses between 6 to 12 months and 1 dose between 12 to 15 months should be given. A booster is recommended at 15 to 18 months. Beyond 18 month a single dose is recommended upto 5 years of age and above 5 years Hib vaccination is not recommended (56,57).

Hib vaccine has not been associated with any serious adverse effects. However, redness, swelling and pain at the site of injection may occur in as many as 25% of those who have been vaccinated(58).

### Japanese B Encephalitis Vaccine

Japanese encephalitis (JE) is the most important form of viral encephalitis in Asia. It is estimated that the JE virus causes at least 50 000 cases of clinical disease each year, mostly among children aged <10 years, resulting in about 10 000 deaths and 15 000 cases of long-term, neuro-psychiatric sequelae.

Currently, the three types of JE vaccines in large scale use are (59)

(a) The mouse brain-derived, purified and inactivated vaccine, which is based on either the Nakayama or Beijing strains of the JE virus and produced in several Asian countries

(b) The cell culture-derived, inactivated JE vaccine based on the Beijing P-3 strain

(c) The cell culture-derived, live attenuated vaccine based on the SA 14-14-2 strain of the JE virus.

Both the mouse-brain derived and the cell culture-based vaccines are considered efficacious and to have an acceptable safety profile for use in children. However, with the mouse-brain derived vaccine, rare cases of potentially fatal acute disseminated encephalomyelitis and hypersensitivity reactions have been reported among vaccinated children in endemic regions and in travellers from non endemic locations(60-62).

Many Asian countries have adopted a schedule of 2 primary doses preferably 4 weeks apart, followed by a booster after 1 year. In some countries, subsequent boosters are recommended, usually at about 3-year intervals up to the age of 10–15 years(59).

This vaccine is based on the genetically stable, neuro attenuated SA 14-14-2 strain of the JE virus, which elicits broad immunity against heterologous JE viruses. Case control studies and numerous large-scale field trials in China have consistently shown an efficacy of at least 95% following 2 doses administered at an interval of 1 year(63).

The Indian strain of the Japanese B Encephalitis vaccine produced by Central Research Insititute, Kasauli, Shimla, is available through central and state health authorities for use in endemic areas during epidemic situation in the specific regions of the country where the infection is prevalent.

### Meningococcal Vaccine

Meningococcal meningitis and septicaemia are caused by various sero groups of Neisseria meningitidis. Endemic disease occurs worldwide and is mostly caused by meningococci of serogroups A, B, or C. The group A meningococcus is the predominant cause of large epidemics.

Vaccines are available against four serogroups of meningococci A, C, W-135 and Y. No effective serogroup B vaccine is presently available. The vaccines are either

monovalent i.e. A, C, etc. or polyvalent i.e. A-C, A-C-Y, A-C-Y-W135, etc. The efficacy rate of a single dose of serogroup A or serogroup C vaccine is 90% in adults and children over 2 years of age. The four polysaccharide antigens ( A, C, Y and W135 ) have been combined into a tetravalent vaccine. It is available in single-dose and multi-dose vials distributed as lyophilized powder that contains 50 micrograms of each component per dose. The vaccine should be stored at -20oC(64,65).

Dosage and Route of Administration

For both adults and children, vaccine when reconstituted is administered subcutaneously as a 0.5 ml dose. Protective levels of antibody can be expected after 7-10 days.

Indications (64)

(a) Routine immunisation of recruits may be considered. This practice has eliminated nearly all diseases among military personnel in the United States(66).

(b) In household contacts, as an adjunct to chemoprophylaxis.

(c) Routine immunization for asplenic people and those with previously described immunodeficiencies.

(d) Vaccination is recommended for outbreak control for disease caused by any of the serotypes carried by the vaccine.

(e) Travellers to hyperendemic or endemic areas .

Precautions and Contra-indications

Adverse reactions are mild and consist of pain and tenderness at the site of injection for 1-2 days. Mild to moderate local reactions range from infrequent to more than 40%, among vaccine recipients(67,68). No adverse effects have been documented among women vaccinated during pregnancy or their newborns. There are no known contraindications. The vaccine is not recommended for use in children under 2 years of age(69,70).

Revaccination

The need for revaccination of older children and adults has not been determined, antibody levels decline rapidly over 2 to 3 years and if indications still exist for immunisation, revaccination may be considered within 3 to 5 years (71).

Varicella Vaccine

**Summary: Varicella Vaccine**

- Developed by Takahashi in 1971 in Japan
- Live attenuated Oka Strain
- Vaccine available as Lyophilized powder
- Dissolve in 0.5 ml diluent
- SC Injection
- Single dose 12 months – 12 years
- Two doses beyond 13 years; 1 month apart
- Efficacy 95- 99%
- No booster dose recommended

Varicella (chickenpox) is an acute, highly contagious viral disease with worldwide distribution. While mostly a mild disorder in childhood, varicella tends to be more severe in adults. It may be fatal, especially in neonates and in immunocompromised persons.

Takahashi et al developed the live attenuated vaccine from Oka strain in Japan.. The recommended dose is 0.5 ml which provides at least 1350 plaque forming units of the virus. The vaccine is administered subcutaneously in the upper arm/thigh region. The vaccine is recommended after the age of 1 year. Upto the age of 12 years, one dose is required and if given after 12 years, 2 doses are needed at an interval of 1 month. Both humoral and cell mediated immunity develops in more than 95% cases after a single dose between 1-12 years and 99% after 2 doses in children 13 years and above(72-74).

**Hepatitis A Vaccine**

Hepatitis A is a relatively benign infection in children. About 85% of HAV infection in children 1-2 years old, 50% between 3-5 years and 20% above the age of 5 years.

Several inactivated or live attenuated vaccines against hepatitis A have been developed, but only 4 inactivated hepatitis A vaccines are currently available internationally. All 4 vaccines are similar in terms of efficacy and side-effect profile. The vaccines are given parenterally, as a 2-dose series, 6-18 months apart. The dose of vaccine, vaccination schedule, ages for which the vaccine is licensed, and whether there is a paediatric and adult formulation varies from manufacturer to manufacturer. No vaccine is licensed for children aged < 1 year(75,76).

**Summary: Hepatitis A Vaccine**

- Inactivated vaccine containing HM 175 strain grown in MRC5 cell line
- 2-dose series, 6-18 months apart.
- Efficacy – 94-100%
- No booster dose

The vaccine efficacy is 94-100% and the duration of protection is long lasting, hence no booster dose is recommended at present. The current vaccines are well tolerated and no serious adverse events have been statistically linked to their use. Contraindications to hepatitis A vaccination include a known allergy to any of the vaccine components(77).

**Pneumococcal Vaccine**

Diseases caused by Streptococcus pneumoniae (the pneumococcus) are a major public health problem worldwide. Serious pneumococcal infections include pneumonia, meningitis and febrile bacteraemia; otitis media, sinusitis and bronchitis are more common but less serious manifestations.

Two types of vaccine are currently available – a 23 valent polysaccharide vaccine (available in India) and a 7 valent conjugate polysaccharide vaccine in some countries of the world(78).

23-valent polysaccharide vaccine is capable of prevention of 85% of meningitis and bacteremia caused by pneumococcus. Each dose is 0.5 ml containing 25 ug of individual serotype polysaccharide. A single intramuscular injection is recommended after the age of 2 years with booster every 3-5 years till the age of 10 years(79,80).

The 7 valent conjugate polysaccharide vaccine manufacturer recommends three intramuscular injections in infants aged under 6 months, the first dose usually given at 2 months of age, with an interval of at least 1 month between doses.

### Influenza Vaccine

Influenza virus types A and B are both common causes of acute respiratory illnesses, although influenza A viruses are the principal cause of large epidemics, as well as pandemics(81). Both inactivated and live, attenuated influenza vaccines are available. There are 3 types of inactivated influenza vaccine, namely whole virus vaccines, split virus vaccines and subunit vaccines. In most countries, whole virus vaccines have been replaced by less reactogenic split virus and subunit vaccines. The inactivated influenza vaccine produced in embryonated eggs are immunogenic and associated with minimal side effects. These multivalent vaccine usually contain 3 virus strains (usually 2 type A and 1 type B) with composition changed periodically in anticipation of the prevalent influenza strains expected to circulate in the country(82).

The vaccine is given in 2 doses in children 6 months to 9 years of age and one dose above 9 years of age. The dose is 0.25 ml between 6 months to 3 years IM and 0.5 ml after the age of 3 years. The vaccine is not routinely recommended in India since the prevalent antigenic types are not known. However, in some high risk children and adolescents, the vaccine may be helpful. The vaccine is effective for only short period(83).

#### Live, attenuated influenza vaccines

For several years, live, attenuated influenza vaccines for nasal application have been used successfully in the Russian Federation. The temperature-sensitive vaccine virus will replicate well in the relatively cool environment of the nasopharynx, but poorly in the lower respiratory tract. This vaccine is reported to be safe and highly efficacious following 1 single dose in adults and children >3 years of age(84-86).

Based on data from industrialized countries, and listed in order of priority, the following groups of individuals may be targeted for vaccination in order to reduce the incidence of severe illness and premature death.

(a) Residents of institutions for elderly people and the disabled.

(b) Elderly, non-institutionalized individuals with chronic heart or lung diseases, metabolic or renal disease, or immunodeficiencies.

(c) All individuals >6 months of age with any of the conditions listed above.

(d) Elderly individuals above a nationally defined age limit, irrespective of other risk factors.

### Rabies Vaccine

Rabies is the most dreaded disease known to mankind, once the disease occurs, it invariably leads to death. Rabies virus is a RNA virus classified as Rhabdovirus family. Rabies occurs due to the bite of rabid animals. In India almost all the rabies cases occur due to the bites of dog. The incubation period averages 4-6 weeks but ranges from 5 days to more than 1 year.

There are 2 types of vaccines available in India

(a) Nerve tissue vaccine

(b) Tissue culture vaccines

  (i) Human diploid cell vaccine

  (ii) Purified chick embryo cell vaccine

  (iii) Vero cell vaccine

Nerve tissue vaccine is no longer recommended because of its poor efficacy and life threatening adverse reactions in the form of neuroparalytic conditions of 1:2000 to 1: 8000 doses(87,88).

#### Tissue culture vaccines

All tissue culture vaccines are having almost equal efficacy and any one of them can be used.

#### Post exposure prophylaxis

After thoroughly cleaning the wound with soap and water and appropriate tetanus prophylaxis, rabies immunoglobulin either human or equine in the dose of 20 I.U. and 40 I.U./kg body weight respectively is infiltrated around the wound in case of severe bite or bites in the upper extremities, trunk, head and face. Currently IM injection of RIG is not recommended (89,90).

#### Pre-exposure prophylaxis

1 ml of any of the tissue culture vaccine is given intramuscularly over the deltoid region on day 0, 7 and 28 for the high risk group

In order to reduce the cost of post-exposure treatment, intradermal multisite regimens using a fraction of the intramuscular volume per intradermal inoculation site have been developed (91).

**Summary: Rabies Vaccine**

**Post exposure Prophylaxis**

**Tissue Culture Vaccine**

- 1 ml per dose irrespective of age in deltoid region in infants >2 years; and in anterolateral aspect of thigh in infants< 2 years.
- Schedule Day 0, 3, 7, 14 and 28
- Re-exposure within 5 years - 2 doses - day 0 and 7 ; after 5 years full course. Earlier if anti rabies antibody titre falls below 0.5 IU / ml

**Pre exposure Prophylaxis**

- 1 ml per dose, any Tissue Culture Vaccine, IM,
- Schedule Day 0, 7 and 28
- Indicated for High Risk Group
  - Laboratory staff working with Rabies Virus
  - Veterinarians
  - Wild life staff

Rabies Immunoglobulin

It is a liquid or freeze dried preparation containing immunoglobulins mainly IgG obtained from plasma or serum of donors immunised against rabies and contains specific antibodies that neutralise the rabies virus. It provides passive protection when given immediately to individuals exposed to rabies virus with minimum interference of active immunization with human diploid – cell vaccine(92).

**Adverse Effects :** Local tenderness, muscle soreness or stiffness at the injection site, low grade fever, sensitization to repeated injections of human globulin in immunoglobulin deficient patients.

**Indications :** All injuries, even licks, on mucous membranes by wild animals (or even pet animals) suspected to be suffering from rabies.

### Immunization against Cholera

Throughout history, devastating outbreaks of cholera have resulted in millions of cases and hundreds of thousands of deaths. Until recently, the only available cholera vaccines was phenol-killed whole cell killed vaccine, administered in 2 doses, 2 weeks apart. Unfortunately, the protective efficacy of vaccine is only about 50%, duration of protection hardly exceeds 6 months.

The live, attenuated CVD 103-HgR vaccine

A live, attenuated oral cholera vaccine containing the genetically manipulated classical V. cholerae strain CVD 103-HgR has been available since 1994 which confer a high level of protection (> 90%) against moderate and severe cholera.

Universal mass immunization in the civil population or in the Armed Forces is not practiced. Both the whole cell killed and the CVD 103-HgR vaccines may be recommended for travellers to high-risk regions(93).

### International Vaccination Requirement

Immunization Against Yellow Fever

Yellow fever (YF) is a mosquito-borne, viral haemorrhagic fever that is endemic in tropical regions of Africa and South America.

Vaccination against yellow fever is the most effective method for the prevention of spread of the disease by international travel(94). Two types of vaccines are available(95).

**(a) 17 D Vaccine**

This is the approved vaccine for international travel. It is a live, attenuated chick embryo grown 17D-strain freeze-dried vaccine. For storage at WHO approved centres, the vaccine can be kept for 3 months at +4˚C. If the storage is for a longer duration, a temperature of -25˚C is to be maintained. After reconstitution, it should be used within half an hour.

**(b) Dakar Vaccine**

It is also called French Neurotoxic Virus at the Pasteur Institute Dakar. It is thermostable and can be easily transported. However, it has produced post-vaccinial encephalitis in children. WHO has not approved use of this vaccine for international travel.

Table - 10 : Validity of international certificate of vaccination

| Type of vaccination | Certificate | |
|---|---|---|
| | Valid for | Valid from |
| Yellow fever-primary vaccination | 10 years | 10 days after vaccination |
| Yellow fever-re-vaccination | 10 years | at once after revaccination |

**Administration of vaccine**

17-D vaccine is given subcutaneously at the insertion of deltoid in a single dose of 0.5 ml. The immunity begins within 10-12 days and lasts for at least 10 years however the Persistence of neutralizing antibody 30--35 years after immunization with 17D yellow fever vaccine has been observed (96). Yellow fever vaccination is available at designated centres certified by the Government of India, Armed Forces Clinic New Delhi is one of such centres.

International certificate of vaccination is required only for one disease i.e. Yellow fever. The period of validity of the certificate is shown in Table 10.

Protection is recommended against certain other diseases for international travellers although the international certificate is not required. These diseases are as under: -

(a) Cholera

Cholera vaccine may be taken by all travellers proceeding to endemic areas. It offers partial protection against the disease.

(b) Enteric Infections

Vaccination and revaccination against typhoid is strongly advised for all travellers proceeding to endemic areas.

(c) Hepatitis A

A single intramuscular injection of human normal Immunoglobulin 500 mg or 1.2 mg/kg body weight is effective almost immediately and its efficacy lasts for six months. Active immunisation with HAVRIX is available in our country.

(d) Tetanus

A booster dose of Tetanus toxoid should be taken if 5 years or more have elapsed since the last injection of a complete course or booster.

### Immunization in Special Circumstances (97)

(a) Immunization in preterm infants

All vaccines should be administered as per schedule irrespective of birth weight or period of gestation except Hepatitis B. If the weight of the baby is less than 2 kg and mother is HBsAg negative, then Hepatitis B vaccine is postponed till the baby attains a weight of 2 kg or 2 months of age. However, if the mother is HBsAg positive, then both Hepatitis B vaccine and Hepatitis B

immunoglobulin is administered within 12 hours of birth followed by 3 more doses at 1, 2 and 6-12 months.

(b) Children receiving corticosteroids:

Children receiving corticosteroids at the dose of 2 mg/kg/day for more than 14 days should not receive live virus vaccines until steroid has been discontinued for at least 1 month.

(c) Vaccination in HIV/AIDS

Table - 11 summarizes the recommendation of WHO and Advisory Committee on Immunization Practices and American Academy of Paediatrics.

(d) Vaccination schedule for children not immunized in time

Table -12 depicts the schedule which should be followed in case of unimmunized child.

(e) Lapsed immunization

A lapse in the immunization schedule does not require reinstitution of the entire series. Immunizations should be given at the next visit as if the usual interval had elapsed and the immunization schedule should be completed at the next available opportunity. In case of r uncertain immunization status, it is appropriate to start the schedule of unimmunized child.

(f) Immunization of Adolescents

Reasons for adolescent immunization fall into the following three broad categories:

(a) To boost the waning immunity by giving booster doses.

(b) To counter a specific risk e.g. due to travel, life style etc.

**International Certificate of Vaccination**

These are individual certificates and should not be used collectively. Certificates are printed in English and French;

Table - 11 : Vaccination reommendations in HIV infected symptomatic and asymptomatic children

| Vaccine | Known Asymptomatic | | Known Symptomatic | |
|---|---|---|---|---|
| | WHO | ACIP/AAP | W H O | ACIP/AAP |
| BCG | Yes* | No | No | No |
| DPT/DtaP | Yes | Yes | Yes | Yes |
| OPV | Yes | No | No | No |
| Measles/MMR | Yes | Yes | Yes | Yes |
| IPV | - | Yes | - | Yes |
| Hepatitis B | Yes | Yes | Yes | Yes |
| Hib | - | Yes | - | Yes |
| Pneumococcal | - | Yes | - | Yes |
| Invluenza | - | Yes | - | Yes |
| Varicella | - | Consider | - | Consider |
| Hepatitis | - | Yes | - | Yes |
| * For regions where risk of TB is high | | | | |

Table - 12 : Vaccination schedule of an unimmunised child

| Age | Less than 5 years | More than 5 years |
|---|---|---|
| 1st visit | BCG, OPV, DPT, HB | TT/Td, HB |
| 2nd visit (1 month later) | OPV, DPT, HB | TT/Td, HB |
| 3rd visit (1 month later) | OPV, DPT, MMR, Typhoid | MMR, Typhoid |
| 1 Year later | OPV, DPT, HB | HB |
| Every 3 Years | Typhoid Booster | Typhoid Booster |

Table - 13 : Vaccination Schedule in Adolescents

| Vaccine | Age |
|---|---|
| Tetanus Toxoid | Booster at 10 and 16 years |
| Rubella vaccine | As part of MMR vaccine or (Monovalent) 1 dose to girls at 12-13 years of age, if not given earlier |
| MMR Vaccine | 1 dose at 12-13 years of age. (if not given earlier) |
| Hepatitis B. Vaccine | 3 Doses (0, 1 and 6 m) if not given earlier |
| Typhoid Vaccine | TA, Vi or Oral typhoid vaccine every 3 years |
| Varicella Vaccine* | 1 dose upto 12-13 years, and 2 doses after 13 years of age. (if not given earlier) |
| Hepatitis A Vaccine* | 2 doses (0 and 6 months) if not given earlier |
| Varicella* and Hepatitis A* vaccine are additional vaccines. These vaccines are recommended depending upon the epidemiology of these diseases especially in the adolescent age group where fatal complications are likely | |

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Col (Mrs) K Kapila & Lt Col (Mrs) N Hazra

# Collection of Specimens for Laboratory Investigations

## Guidelines for sample collection, transport and dispatch

The proper collection and transport to the laboratory of a specimen for examination is a critically important step in the ultimate confirmation that a microorganism is responsible for the infectious disease process. A poorly collected specimen not only may result in failure to recover important agents, but also lead to incorrect or harmful therapy if treatment is directed towards a commensal or a contaminant organism.

Specimens collected and submitted for laboratory investigations are utilized for microbiology, biochemical estimations, immunological tests, histopathological studies, and even molecular diagnosis and electron microscopy studies. High quality specimens should be optimally timed, of adequate quantity, correctly sampled with minimum contamination from resident flora and accompanied with relevant history and clinical details of the individual. Information which is of value for the investigation, such as, identity of the source and of the sender and precise nature of the examination required, should be provided legibly.

Specimens must be preserved in such a way that the delay in transit will not materially reduce the chances of successful examination. All precautions must be taken so that the specimen is not contaminated or damaged during transit.

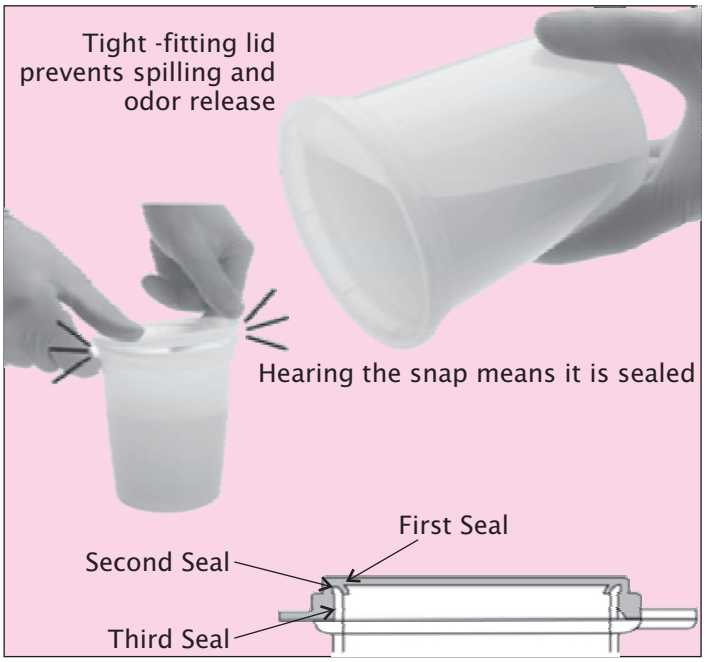
In the subsequent paragraphs only basic methods for collection and dispatch are outlined. These must be supplemented and modified in accordance with instructions issued from time to time and by liaison with the laboratory undertaking the work. All medical officers should be familiar with new methods that may be introduced or modifications made in the established methods.

Medical Officers will be required to collect and ensure proper transport of various specimens for laboratory testing, not only for individual cases in clinical settings but also in mass occurrence of cases in outbreak / epidemic situations. During such settings it would also be wise to dwell upon the "syndromic approach" to decide which specimens would need to be collected as well as to work out the methods of proper collection and transport of such specimen, as mentioned in detail in standard publications of WHO (1,2).

### Routine safety precautions

Specimens should be collected in sturdy containers with adequate closure to prevent spillage or leakage. Spill-proof containers are essential for transport of specimen to distant tertiary laboratories to ensure that the specimen does not leak, get contaminated or pose any kind of hazard to the specimen handler / transporter or laboratory personnel at destination. Such spill-proof containers are commercially available. The lid may be a snap-close or a screw cap one (Fig - 1).

Fig - 1 : An ideal Universal container showing the triple mechanism of sealing.




Specimen transport bags may be used to transport specimens by hand especially over long distances. This specimen bag could be improvised with a large zip lock bag containing a smaller size zip lock bag for samples and another separate bag firmly taped to the outside used for holding the requisition slip and other relevant documents. This 3 pocket design prevents soiling of the requisition slip should accidental spillage occur and helps contain the spillage within a closed space. They may also be printed with red-and-black biohazard warning and handling instructions (Fig - 2).

(a) Open the Zip lock bag, insert specimen in the inner bag and seal.

(b) Seal the outer bag to prevent leakage of specimen.

(c) Insert requisition papers in another bag taped to the outside.

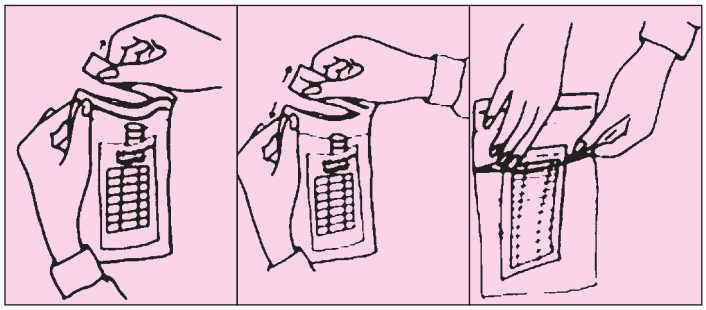
Alternately, sturdy plastic bags, one inside another may be used and sealed using a simple electric sealer or by using the flame.

### Safety while collecting specimens: Universal Safety Precautions (USP)

Universal safety precautions advise that blood, body fluids and tissue material from all patients should be considered as potentially infectious.

USP is intended to protect the Health Care Worker (HCW) and the patients from infections with blood borne agents in health care settings. USP is not intended to prevent

Fig - 2 : Method of using ziplock bags for sample transport




transmission of all pathogens; additional precautions are necessary to prevent transmission of other infectious agents. The fluids to which USP apply include blood, semen, vaginal fluid, amniotic fluid, peritoneal fluid, pleural fluid, synovial fluid, breast milk (only in case of situations like breast milk banking), and saliva (mainly in respect to practice of dental surgery, since saliva in such practice is often contaminated with blood). USP does not apply to following fluids unless they contain visible blood: feces, nasal secretions, sputum, sweat, tears, urine and vomit.

USP have the two main elements which need to be remembered while handling specimens. These include hand-washing and use of gloves.

(a) Hand-washing

This is the single most important measure for preventing the spread of infection. Hands should be washed between patient contact, after contact with blood, bloody fluids and secretions and after removal of gloves. Washing hands with plain soap is adequate and is likely to prevent as much as 70% of transmissible infections. However recent studies state that an alcohol based hand scrub may also be used

(b) Use of gloves

All specimens must be considered a potential health hazard. Use of gloves is necessary and cuts and abrasions on hands should be adequately covered with adhesive bandages if individual is handling specimens. Gloves should be used when touching blood, body fluids, mucous membranes and non-intact skin and also when performing procedures in which contact with blood/ bloody fluids is likely, e.g., suturing lacerations, venepuncture, catheterization, endoscopy, cleaning a spill etc. Gloves should be changed when contaminated, damaged and between successive patient contact. It may be noted that using gloves does not replace the need for washing hands. Both vinyl and latex gloves are equally effective. Utility gloves can be decontaminated and reused 3 to 4 times (after proper sterilization each time), but they should be discarded if there is any evidence of deterioration or tear. The use of gloves should be limited to the particular task and removed as soon as it is complete. Hands should always be washed after removal of gloves as micropores or inevident damage may allow infectious material inside

**Disposal of Sharp objects**

Used disposable syringes and sharps such as broken glass should be placed in a puncture-resistant container located as close to the working area as possible. Used needles should never be recapped or manipulated with both hands, or by any other technique that involves directing the point of a needle towards any part of the body. Used needles from disposable syringes should not be removed by hand, nor should they be bent, broken or other wise manipulated by hand. Once these 'sharps' have been placed in a puncture resistant container, the container should be sealed properly. The exterior of the container should be wiped with Sodium Hypochlorite solution having 0.1% available chlorine (1000 parts per million of available chlorine).

**Cleaning spills of infectious material**

Don appropriate protective equipment i.e. at a minimum one must wear gloves and eye protection during spill clean-up to protect oneself from exposure. Large fragments of glass should be removed individually using paper towels, after having poured the disinfectant and given the contact time specified. Smaller pieces of glass are best removed by using moistened absorbent cotton after adequate contact with the disinfectant.

**Procedure to clean up spills:**

(a) Pour 1% freshly prepared Sodium hypochlorite solution over the spill in sufficient quantity to completely cover the area starting from outer edge inward.

(b) Cover the spill with paper towel or absorbent material such as absorbent cotton

(c) Leave for 30 min

(d) Clean the spill using gloved hands and dispose all material into 1% Sodium hypochlorite

(e) Wipe up the whole spill area again with fresh absorbent material using gloved hands and dispose of the absorbent material into Sodium hypochlorite

(f) Wipe the surface with soap and water

(g) Remove gloves and discard into Sodium hypochlorite

(h) Wash hands in running water

(j) Decontaminate all equipment that have been used in the cleaning such as mug, bucket, mops etc. in Sodium hypochlorite

If blood or other body fluids spill on work surfaces, recommendations from the Centers for Disease Control (CDC) advises cleaning the contaminated area with either a high-level disinfectant or a bleach solution. The CDC recommends a solution of one part bleach to 10 parts water (1:10) for heavy spills and a solution of one part bleach to 100 parts water (1:100) for lighter spills.

**Caution**: (1:10) bleach solution is caustic. Avoid direct contact with skin and eyes. Prepare the bleach solution in a well-ventilated area.

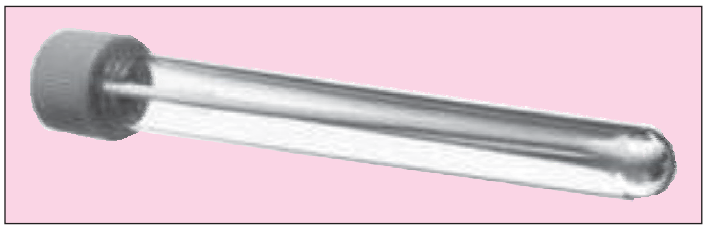
## Specimen collection for infections of various sites

The specimen to be collected is largely determined by the type of infection. The kind of specimens is as outlined in Table - 1.

### Swabs

These are used for obtaining specimens, from sites easily approachable from the outside such as nasal, naso-pharyngeal, laryngeal, conjunctival, cervical, vaginal, rectal swabs and so on. They are made by wrapping a piece of cotton wool round one end of a wooden swab stick. This is placed in a clean test tube, the mouth of which is closed with a cotton plug, and sterilized in the Hot air oven. Such swabs are also available commercially (Fig - 3)

Fig - 3 : A commercially available cotton tip applicator



For collection of specimen the following procedure should be followed:

(a) Two swabs should be taken. These should be thoroughly soaked in the pus or the exudate and put back in the sterile test tube and sent to the laboratory immediately. If some delay is anticipated one of the swabs should be put in a sterile transport medium like Stuart's medium and both these stored at 4°C in the refrigerator.

(b) When specimens are collected involving minimal or no exudate as in case of a diphtheritic membrane, the swabs should be moistened before collection in a sterile medium such as nutrient broth or sterile normal saline. After collection the

Table - 1 : Specimen collection of various infections

| S no | Site of infection | Specimen to be collected |
|---|---|---|
| 1 | Blood stream / Systemic | Blood / bone-marrow aspirate/ IV catheter tip |
| 2 | Respiratory tract | Sputum/ Bronchoalveolar lavage/ Trans Tracheal Aspirate / Lung aspirate |
| 3 | Gastrointestinal tract | Duodenal aspirate/ fecal sample/ rectal swab |
| 4 | Urinary tract | Mid-stream urine/ catheter urine/ cystoscopic sample of urine/ suprapubic aspiration |
| 5 | CNS | CSF/ ventricular tap |
| 6 | Eye, ear, nose, sinus & throat | Swabs/ antral puncture material |
| 7 | Wound infections & infections of fascial planes | Swab from under scab/ aspiration from deep planes. For tissues & biopsies for culture, send in saline not in formalin!<br>For anaerobic culture, send aspirate in a syringe where the needle is impaled into a sterile rubber bung or send material on swab/ bits of tissue in Stuart's transport medium. Alternately, material can be sent in Thioglycollate or Robertson's cooked meat medium. Liaise with the laboratory. |
| 8 | Genital tract (Female) | High vaginal swab / intracervical swab/ aspiration from pouch of Douglas/ aspiration from uterine cavity |
| 9 | Genital tract (Male) | Material from urethral discharge on slide for staining and also on swab (transported in Stuart's transport medium). Urine after prostatic massage |
| 10 | Dentistry- gingivocrevicial fluid in periodontitis/ abscess | Aspirated material in syringe in which needle is impaled into a sterile rubber bung; paper points & material using microcurette (capillary) can be sent in Stuart's transport medium. |

swabs should be sent to the laboratory immediately. If any delay is anticipated the swabs should be preserved at 4°C in the refrigerator, upright on a stand.

(c) For obtaining laryngeal swabs care must be taken that the swab does not touch the tongue.

(d) The throat swab is guided to the posterior pharynx under illumination of the oral cavity. The patient is instructed to tilt the head back and breathe deeply. The tongue is gently depressed with a tongue depressor to visualize the tonsillar fossae and posterior pharynx. If not available, a gloved finger or an icecream stick may be used for the same. Having the patient to phonate "ah", the tonsillar areas and the posterior pharynx are firmly rubbed with the swab which is then placed back in the glass tube to prevent drying. Care should be taken not to touch the tongue or oral cavity. Any purulent exudate should be sampled separately and correctly labeled. In all circumstances the individual obtaining a sample of throat swab from suspected diphtheria infection should wear gloves, goggles and mask as the organism is highly infectious.

(e) On no account should a swab reach the laboratory dry, as organisms are often killed by dessication and valuable information may therefore be lost.

**Collection of Blood for culture**

Blood culture is carried out for the diagnosis of bacteremia which may be present in the Enteric group of fevers, Brucellosis, Subacute bacterial endocarditis and other bacterial causes of PUO. Ten ml of blood is collected in 50 - 100 ml of medium. This prevents clotting of blood by dilution and a large volume of blood ensures a better chance of isolation of organisms. Blood should be collected before starting antibiotics. Ideally three and at least two samples must be taken from different sites within a half to one hour interval. Alternatively, in patients requiring early institution of antibiotics, three samples of blood 10 ml each should be taken from three different sites using three separate syringes and needles. In children 1-5 ml blood may be drawn in place of 10 ml in adults.

Strict aseptic precautions should be observed while collecting the blood sample and the phlebotomist should wear sterile gloves. A tourniquet is applied above the site of collection. The site of venepuncture is disinfected in a circle of about 6 cm diameter with 70% alcohol on a sterile swab. The alcohol is allowed to dry. This is followed by application of tincture iodine or 10% povidone iodine starting from the centre of the circle. The iodine is allowed to dry and then 70% alcohol swabbing is repeated as before. After allowing the skin to dry the blood is collected in a sterile autoclaved syringe and immediately transferred to the culture media in blood culture bottles. The screw cap of the blood culture bottle should be opened over the flame of a spirit lamp and after the blood is delivered in the bottle, the screw cap and the mouth of the bottle is flamed and then closed tightly. When the bottle has a rubber cap, the top of the cap is sterilized using 70% alcohol, allowed to dry and the blood inoculated through the rubber cap. The collected blood should be thoroughly mixed with the medium and the bottles sent to the laboratory.

The following culture media are used for culturing blood:-

(a) Brain heart infusion (BHI) broth with 0.5% agar or Glucose broth- supports growth of most organisms

(b) Taurocholate broth- enrichment medium for enteric group of organisms especially for Salmonellae.

(c) Castaneda biphasic medium- this medium need not be opened repeatedly for subculture as an agar slant is incorporated. It is preferred where incubation is likely to be more than two weeks as in suspected brucellosis.

(d) Thioglycollate broth- for anaerobic organisms.

When leptospirosis is suspected, blood is collected in 1% sodium oxalate in phosphate buffer (pH 7.5), 1% Liquoid (sodium polyanethol sulphonate) in sterile saline or in EDTA and sent across to a surveillance centre that uses special semisolid and liquid media (Fletcher's, Korthof, Ellinghausen- McCullough) to grow the organism.

**Cerebrospinal fluid**

(a) The lumbar puncture set is made up of one or more lumbar puncture needles, glass syringe, hypodermic needles and a piece of folded lint to serve as a towel. All these articles are wrapped in two pieces of lint so that the outer piece maintains the remainder of the packet in a sterile state at all times. This packet is packed into a stainless steel drum, autoclaved and kept ready by 'Central Sterile Store Department (CSSD)". After use the instruments are cleaned, repacked and autoclaved so that a sterile set is always ready for use.

(b) Lumbar puncture is carried out with the patient lying along the edge of the bed, with the head and spine well flexed. The spine should be in a horizontal plane. Tincture of iodine / povidone iodine should be used to clean the skin. Scrubbing up and sterilisation of the hands must be carried out as thoroughly as for any surgical operation. A local anaesthetic may be used. The puncture is made in the midline in the interspace between either the third and fourth or fourth and fifth lumbar spines.

(c) The first few drops are allowed to flow into a sterile bottle and then the samples required for culture and serological tests collected in another sterile bottle. It is advisable to collect the sample in screw capped flat bottom sterile plastic vials so that spillage and contamination are avoided. If suitable media are available, these can be inoculated by allowing the fluid to pour direct onto the media plate/ tube. If suitable culture media are not available by the bed-side, the sample of CSF that is collected should be dispatched immediately to the nearest laboratory ensuring that the fluid is kept warm at body temperature during transit. Any admixture with blood will render the fluid

unsuitable for biochemical examination. For a cytological examination, the fluid may be collected in a bottle containing Wintrobe's anticoagulant. A cytological examination must be carried out as soon as possible, preferably within 1/2 hour as otherwise the cells undergo degeneration rendering correct reporting impossible.

CSF specimens for culture must never be refrigerated as most of the incriminating organisms are sensitive to cold. When transporting CSF to another laboratory for bacterial culture, send at ambient temperature and not in ice but if being sent for serology, ice can be used around the sample. CSF samples do not need a transport medium.

**Urine for Bacteriological Examination**

The sample required is a midstream specimen of urine (MSU) after thorough local toilet using running water. Other samples that may be sent for bacteriological culture, in special situations, are suprapubic aspirate (SPA), catheter sample, sample through cystoscope and, for acid fast bacilli (AFB) Early Morning Specimen of Urine (EMSU) X 3 consecutive days. Unlike earlier belief, there is no role of 24 h collection of urine for mycobacterial culture. The kind of sample should be clearly stated on the requisition form. A proper history of the case in terms of intake of antibiotics, past infection, use of diuretics and if the sample is of an antenatal case should be clearly outlined.

The urine collected must be labeled with the name and examination required and sent to laboratory as fresh as possible, preferably within 2 hours of collection. The best method is to use sterile screw-capped wide mouth bottles with a flat bottom (universal container). Such containers are available commercially. Penicillin vials should not to be used under any circumstances. Urine specimens should be collected before administration of antibiotics and after a bladder holding of at least 2 hrs.

**Pus**

Although pus is usually sampled with a swab, it is more satisfactory whenever possible, to take a liquid sample with a syringe or pipette. When the lesion is deep-seated and opens through a sinus, the whole of the inner dressing should be sent in a sterile container. Swabs should be placed in Stuart's Transport Medium for the preservation of anaerobes and microbes sensitive to drying. There must be no delay in submitting swabs in transport medium because some species will grow in it at room temperature and may obliterate the true pathogens. In suspected anaerobic infections (foul smell, deep abscess etc.) aspirated material is mandatory. If collected in a syringe the entire syringe along with the material should be sent to the laboratory with the tip of the needle plunged into sterile rubber bung.

**Exudates and Other Pathological Fluids**

Pleural, cystic and ascitic fluids are collected direct from the cannula or aspirator into sterile test tubes for general examination. For bacteriological examination, collect 5 ml directly in a sterile test tube and forward to the laboratory as soon as possible. If the fluid tends to clot, a small crystal of potassium oxalate may be added. In order to avoid contamination due to spillage, screw capped universal containers should be used instead of test tubes. If tuberculosis is suspected, as much of the material as possible should be collected and forwarded.

**Eye infections**

Suppurative material from the conjunctiva should be taken from the inner canthus with a swab which is moistened previously with sterile saline. Sample swabs from the eye should be put into Stuarts transport medium as these specimens may have organisms which may not survive any delay in transportation. Alternatively, a bed-side inoculation is done on Blood agar, MacConkey agar and Sabouraud's agar.

**Ear and nose infections**

Antral puncture material from ENT cases should be taken for aerobic & anaerobic culture. In diabetics with swelling over maxillary region, suspect a mycotic etiology & take a punch biopsy for fungal culture. Forward this in sterile saline in a sterile capped container.

Samples for diagnosis of Upper respiratory Infections

Throat swab, nasopharyngeal swab and naso-pharyngeal (NP) washings can be assessed for pathogens.

Samples For Diagnosis Of lower Respiratory Infections

Sputum and broncho-alveolar lavage (BAL), Trans-tracheal aspirate (TTA)-in debilitated cases, failure of routine sputum culture and when anaerobes are implicated and Trans-cutaneous lung aspirate is used in selected areas.

**Collection of Sputum**

Only the early morning sputum obtained from the lower respiratory passages should be sent for examination. Saliva or nasopharyngeal secretions are useless. Suitable postural drainage (physiotherapy assisted) or nebulisation may have to be arranged before a representative sample can be obtained. The sputum should be coughed up and directly collected in a wide mouth screw capped sterile container. If the laboratory is near, the bedside spittoon without a disinfectant in it should be sent. For cytology of the sputum, two thin smears fixed for half an hour in a mixture of equal parts of ethyl alcohol and ether, and air-dried should also be forwarded. These slides may be wrapped in foil after fixing and dispatched to the nearest centre for reporting. For culture of tubercle bacillus, specimens of sputum collected in screw-capped container early in the morning for three consecutive days may be used. Alternatively sputum may be collected directly into McCartney bottles containing 5 ml of Tri-sodium phosphate (TSP) medium and sent to the laboratory for making slides for ZN stain and for culture of tubercle bacillus.

**Collection of Pleural Fluid**

This is collected under aseptic precautions in sterile containers like any other body fluid and sent at the earliest to the laboratory.

Preparation for Microscopy

Using a wire loop a purulent portion of the sputum is placed on the slide and spread evenly to give a smear of approximately 3 x 2 cm. The smear is allowed to air-dry

Table - 2 : Interpretation of Microscopy for Acid fast bacilli (WHO)

| Examination | Grading | No. of fields to be examined |
|---|---|---|
| More than 10 AFB per one oil immersion field | 3+ | 20 |
| 1-10 AFB per one oil immersion field | 2+ | 50 |
| 10-99 AFB per 100 oil immersion fields | 1+ | 100 |
| 1-9 AFB per 100 oil immersion fields | Record exact no. seen | 100 |
| | | 100 |

**Stool collection procedure for Ova, Cyst and Culture**

Stool for ova/cyst of parasites may be collected in a clean, dry, disposable container, plastic wrap stretched under the toilet seat, or into a waxed cardboard container. It must be a dry specimen i. e. not contaminated with water or urine, with an acceptable specimen being: faeces. For collection of material for demonstration of ova of pinworm, a cellotape can be used over the perianal area, removed and attached to a clean dry microscope slide. The slide is wrapped in paper and sent to the laboratory with the requisition form.

For culture, portion of stool which contains pus, mucus or blood should be transferred to a dry sterile container, preferably screw capped. The specimen should be delivered to the laboratory as soon as possible preferably within two hours of collection. If delay is anticipated, store specimen at 4°C. It is sometimes useful, in cases of chronic dysentery, to obtain a rectal swab through the proctoscope. Dispatch the rectal swab as quickly as possible to the laboratory to avoid drying.

Preservation of Helminths for examination later:

Cestodes should be washed in water and trematodes in saline; they should be killed and preserved in 4 % formalin and not in spirit. Nematodes should be washed in saline, killed by hot water at 70°C and preserved in 70 per cent alcohol.

**Stool samples for Enteropathogens**

(a) Dysentery Group of Organisms :

(i) When the laboratory is near, send the fecal sample to the laboratory, as soon as it is passed in a bedpan. The sample must not contain any antiseptic, and the urine must be passed separately and not in the pan.

(ii) When the laboratory is some distance away or it is not practicable to get the specimen to the laboratory quickly, take about one ml of sample with mucus flake and put it into a bottle containing neutral glycerin - saline solution (Cary Blair medium). This medium should be pink in color; yellow solution is acidic and should not be used. The selection of the sample is important and must be carefully done by the medical officer himself.

(iii) In cases of suspected amoebic infection, finding of vegetative form of *E. histolytica* is diagnostic. This is possible only by examination of a fresh specimen of stool.

(b) Cholera

The isolation of *Vibrio cholerae* from a suspected case of cholera is made from a specimen of freshly passed stool or the rectal swab obtained from beyond the anal sphincter. A hanging-drop preparation of the sample will show *Vibrio cholerae* exhibiting "darting motility". If facilities for bacteriological examination are available locally, the material should be placed directly on a suitable solid medium - MacConkey's agar and Thiosulphate citrate bile salt sucrose agar (TCBSA). If however, a delay of some hours is anticipated, the specimen of faeces should be placed in a bottle containing 10 ml of an alkaline transport/ preserving medium such as Alkaline peptone water (pH 8. 4) obtained from the nearest laboratory. In the case of the examination of convalescents or contacts, about I-3 g of stool should be sent in Alkaline peptone water.

(c) Other Enteric group of organisms

Similar to that outlined in para (i) & (ii) above.

(d) Helminths

Sample of faeces may be preserved for subsequent examination for presence of helminthic eggs by mixing a specimen of faeces, the size of a pea, in 30 ml of 1 per cent solution of common salt or 2 % antiformin in water.

(e) Coccidian parasites

Fresh stool may be sent in a clean dry screw capped container for detection of cyst of Isospora, Cryptosporidium and Microsporidium. The cold ZN stain (Kinyoun stain) is used to detect this group of parasites. Coccidian parasites are often the cause of intractable diarrhea in the HIV affected but may also, at times, affect an immunocompetent host.

**Preparation of Blood Slides**

(a) Cleaning of Slides

(i) New Slides

The new slides are placed in dichromate cleaning-fluid for 48 hours and then washed in running tap water. This is followed by rinse in distilled water and thereafter stored in 95% ethyl alcohol. The slides are wiped dry with clean muslin cloth before use.

(ii) Used dirty Slides

After use, slides are put into 2% chlorosol, washed in tap water and boiled in washing soda solution for 20 minutes. A tap-water wash follows and then

a rinse in 5% hydrochloric acid. This is followed by wash in tap water and then distilled water. Thereafter, they are wiped using soft muslin and air-dried.

(b) Thin Blood films

The sides of the finger are pressed so as to raise the pulp of the finger. Ideally, commercially available pricking lancet is used. Otherwise, a bayonet pointed disposable needle serves well for the purpose of pricking. Pins, injection needles, and sewing needles should be avoided. The prick should be bold and about 3 mm deep. Light pressure on the sides of this finger in an outward direction helps the flow of blood by opening the wound. Squeezing is to be discouraged as it leads to dilution of capillary blood with tissue fluid and thus to erroneous results. The first drop of blood from a skin puncture is wiped dry with cotton wool and subsequent drops of blood are utilized for tests. A drop of blood is placed ½ inch from the edge of the slide. Take two or three polished slides and select one with a smooth and even end as a "spreader". Place the slide with drop of blood on a table so that the end with the blood drop is towards the right, while holding the other end by the edges with the forefinger and thumb of left hand, place the spreader somewhere about the middle of the slide at an angle of about 45˚ and draw it to the right till it touches the drop of blood which then runs and spreads along the edge of the spreader. Before the blood has reached the margins, push spreader with a firm steady motion but without unnecessary pressure, to obtain a tongue - shaped smear. An ideal film should be about 1½" long and ¾ " wide. It should be slightly thick at its beginning but reasonably thin near its tail, where red cells when seen under a microscope should be seen, just touching one another but not overlapping. When held against light, the thin portion of the films should show a play of colors. Films which are too long or too wide, which show bands due to irregular thickness, vacuoles due to grease, or streakiness due to an irregular edge to the spreader should be rejected.

(c) Thick Blood Films

These smears are better suited for the detailed examination of blood for haemoparasites such as malaria and microfilaria. Thick films are preferable when a large number of examinations have to be made. As a large volume of blood is examined, the thick film method increases the number of positive findings. Three to five drops of blood, each of the size of a drop for the thin film, are collected on a clean and polished slide, pooled together and spread with a needle into an even thick film about 10 mm square. The thickness of the film should be such as to allow newsprint to be read through it. The slide is then placed on a flat surface to dry in the air, but not in the sun, and covered with a saucer or petri dish. When dry, the slide is wrapped in a piece of paper on which the date and patient's name are written. When examination for microfilaria is needed, the slide is fixed in methanol for a few minutes before wrapping it up in paper for dispatch to the laboratory.

**Specimens for molecular diagnosis**

It is important to liaise with the laboratory before sending the sample. The sample (biopsy/ autopsy tissue, aspirate, body fluids) sent should be representative, adequate & fresh. No sample should be sent in formalin or heparin. If blood is sent, collect whole blood in EDTA with the cold-chain being maintained especially when specimens are being sent over long distance. Body fluids should be sent in cold chain, without any preservative added. A detailed history of the case and the suspected bacteria/ virus for which PCR is required should be entered on the form. It is also necessary that whatever results are available, should be correlated with clinical & other findings.

## Diagnosis of viral infections

With the demand for viral identification having markedly increased, refinements in viral identification are seeing the light of day.

The lab diagnosis of viral infections rests upon these predominant approaches:

(a) Isolation/cultivation of viruses on cell lines
(b) Direct detection of the viral antigen by Immunofluorescence or ELISA
(c) Detection of the specific antibody by Indirect Immunofluorescence or ELISA
(d) Detection of the specific genetic sequence by molecular method such as PCR

The procedure followed in collecting specimens for virological investigations is as given below:

**General Principles**

The choice of specimen to be collected for viral diagnosis depends on the nature and symptoms of the patient and the pathogenesis of the suspected agent. Specimens should be taken as early as possible in the acute phase of the illness. All samples including blood samples for serology should be taken aseptically. For virus isolation, swabs and other specimens that may dry in transit should be placed in Viral transport medium (VTM) such as Hank's Balanced salt solution (BSS). Samples for isolation of virus should never be frozen but held at 4 - 6 ˚C in an ordinary refrigerator. This can preserve the sample for upto ten days. For composition of VTM, see Appendix E.

**Throat swab**

A throat swab should be obtained as described earlier. The swab should be put in VTM in a sterile screw capped bottle, the swab stick being broken off at the mouth of the bottle and the screw cap closed after flaming the rim of the bottle. The specimen should be sent to the laboratory surrounded by ice in an insulated container and send in ice in an insulated container.

**Throat washings**

Let the patient gargle with about 5 ml of sterile physiological saline/ VTM and collect the washings in a clean disposable paper cup. Transfer this to a sterile screw capped container and send it in ice in a insulated container.

**Nasopharyngeal swab**

A nasopharyngeal swab should be obtained by carefully

inserting a dry sterile cotton wool swab through a nasal speculum parallel to the floor of the nose. The swab is then rotated on the nasopharyngeal membranes for a few seconds and then put into VTM in a sterile screw capped bottle, the swab stick being broken off at the mouth of the bottle and the screw cap closed after flaming the rim of the bottle. The specimen should be sent to the laboratory surrounded by ice in an insulated container.

**Nasopharyngeal washings**

1- 1. 5 ml of normal saline is instilled into one nostril with a sterile syringe with the head of the patient slightly tilted back. Aspirate the normal saline from the nostril with a sterile plastic catheter inserted into the nostril parallel to the palate. Repeat with other nostril. Aspirate nasopharyngeal secretions collecting 1-2ml in VTM. Send in ice in an insulated container.

**Blood and serum**

Blood should be obtained by aseptic venepuncture. For virus isolation, the sample of blood should be prevented from clotting by adding 1 IU of heparin per ml of blood. For serology, sample of blood should be allowed to clot in a sterile container and serum separated aseptically. Blood is allowed to clot at 4°C. Whole blood should not be frozen before serum preparation since blood may get hemolysed. To show rise in antibody titre two samples of blood for serum should be taken as follows :

(a) First sample for detection of IgM to be drawn as early in the disease as possible but not later than 5 days after onset.

(b) Second specimen for IgG detection 10-14 days after onset of symptoms.

**Faeces**

A piece of faeces weighing approximately 4-8 g is collected and dispatched to the laboratory in ice. Liquid stool is dispatched as it is in a sterile screw capped container maintaining cold chain.

**Cerebrospinal Fluid (CSF)**

About 1-1. 5 ml is collected aseptically in a sterile screw capped container without adding VTM and dispatched to the laboratory in wet ice.

**Biopsy and Postmortem Specimen**

The biopsy and postmortem specimens of tissue for virus isolation should be collected aseptically using several sets of sterile instruments. The specimens should be cut into 1cm$^3$ size and placed in VTM in sterile screw capped containers.

Apart from the above mentioned specimens, vesicular lesion smears and nasopharyngeal smears as well as smears from cell sediments after centrifugation may be sent for **Immunofluorescence** (for detection of viral

Table - 3 : Type of specimen for viral studies by principal body system infected

| System/ Organ | Specimen Required For Isolation | Serological Examination |
|---|---|---|
| Central nervous | blood, CSF, brain biopsy, throat swab | Faeces, Paired sera |
| Cardio-vascular | Faeces | Paired sera |
| Skin | Macular/papular scraping, vesicular/pustular fluid, crusts, throat swabs | Paired sera |
| Eye | Conjunctival scrapings or swabs | Paired sera |
| Liver | Blood, serum | Paired sera |
| Fever | Heparinised blood, | |

Table - 4 : Method of collection of samples for viral studies

| Type of specimens | Method of collection |
|---|---|
| Rectal swab | Insert swab 4-6 cm into rectum- VTM |
| Stool | Collect 2-4 gm in VTM |
| Genito-urinary | Collect in VTM |
| Dermal swab | Disrupt vesicle & collect fluid with swab - VTM |
| Mucosal swab | Swab back and forth over lesion & place swab into VTM |
| Conjunctival swab | Swab lower conjunctiva with flexible fine-shafted swab premoistened with saline - VTM |
| Respiratory | Nasal, naso-pharyngeal, throat swabs and fluids - VTM |
| Blood | Collect 8-10ml in Na Citrate or EDTA |
| Bone marrow | Collect 2ml in Na Citrate or EDTA |
| CSF | 2-5ml in sterile container - No VTM |
| Urine | Collect 10-20ml mid stream sample - No VTM |
| Tissues | Place tissue bits ( lung, brain etc.) in VTM |

Table - 5 : Optimal specimen for viral studies

| Specimens | Transport media if required (VTM) | Purpose/ Lab investigation |
|---|---|---|
| Throat swab PCR | Yes | Isolation of virus, IF, |
| Nasopharyngeal swab /aspirate | Yes | Isolation of virus, IF, PCR |
| CSF | No | Serology, Isolation of virus, PCR |
| Faeces | No | Isolation of virus |
| Urine | No | Isolation of virus |
| Blood(clotted), serum | No | Serology, Isolation of virus |

antigen). Many viruses can be detected at tertiary centers by this technique or the Shell-vial technique.

Important information about specimens required for different viral infections is shown In Table - 3, Table - 4 & Table - 5.

Note:

(a) The storage condition for serum separated for viral serology, pending immediate testing, is 20°C and during transport and prior to immediate testing, is 2-8° C. This however does not apply to clotted blood or whole blood in EDTA which should not be frozen as haemolysis occurs. Urine collected for virus isolation should be preserved at 2-6°C and not frozen. This temperature can preserve the sample for 7-10 days.

(b) For serology, paired sera are indicated, spaced 2-3 weeks apart. No preservatives should be added to serum separated for serology.

(c) Fluid specimens (body fluids, CSF, urine) do not require any transport media and should not be diluted.

(d) If viral isolation is contemplated, do not freeze specimens at minus 20°C Celsius, as infectivity of many viruses is rapidly lost at this temperature. Storing for such specimens, for periods up-to 10 days can be at 2-8°C and for longer periods, at -70°C.

(e) Any type of swab may be used for collection of specimen except calcium alginate fibre-tip which may inactivate Herpes simplex virus (HSV).

## Transport media for bacteriological tests

When the patient is not close to the bacteriological laboratory there is a risk that the pathogen in a bacteriological specimen may not survive or may be overgrown by non-pathogens during the time it takes to transport the specimen to the laboratory. A swab can be inserted into the medium and the extra stem nipped off after which the rubber cap is put. The medium maintains anaerobic conditions within and thus, prevents multiplication of organisms. The nutrients are limited hence it does not allow overgrowth by commensals.

### (a) Stuart's transport medium

An opaque white gel. The medium contains leuco-methylene blue that becomes blue on oxidation. Do not use if the medium is blue in color. The medium contains sod thioglycollate, sod glycerophosphate, calcium chloride, agar, Methylene blue and DW at pH 7. 4. It is distributed in small bijou bottles almost till brim and is autoclaved at 121°C X 15 min.

### (b) Amies transport medium

This has Sodium thioglycollate, sodium chloride, Potassium chloride, Calcium chloride, Magnesium chloride, disodium hydrogen phosphate, Potassium dihydrogen phosphate along with agar 0. 4%, finely powdered charcoal and distilled water at pH 7. 2. It is dispensed in the same way as Stuart's transport medium.

### (c) Pike's medium

This medium is used to preserve *Streptococcus pyogenes, pneumococci* and *Haemophilus influenzae* in nose and throat swabs. It is blood agar containing crystal violet 1 in 1, 000, 000 and sodium azide 1 in 16, 000 distributed as stab cultures in tubes/ bottles.

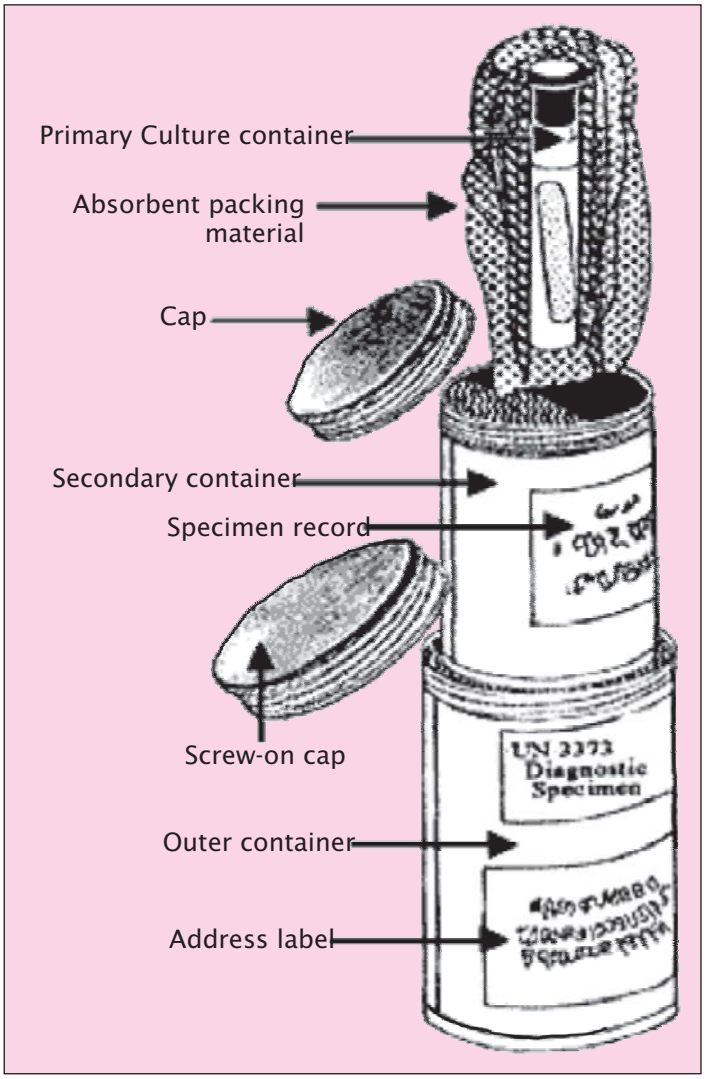
### (d) Glycerol saline transport medium for Typhoid bacilli (Cary-Blair medium)

Prevents overgrowth of other intestinal organisms and preserves typhoid bacilli. It contains Glycerol, NaCl, disodium hydrogen phosphate, phenol red and water and is a purple-pink colour. It is dispensed in 6 ml volume in universal containers. The fluid should not be used if it becomes acidic indicated by a change in colour to yellow.

### The Three-tier packaging method for transport of diagnostic specimens (Fig. 4)

The packaging comprises a diagnostic specimen within a cryovial (a specimen carrier), a secondary container and an outer transport container. The specimen in the labeled primary container must be water tight, air tight and wrapped in absorbent material such as cotton wool to

Fig - 4 : The three tier packaging method for transporting samples



absorb any leakage. After tightening the cap, sealing tape may be applied e. g. Parafilm or a waterproof plastic tape over the cap and the top of the specimen container. The sealed cryovial is in turn placed in a suitably sized plastic bag together with a small amount of absorbent material. The bag must be sealed either using a sealer or a flame. Alternatively, zip lock bags may be used.

The secondary container is sealed with a screw capped lid, labeled, packed with absorbent packing material and placed within an outer transport container. The outer container protects the contents from physical damage and water while in transit. It should therefore be made of metal, wood or fibreboard with a shock absorbent padding within and a tight fitting lid. Two or more sealed specimens from the same patient may be placed in a larger plastic bag and sealed.

Specimens from different patients should never be sealed in the same plastic bag but may be double bagged and thereafter proper labeling put into the same secondary container. In daily practice, coolant packs that have been frozen in the deep freezer are used to keep the temperature at 4-8$^{o}$C which is maintained for a period of 2-3 days. These ice packs can be reused after disinfection of the surface. A good substitute is sealed plastic bags containing ice cubes. Dry ice may also be used wherever available. A vaccine carrier if used instead of a transport carrier needs to be thoroughly disinfected before reuse but must never be reused for vaccine carriage again. A Biohazard symbol is to be fixed outside the secondary as well as the outer container.

**Processing of Tissue for Histopathological Examination**

Specimens for histopathological examination or gross preservation must be placed immediately after removal in a fixing fluid consisting of one part of commercial formalin to nine parts of normal saline. This should be up-to 50 times (but not less than 10 times) the volume of the specimen. Normal saline without the addition of formalin is not a preservative. If a properly equipped laboratory is available, the whole specimen should be sent without delay to the pathologist; otherwise proceed to treat the specimen as follows before its dispatch to the laboratory :

(a) Biopsies and small operative specimens up-to bean-size should be placed in a bottle with fixing fluid and forwarded without delay.

(b) Medium size and bulky operative specimens should be adequately incised to ensure quick penetration of the fixation fluid in to all parts of the tissue and prevent autolysis, and then placed in a large container with an excess of fixing fluid. This specially applies to lymph glands. The direction of incisions should be such that surfaces useful for demonstration remain intact.

(c) Large solid organs should be cut into representative slices about 2 cm thick.

(d) Hollow organs should be filled with fixing fluid and tied.

(e) Postmortem material should be obtained soon after death.

(f) Cover the floor of the container with cotton wool or suspend the specimen in the fixing fluid without it touching the sides of the container.

(g) All specimens should be accompanied by a properly completed laboratory examination request form. In case of postmortem material a copy of clinical history and postmortem report should be included.

(h) Endometrial Specimens

Since the endometrium is exceedingly soft and undergoes rapid autolysis, it should be carefully handled and properly fixed. Before fixation, however, it is best to remove clots of blood and mucus. These may be separated either by rinsing the fragments of tissue gently in physiological saline or by spreading them on a fine-meshed sieve or fabric, from which they may be transferred into the fixing solution with one arm of a blunt forceps, exercising care to avoid squeezing or pinching them. Endometrial curettings are never to be wrapped in fabric. The ideal fixative for endometrium is 10% neutral formalin. Tissue may be left in the fixative for weeks without harm.

(j) Tissue for Electron Microscopy

The biopsy specimen is cut into small pieces of 1 mm size and immediately transferred into buffered glutaraldehyde fixative (3% phosphate buffered cold glutaraldehyde solution of pH 7. 2 to 7. 4). Fix the tissue in this fixative for 2 hours. The specimen may be washed with the same buffer which was used to prepare the buffered glutaraldehyde. Seal the container properly and dispatch to EM Laboratory, AFMC, Pune.

## When called to Investigate an outbreak

The investigation of an outbreak needs a syndromic approach. The case definition needs to be adhered to. The case details are an extremely important part of the investigation. A laboratory investigation form is shown in Appendix “A”. The laboratory should be ready to move at short notice and an “Outbreak Investigation Kit” as shown in Appendix “B” needs to be kept ready and periodically checked. Samples to be collected must be planned in advance and all prerequisites should be methodically packed. Proper planning, sampling and transport will pay good dividends and go a long way in providing a scientific answer.

**Selective commonly-encountered conditions: Parasitic**

Malaria

**Microscopy**

The gold standard for the diagnosis of malaria is microscopy. The sample is a thick and thin blood film made on the same slide or on different slides. In experienced hands, microscopy on dehaemoglobinised thick film can detect as low as 5-10 parasites/µl of blood. Dehaemoglobinization is done by either of the following two ways: a) With glacial acetic acid & tartaric acid mixture

(4 parts of 2% glacial acetic acid and 1 part of 2% crystalline tartaric acid) : The film is flooded with the mixture and as soon as the dehaemoglobinization is complete (evidenced by a grey-white color of the film) the fluid is drained off by tilting. It is then fixed with methyl alcohol for 3-5 min. Next the slide is washed with neutral/slightly alkaline distilled water so that every trace of acid is rid of b) Using distilled water by placing the slide with blood film in a vertical position in a glass cylinder for 5-10 min. When the film is colorless, it is taken out and dried in an upright position. Then staining with Leishman, Wright stain or Leishman-Giemsa is done as usual. A "Parasite index" must always be provided to quantify the infection (100 oil immersion fields of a thick dehaemoglobinised blood smear are scanned using X 7 ocular and X100 of oil immersion lens; this scans roughly 0. 25 ml blood; the final result is expressed in parasites/ml blood) This may also be done on a stained dehaemoglobinised thick blood smear by counting the number of parasites alongside 200 WBC and multiplying the result by 40 (the TLC count is presumed normal at 8000/mm$^3$). Despite inaccuracies due to variation in WBC count among individuals it provides reasonable information. Alternately, total number of parasitized RBC is counted against 10, 000 RBC in a thin stained film that has roughly 20 RBC per oil immersion field. Parasitized RBC more than 5% is labeled as hyperparasitaemia.

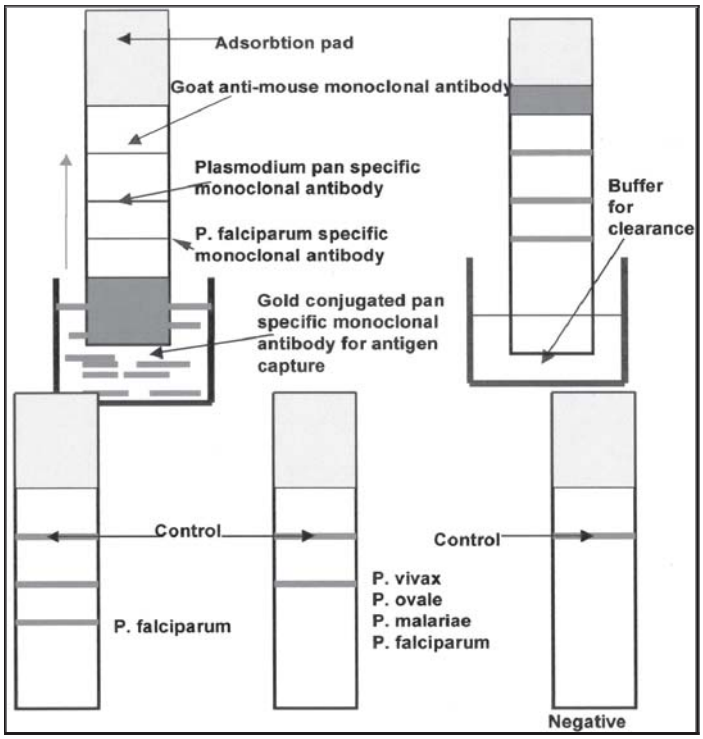
**Immunological test**

The target for immunological tests is the use of monoclonal antibody against one of the antigens associated with malaria. The tests for malarial antigen are grouped as **Rapid Diagnostic Tests (RDT)**. These tests use finger-stick or whole blood in EDTA, take only 10-15 min to perform and can be done in field conditions. Two types of rapid tests are available: one that identifies Histidine-rich-protein-2 (HRP-2) of *Plasmodium falciparum* (Pf) and others based on detection of isomers of parasite lactic dehydrogenase (pLDH) of falciparum malaria as well as a common pLDH for all four malarial species (Fig. 5). The HRP-2 antigen is synthesized and released by trophozoites and immature gametocyte stage and persist in peripheral blood up-to 2 weeks after chemotherapy and parasite clearance as confirmed by microscopy. These tests have a low sensitivity for detection of infection with low-level parasitemia (<100 parasites/ul) and mature gametocytes. Parasite LDH is produced by both asexual and sexual stages of the malaria parasite. Test kits currently available can distinguish *P falciparum* from non-falciparum infections but cannot distinguish among the three other species. Tests that detect pLDH do not generate persistent positive results following chemotherapy. Use of RDT does not eliminate need for malaria microscopy and all RDTs must ideally be followed by microscopy as low level infections are often not possible to detect. Immunological test for detection of antibody is an ELISA based assay and does not necessarily detect a current infection.

**QBC (Quantitative buffy coat from Necton-Dickinson, USA)**

This is based on microscopy using capillary tubes coated on the inside with fluorochromes such as acridine orange

Fig - 5 : RDT for Malaria




that stain any parasite present. These tubes are evaluated after centrifugation of the blood using fluorescence based microscopy of the RBC layer. The method is expensive but specific and requires special equipment and supplies (centrifuge and centrifuge tubes, special light sources and filters) besides individual expertise.

**Molecular method**

Polymerase chain reaction using a Multiplex PCR for all four species is possible but needs special equipment and expertise.

Kalazar (visceral Leishmaniasis)

**Microscopy**

The protozoan parasite *Leishmania donovani* causing visceral Leishmaniasis may be detected in a thick blood film stained by Leishman, Leishman-Giemsa or Wright stain. The amastigote forms may be seen within circulating monocytes. These look pinkish oval in outline with dark purple kinetoplast and nucleus. However, they are best detected by examination of an aspirate from spleen or bone marrow where the amastigote forms are seen within the macrophages. Cutaneous and Mucocutaneous leishmaniasis is confirmed by histopathology of the lesion for amastigote stage of the parasite.

**Demonstration of antibody: by ELISA**

**Non-specific serological tests**

These tests are based on the detection of increased gamma globulins in the blood. In Napier's aldehyde test, a drop of 40% formalin is added to 1 ml of serum. A positive test shows rapid and complete coagulation of serum. In Chopra's Antimony test a 4% urea stibamine solution is

mixed with serum. A positive test is indicated by the formation of a profuse flocculent precipitate.

**Culture**

Culture of the parasite is possible in a well equipped laboratory undertaking such procedures regularly. The medium used is NNN (Novy-McNeal-Nicolle) medium. Specimens are inoculated into the water of condensation and incubated at 22˚C for 1-4 weeks. At the end of every week, a drop of condensation fluid is examined for Promastigote forms of *L. donovani.*

**Molecular technique (PCR)**

This is very specific but needs expertise and sophisticated apparatus.

**Selective commonly-encountered conditions: Bacterial**

Leptospirosis

Leptospirosis is a bacterial infection that affects humans and animals. It is caused by bacteria of the genus Leptospira. In humans it causes a wide range of symptoms. Some infected persons may be asymptomatic. Others develop high fever, severe headache, chills, muscle aches, vomiting and diarrhea. They usually have jaundice, conjunctival congestion or a rash. If the disease is not treated, the patient can develop encephalitis, hepatic or renal failure and respiratory distress. In rare cases death occurs. Many of these symptoms mimic Dengue fever, Malaria and Chikungunya.

Screening test is available based on latex agglutination technique with serum for detection of the Leptospira Group specific IgM antibody. Confirmation requires culture and detection of specific Leptospira antibody by a sensitive test such as ELISA followed by Microscopic Agglutination Test (MAT) to determine the serotype. The MAT is only possible in a reference laboratory. For culture, blood is collected in EDTA and sent in ice to an appropriately equipped lab for culture. Specially devised media have to be used. The same sample can also be used for examination of the organism using dark ground illumination (DGI). A fresh sample of urine, alkalinized by adding Sodium bicarbonate so as to have a pH around 9. 0, can be sent to an appropriately equipped lab for DGI. A sample of 5 ml blood must be taken in a sterile screw cap vial for serum for carrying out

a) Screening test for group specific antibody by latex agglutination
b) ELISA test for specific IgM antibody and, if indicated
c) MAT (Microscopic agglutination test)

The samples consisting of blood in EDTA, blood in sterile container for serum and alkalinized fresh urine may be sent to the lab with prior intimation, with clinical and investigation details of the case.

Leprosy

**(a) Skin Biopsy**

It is taken from a lesion situated in a richly innervated area e. g. forearm. The biopsy should be reasonably large and taken from the progressive edge of the lesion including normal skin. It should be wedge shaped reaching deep into the subcutaneous tissue. The base of the wedge in the subcutaneous tissue should be broader than the skin surface. The longitudinal axis of the wedge should be parallel to the general course of the subcutaneous nerve bundle in the area chosen. The biopsy material obtained is immediately fixed in 10 percent normal saline and forwarded for histological examination. In the lepromatous type of leprosy, material is collected for demonstration of *Mycobacterium leprae* by Ziehl-Neelsen (ZN) stain. In the neural type, clinical examination suffices for diagnosis and bacteriological methods are of little use.

**(b) Skin and Nasal Scrapings**

Thickened area of skin is selected. The site is cleaned with alcohol and ether, pinched up between thumb and index finger and a linear cut is made up to the dermis at the apex of the fold by means of a sharp scalpel point. The base and the sides of the incision are thoroughly scraped and the material collected is smeared on the slide and fixed with heat. For nasal scrapings the nose is cleaned with moist swabs and a cut is made in the mucus membrane of the septum if no obviously ulcerated areas are present. The site is scraped gently to obtain the material for smears.

Polymerase chain reaction (PCR) is a sensitive and specific molecular diagnostic test for Leprosy, but needs infrastructure and expertise. It is however, of limited utility for paucibacillary or borderline cases. Tissue biopsy or aspirate from lesion in sterile saline may be subjected to PCR. All results should be correlated with other clinical and laboratory findings.

Bacterial STD

Syphilis

The Spirochaete Treponema pallidum is highly infectious. Therefore, while collecting serous exudate from lesions, such as chancre, mucous patch etc. rubber gloves and eye-protection should be worn. Thoroughly cleanse the sore and its surroundings with a swab of cotton wool, which has been soaked in 2 per cent saline. If an antiseptic has been applied to the sore, a wet dressing of saline solution is applied carefully to the sore for three days prior to taking the specimen. Scrape the margin of the sore lightly with a blunt instrument to remove the superficial epithelium. Squeeze the base of the ulcer so as to promote oozing of serous fluid. Slight bleeding will probably occur but will soon cease and in a minute or two, clear serum will exude from the scarified area. Transfer a portion of the serum to a slide, cover it with a cover-slip and ring with Vaseline to prevent currents occurring due to evaporation. The preparation should be examined by DGI immediately. Darkfield examination for T. pallidum, of material aspirated from enlarged lymph glands is of particular diagnostic value in intra-urethral chancres, lesions obscured by phimosis or paraphimosis, old involuted chancres upon which the local darkfield examinations are repeatedly negative, dirty, painful and secondarily infected chancres, all chancres or secondary lesions within the oral cavity (specially chancres of tonsils), secondary syphilitic lesions with moderate lymhadenopathy and in the differential diagnosis of

syphilis and lymphogranuloma venereum. A positive finding is diagnostic as non- pathogenic spirochetes do not occur in lymph nodes. The material aspirated can also be submitted after fixing in alcohol for silver impregnation such as Fontana stain. The technique of aspiration is simple. After swabbing tincture of iodine on the skin over the enlarged gland, take about 0. 5 ml sterile saline into a 5 ml syringe. Fix the gland with the fingers, insert the needle in it, inject the saline, rotate the needle for 30 to 40 seconds and gently move the gland from side by moving the needle. Withdraw the slightly blood-tinged serum and carry out a thorough darkfield examination.

When facilitiy for immediate microscopic examination does not exist, touch the drop of serum with a sterile 15 cm long capillary tube with both its ends opened and hold in a horizontal position. The exudate from the sore or gland will then rapidly enter the tube. When about 2 to 3 cm of the exudate has entered, the tube is sealed at one end by heating; and when the serum retracts on cooling of the sealed end, seal the other end while holding the tube horizontally. Pack carefully and send to the nearest laboratory.

Simultaneously, sample of 5 ml blood has to be collected for serological tests (VDRL or RPR, TPHA).

Gonorrhoea

(a) The sample for Neisseria gonorrhoeae is the purulent urethral discharge. The meatus is cleaned with gauze soaked in saline, the purulent material is collected on a sterile charcoal impregnated swab, put in Stuart transport medium and sent for culture. Culture is done on chocolate agar and Mueller-Hinton medium in an atmosphere of carbon dioxide. Thayer Martin medium is employed as a selective medium in chronic cases. The material is also taken on-to a clean slide, air-dried and sent to the laboratory, wrapped in paper for Gram stain. The organisms are seen as Gram negative intracellular diplococci. In appropriately equipped laboratories, Fluorescent antibody technique can be used on the smears to demonstrate the gonococcal antigen.

(b) In women, besides the urethral discharge, cervical swabs should also be collected using a speculum. As the organism is extremely delicate and fastidious, it is preferable to carry out a bedside inoculation of media.

(c) In chronic infections there may not be any urethral discharge. The "morning drop" of secretion may be examined or some exudates may be obtained in males after prostatic massage. It may be possible to demonstrate gonococci in centrifuged deposits of urine.

Chancroid (soft sore)

Because a clinical diagnosis of chancroid is often inaccurate, laboratory confirmation of the diagnosis should be sought.

(a) Gram stain of a swab of the ulcer may reveal a predominance of Gram negative coccobacilli but is often difficult to interpret.

(b) Isolation of Haemophilus ducreyi from a swab of the lesion or from the aspirate of suppurative lymph nodes confirms the diagnosis. Selective and supplemented media and use of a $CO_2$ jar are required.

(c) A multiplex PCR based assay is available commercially and is more promising.

**Selected viral conditions**

Dengue fever and Dengue haemorrhagic fever (DHF)

Dengue fever, caused by a flavivirus is a mosquito-borne infection which in recent years has become a major international public health concern. There are four distinct, but closely related serotypes of dengue virus (serotypes 1-4) that cause dengue. Most dengue virus infections are subclinical. Self-limited dengue fever is the usual outcome. Recovery from infection by one provides lifelong immunity against that serotype but confers only partial and transient protection against subsequent infection by the other three. There is good evidence that sequential infection increases the risk of more serious disease resulting in Dengue Hemorrhagic Fever (DHF).

The case definition of Dengue fever is an acute febrile illness of 2-7 days duration with 2 or more of the following: headache, retro-orbital pain, rash, haemorrhagic manifestations and leucopenia. A probable or confirmed case of dengue fever with haemorrhagic tendencies is evidenced by one or more of the following: positive tourniquet test, petechiae, ecchymoses or purpura, bleeding from buccal mucosa, GI tract, injection site and signs of plasma leakage (pleural effusion, ascitis, hypoproteinemia). The haematological criteria are thrombocytopenia (platelets 1, 00, 000/$mm^3$ or less) and haemoconcentration (>20% rise of PCV for age & sex).

**Samples that need to be collected for diagnosis are as follows:**

**For serology**

(a) A blood sample for serum as soon as possible after the onset of illness (acute serum)

(b) A second sample after 10 days (convalescent serum)

(c) A third sample may be drawn 21 days after first sample (late convalescent serum).

The tests required to be done are Dengue IgM and IgG ELISA test and, in field conditions, Dengue IgM & IgG Rapid strip test (Immunochromatographic test). Early dengue is characterized by the presence of detectable IgM antibodies 3-5 days after the onset of infection. Later in the disease there is elevation of specific IgG antibodies. In case clinical suspicion is high and initial IgM test is negative, repeat the test after 2-3 days for confirmation. In neurological involvement CSF can also be used for serology using appropriate kits.

**For virus isolation**

This has to be an early sample. Virus can be isolated

provided the sample is taken in the first few days of illness and processed without delay. Suitable specimens are acute phase serum, plasma, washed buffy coat from the patient, autopsy tissues from fatal cases especially liver, spleen, lymph nodes and thymus as well as mosquitoes collected from the area under surveillance. Samples for virus isolation should be immediately transported within 48 h to referral centre in an ice-box.

**Molecular method**

A PCR can be undertaken in a tertiary laboratory to detect the genetic sequence for a particular strain or all four strains in a Multiplex format.

### Japanese encephalitis (JE)

Japanese encephalitis is a zoonotic viral disease by a Group B arbovirus (flavivirus) that involves the central nervous system. In nature the virus is maintained in animals especially pigs and in birds particularly in cattle egrets, pond herons etc. The case definition for JE is a case of high grade fever of acute onset with at least two of the following: decrease in level of consciousness independent of convulsions, significant change in mental status/ behavior and convulsions.

**Laboratory diagnosis of JE**

Laboratory diagnosis of JE is done by following methods:

(a) Demonstration of viral antigen in the autopsied brain tissue by the fluorescent antibody test

(b) Isolation and identification of the virus from CSF, occasionally from peripheral blood (within 3-4 days after onset of symptoms) or in autopsied brain tissue.

(c) Detection of antibodies to JE virus detected by haemagglutination inhibition test and IgM capture ELISA test. The antigen and reagents for both tests are available from National Institute of Virology at Pune.

The tests mentioned are not available in peripheral hospital laboratories. The samples (separated serum, whole blood in EDTA, autopsied brain in saline) should therefore be preserved at refrigerator temperature of 2-8°C and transported to referral laboratory for further processing. The laboratories that are undertaking work on JE in India are: National Institute of Virology, Ambedkar Road Pune, National Institute of Communicable Disease, 22, Shyam Nath Marg, Delhi, Sanjay Gandhi Post Graduate Institute of Medical Research, Rae Bareilley Road, Lucknow, King George Medical College, Lucknow, School of Tropical Medicine, 110, Chittaranjan Avenue, Kolkata, Veterinary Biological Institute, Hyderabad and King Institure of Preventive Medicine, Chennai. Armed Forces Medical College liaises with NIV Pune for the samples received.

### Kyasanur forest disease (KFD)

This condition came to the fore with an outbreak of monkey deaths and haemorrhagic fever with jaundice in 1957 in the Kyasanur forest of Mysore (now Karnataka) State. The virus, a flavivirus, was isolated from the dead langur monkeys and *Haemophysalis* ticks. Outbreaks have occurred among the human population within Karnataka and serologic evidence of infection exists in North Western States and even the Andaman islands. The illness begins abruptly with fever, headache, chills, vomiting, myalgia, photophobia and conjunctival suffusion. There is hepatosplenomegaly and lymphadenopathy. Petechiae may be present. At this stage clinically it can be mistaken for dengue fever, chikungunya or malaria. Acute haemorrhagic manifestations may occur and renal failure is known. After defervescence, a second phase starts with neurological symptoms. Laboratory findings are similar to that for DHF with leucopenia, thrombocytopenia, rise of haematocrit and elevated hepatic transaminases. Patients have detectable viremia upto 12 days after onset of illness. Laboratory diagnosis consists of serologic demonstration of IgM antibody, isolation of the virus and molecular detection of the viral genomic sequences. These tests are undertaken by a reference laboratory such as NIV at Pune. For virus isolation and molecular methods, blood should be collected in EDTA and serum should be preserved for serological studies.

### Chikungunya

The chikungunya fever is caused by chukungunya virus (CHIKV) of genus Alphavirus of Togaviraedia family and spread by culicine mosquitoes (*Aedes aegypti* and *Aedes albopictus*). Chikungunya was first reported in 1952 from Makonde plateaus between Tanzania and Mozambique and virus isolated by Ross in 1953. It is a Makonde word meaning "the one which bends up". This refers to the position of the affected patient acquired due to excruciating pain in joints. The arthropod vector remains infected for life. In India there have been several outbreaks as far East as Kolkata and also in Kerala, Tamil Nadu and Karnataka. The case definition is an acute febrile illness with several of the following symptoms: headache, incapacitating joint pains, backache, photophobia and itchy rashes. Usual presentation is a triad of "fever, rashes and arthralgia". The routine laboratory parameters may be similar to dengue fever with leucopenia, thrombocytopenia, rise of haematocrit. It may rarely be complicated with meningoencephalitis, hepatitis and myocarditis.

The diagnosis is confirmed by

(a) Serum positive for specific IgM antibodies by IgM capture ELISA (Immunochromatographic tests are available and a combined strip test with dengue fever IgM is also available)

(b) A four-fold increase of titer in paired sera by Haemagglutination Inhibition (HAI) test

(c) RT-PCR of the viral RNA

(d) Virus isolation from serum.

### Hepatitis A

Hepatitis A, a picornavirus, is acquired by the faeco-oral route with the initial source being contaminated water supply. Contacts of patients are often affected and need to be protected using the Hepatitis A vaccine or the specific Immunoglobulin preferably within 2 weeks of contact.

Laboratory diagnosis consists of demonstration of Anti HAV IgM antibody in serum along with biochemical parameters. Anti HAV IgG develops in an affected patient and is known to persist for prolonged period of months.

Hepatitis E

Hepatitis E, as yet an unclassified virus, is acquired by the faeco-oral route and often causes outbreaks of jaundice in the community. It is particularly common among the developing countries of SE Asia. The source is contaminated water. This condition may often take a serious turn in pregnant women in the third trimester of pregnancy. Laboratory diagnosis consists of demonstration of IgM antibody to Hepatitis E by ELISA. Molecular methods are possible with whole blood in EDTA or with serum.

Rabies

**Antemortem diagnosis**

Specimens that can help in antemortem diagnosis in an affected individual are skin biopsy with dermis from the nape of the neck, antemortem saliva, CSF and corneal smears (in 2ml PBS or phosphate buffered saline with 0. 75% bovine albumin) for detection of the rabies antigen using direct Immunofluorescence (FAT). The titer of rabies specific antibody by Rapid Fluorescence Focus Inhibition Test (RFFIT) has to be ascertained in both the CSF and the serum at the same time. A sample of 5 ml blood should therefore be collected at the same sitting. Presence of antibody in CSF is pathognomonic for rabies irrespective of immunization status. RFFIT is done in a reference laboratory such as NIMHANS Bangalore.

**Post-mortem examination:**

The diagnosis of rabies, post-mortem, is carried out by examining the brain tissue for the presence of the virus. This is done by

(a) Demonstration of Negri bodies in the wet impression smears of the hippocampus or cerebellum stained with Seller's Stain. Seller's stain is made up of two components: Seller's A is 1% basic fuchsin in methyl alcohol and Seller's B is 1% methylene blue in methyl alcohol. For use 1 part of A is mixed with 2 parts of B and used immediately on a wet preparation of “imprint smear”.

(b) Isolation of the virus by intra-cerebral inoculation into suckling mice.

(c) Direct Fluorescent Antibody Test (FAT) for rabies virus antigen. Of these, demonstration of the Negri bodies can be carried out in the peripheral laboratory. However, as the Negri bodies may be absent in an animal suffering from rabies, it is essential that the brain tissue should be sent to AFMC for other tests. The following is the systematic procedure for the removal of the brain of the deceased individual or the animal suspected to be rabid:

The removal of the brain must be undertaken with all precautions for personal protection. Apron, goggles, face masks and gloves must be worn. If during removal there is accidental contact with the infective material, an appropriate dose of human rabies immunoglobulin (HRIG) 20 IU/KG and simultaneous course of antirabies vaccine has to be taken as per laid-down guidelines of post-exposure immunisation.

For the removal of the brain, incise the skin along the mid - coronal line. Reflect the skin along with underlying muscles on either side and remove the skullcap by sawing all around. In absence of a saw, the skull can be opened by a chisel with a sharp tap from the hammer. The dura is incised and the brain is removed by dividing the spinal cord at the foramen. The brain is divided into two halves along the median sagittal plane. One half is fixed in ten percent formal-saline or in Zenker's fixative for histopathology. Prepare impression smears from the cerebellum, hippocampus and cortex before putting in 50% glycerol-saline. This tissue in 50% Glycerol-saline will be used for virology studies (demonstration of Negri bodies by Seller's stain, virus isolation, fluorescent antibody test). Five millimeter thick sections are taken from the hippocampus, cerebellum and cortex and put in 10 times their volume of 50 per cent glycerol in sterile isotonic saline for dispatch by fastest means to AFMC. While removing the brain from an animal, the salivary glands should also be removed and sent to AFMC in a sterile container surrounded by wet ice.

To expose the hippocampus, a longitudinal incision about 2. 5 cm long is made in the posterior third of the cerebral hemisphere, about ½ cm away from the midline. The incision is continued down through the grey matter and then completely through the white matter until the lateral ventricle is reached. Hippocampus major is a glistening white and semi-cylindrical body which on section presents a characteristic rolled surface extending laterally on each side forming the bases of lateral ventricles. One or two millimeter thick smooth cut slices are made in the middle of each hippocampus for making impression smears. These slices are placed on a smooth board and scrupulously cleaned slides are then pressed down upon them. Thin films of cells which will adhere to the slides (“imprint smear”) are fixed for 2 to 3 min in methyl alcohol and then stained by Giemsa, Mann or Seller's method of staining.

HIV infection

An arsenal of laboratory methods is available to screen blood for HIV infection, diagnose HIV infection, and monitor disease progression in individuals infected by HIV. These tests can be classified into those that:

(a) Detect antibody

(b) Identify antigen

(c) Detect or monitor viral nucleic acids

(d) Provide an estimate of T lymphocyte numbers and cell phenotype.

Antibody detection is, however, the most widely used and most effective way to identify HIV infection. Tests to detect antibody to HIV can be further classified as:

**(a) Screening tests**

Screening tests which are designed to detect all infected

individuals or samples.

**(b) Supplemental assays**

Supplemental assays which are designed to identify individuals who are not infected but who have reactive screening test results.

Accordingly, screening tests possess a high degree of sensitivity, whereas confirmatory assays have a high specificity. Tests with high sensitivity produce few false-negative results, whereas tests with high specificity produce few false-positive results. Regardless of the results, because laboratory tests have their limitations, they are meant to be used ideally in conjunction with clinical diagnosis.

**Screening tests**

These tests which are basically rapid and relatively cheap include

(a) Enzyme Linked Immunosorbent Assay (ELISA)
(b) Rapid tests
(c) Simple tests

**(a) ELISA**

This is the most commonly used test to screen for HIV infection because of its relatively simple methodology, inherent high sensitivity, and suitability for testing large numbers of samples, particularly in blood testing centers. More than 40 different ELISA test kits are currently available, but only about 10 are licensed. A common feature of all varieties of ELISA is the use of enzyme conjugates that bind to specific HIV antibody, and substrates / chromogens that produce color in a reaction catalyzed by the bound enzyme conjugate. The most popular **ELISA** involves an **indirect method** in which HIV antigen is attached to a well of a 96-well microtiter plate, or to a macroscopic bead that subsequently is placed in a well of a plate. Antibody in the sample is allowed to react with the antigen-coated solid support, usually for 30 minutes at 37˚C or 40˚C. After a wash step to remove unbound serum components, addition of a conjugate (an anti-human immunoglobulin with a bound enzyme) binds to the specific antibody that is attached to the antigens on the solid phase. Another wash later, addition of an appropriate substrate results in color development that is detected by a spectrophotometer. The color is proportional to specific HIV antibody concentration in the sample and is expressed as Optical density values (OD).

**An addition to ELISA** technology is the **antigen sandwich method** in which an enzyme (alkaline phosphatase or horseradish-peroxidase) is conjugated to an HIV antigen (similar to the immobilized antigen on the solid phase). The antibody in the sample is "sandwiched" between two antigen molecules, one immobilized on the solid phase and one containing the enzyme. Subsequently, the addition of substrate results in color development in proportion to antibody concentration. The antigen sandwich ELISA is considered the most sensitive screening method, given its ability to detect all isotypes of antibody (including IgM). Although ELISA tests require an initial investment of expensive instruments like plate washer, spectrophotometers etc. , the running cost is rather low as compared to the supplemental tests.

**(b) Rapid tests**

These tests have a total reaction time of less than 30 minutes. They are more expensive per test than ELISA, though they do not require complex equipment. Importantly, these rapid assays are easy to perform and have utility in developing countries where facilities may not be optimal, stable electricity may be unavailable, and formally trained laboratory workers are not always available.

**There are two types of rapid tests :** Latex agglutination and Dot-blot assays. In Latex agglutination test a colloidal suspension of latex beads is coated with synthetic peptide antigen e. g. env polypeptide. Reaction with HIV antibody produces cross-linking of the latex antigen, which results in agglutination. In Dot-blot assay microscopic particles are coated with a synthetic peptide and then immobilized on a nitrocellulose membrane. Patient's serum containing antibodies, conjugate, developer and stop solutions are then added in sequence with usual incubation and washing steps. Color then develops which is in proportion to the amount of HIV antibody bound to the peptide coated microparticles. Most of these rapid assays now incorporate a built-in control that indicates that the test was performed correctly. In addition, several varieties are available that include two "dots, " which allow the differentiation of HIV-1 and HIV-2 infection. Other rapid test formats include dipsticks, in which antigen is attached on the "teeth" of comb-like devices; several of these rapid tests have the ability to differentiate HIV-1 and HIV-2.

**(c) Simple tests**

This type of HIV test requires greater than 30 minutes but has procedures that can be performed easily without instrumentation. Within this class of tests are agglutination assays in which antigen-coated particles (RBC, latex particles, gelatin particles) are allowed to react with serum antibodies to form visible clumping (agglutination). If RBC is used, the technique is termed passive hemagglutination (PHA); with the use of latex particles, it is known as latex agglutination (LA).

**Supplemental tests**

These tests are also serological tests for detection of antibodies against HIV. These tests are recommended for validation of the positive results of the screening assays. The primary purpose of supplemental tests is to ensure that uninfected individuals who test reactive by screening assays are not incorrectly identified as being HIV infected.

There are two types of supplemental tests that are commonly used: Western blot assay and Immunofluorescence test

**(a) Western Blot Test**

The Western blot is probably the most widely accepted supplemental assay for the detection of antibodies to the retroviruses; most authorities consider it the "gold standard" for validation of HIV results. It is based on using an electrophoretic technique to separate HIV antigens derived from a lysate of virus grown in culture. This

technique denatures the viral components, imparts a negative charge to the antigens, and separates them based primarily according to their molecular weights. The separation of antigens in the technique allows for the identification of specific antibodies to each of the viral antigens in a subsequent set of steps similar to the ELISA methodology.

Depending on the particular antibodies in the sample, reactivity with the separated antigenic components results in band profiles. The classification of Western blot results is determined by certain criteria. Most institutions now follow the CDC guidelines, which require reactivity to at least two of the following antigens: p24, gp41, gp120/160 for a positive classification. It is now universally accepted that a negative result is the absence of all bands.

**(b) Indirect Immunofluorescent Antibody Assay (IFA)**

In this technique, cells (usually lymphocytes) are infected with HIV and are fixed to a microscope slide. Serum containing HIV antibodies is added and reacts with the intracellular HIV. The slide is washed and then allowed to react with anti-immunoglobulin antibodies with a covalently bound fluorescence label attached. The reaction is visualized using a fluorescent microscope.

**Line Immunoassay for HIV**

Another alternative to the classic Western blot and IFA confirmatory tests is the line immunoassay (LIA). In this assay, recombinant or synthetic peptide antigens are applied on a nitrocellulose strip, rather than electrophoresed as in the Western blot. This use of "artificial" antigens decreases the presence of contaminating substances derived from cell culture that can cause interference and sometimes - false reactions.

**HIV-2 infection**

As with HIV-1 screening tests, a variety of test formats are available to detect antibodies to HIV-2, including ELISA beads, ELISA microtiter, and rapid/simple assays.

Diagnostically, HIV-2 infections can present problems. Screening tests designed to detect infection by HIV-1 do not always detect infection by HIV-2 and vice-versa. To address this issue, commercially available HIV-1/2 "combination tests, " which incorporate antigens from both viruses, can be used to screen sera in an attempt to identify either infection.

**Detection of HIV-Specific circulating antigen (p-24):**

The antigen test detects HIV free antigen (p-24) in the serum. HIV antigenemia occurs during "window period" and during late disease when the patient is usually symptomatic. HIV antigenemia is also seen in a newborn. Therefore, an antigen test may be useful, (a) during "window period", (b) during late disease when the patient is symptomatic, (c) to detect HIV infection in a newborn because diagnosis is difficult due to the presence of maternal antibodies. (d) When HIV dementia and encephalopathy is suspected and the test is performed with the cerebro spinal fluid. Only 30% patients during window period, 50-60% of AIDS patients, 30-40% of patients with AIDS related complex (ARC) and 10% of asymptomatic patients are antigen positive.

This test employs indirect ELISA technology.

**Polymerase Chain Reaction (PCR) for HIV:**

In this technique, the target HIV RNA or proviral DNA is amplified enzymatically in vitro by chemical reaction. It is an extremely sensitive assay because a single copy of proviral DNA can be amplified and then be detected by the probe. This technique allows detection of HIV prior to the detection by antibody assays. PCR can probably detect infection even before viral culture becomes positive. Presently, it is the most sensitive known method for identification of HIV infection. However, at present, the PCR technique is not suitable for use in routine laboratories.

**Quantification of HIV-1 plasma viral RNA**

Quantitative measurement of HIV-1 RNA (viral load) has been invaluable in studies of HIV-1 replication dynamics, individual prognosis, and treatment response to antiretroviral medications. In clinical practice, HIV-1 plasma viral load measurement has become the standard of care for decisions regarding initiation and monitoring of antiretroviral therapy. Three different techniques namely RT-PCR (Reverse transcriptase PCR), NASBA (nucleic acid sequence based amplification) and branched-DNA (b-DNA) assay have been employed to develop kits by commercial companies. RT-PCR and NASBA reactions are template (plasma RNA) amplification assays, whereas b-DNA assay amplifies the signal from the RNA-DNA hybridization reaction. As of now, only the RT-PCR method marketed by M/S Roche (Amplicor HIV-1 Monitor version, 1. 5) is FDA approved. It is important to get the CD4 and HIV-1 plasma Viral loads to be measured by the same laboratory every time for follow-up.

## Water for Chemical and Bacteriological Examination

**(I) Collection of samples**

These should be collected under the supervision of the MO. A fair average sample of the supply should be collected and submitted. Samples from any individual source should be taken at the same point and at the same time for chemical and bacteriological examination.

(a) Samples for chemical examination should measure at least 5 L and should be forwarded in Winchester bottles. Samples should be taken without disturbing any sediment and while the bottles are fully submerged.

(b) For bacteriological examination, 180 ml are required. If circumstances allow, the media should be inoculated with water on the spot; a delay of 24 h in inoculation does not, however, affect the results. Samples must be collected and forwarded in sterile bottles obtained from the laboratory. If chlorinated water is being tested a crystal of sodium thiosulphate should be sterilized with the bottle, so that the bacteriological picture at the time of sampling is obtained; otherwise sterilization will continue during transit.

(c) In piped supplies samples should be taken direct from the mains and from delivery taps to the

houses. Before a sample is taken, water should be allowed to run freely so that the impurities in the pipes lumen may be washed out. Flame the tap for a minute before taking the sample, ensuring against leakage from the washer at the top of the tap into the samples. Before reopening the sterilized bottle, flame its neck and stopper for half a minute by means of Spirit-lamp. Remove the stopper and hold it with a sterilized pair of forceps. The stopper is flamed again before it is replaced in the bottle, which in the meanwhile has been completely filled in, so that no bubble of air is retained.

(d) In the case of streams, rivers and lakes, collect water from the middle as well as from near the banks. The bottle is filled by dipping the bottle (with a stopper in position attached to the neck with a piece of string) below the surface and then removing the stopper under water with forceps. This avoids the collection of surface water with scum.

(e) Samples from a well are obtained with bottles weighted with lead or stone having two cords attached, one to the neck and the other to the stopper. The bottle is lowered to the required depth and is filled by jerking out the stopper by means of the attached cord. The bottle should be quickly raised after it is filled and then re-stoppered.

All bottled samples of water must be sealed before dispatch to the laboratory and should be accompanied by the filled requisition form.

**(II) Transportation of water for testing**

Each sample should be labeled giving full particulars of its source, date of collection and examination requested. Samples should be forwarded by the most expeditious route. Those for bacteriological examination should reach the laboratory within three hours of collection. Where a delay of more than three hours is unavoidable the bottle must be kept on ice; and where the specimen has to be transported some distance, it must be packed with saw dust and ice and dispatched by courier escort. Full information on the form at Appendix " C" at the end of this chapter must be dispatched separately at the same time mentioning the identity of the sample referred to. Report on the water sample must be as per form shown in Appendix "D". Microbiology result is usually given separately in terms of coliform count per ml of water submitted.

**Food and Beverages**

Samples of fresh milk, water and aerated waters for chemical and bacteriological examination are sent to the nearest laboratory. Samples of tinned food, grains and beverages are sent to the composite food laboratories (ASC) located at Delhi, Mumbai and Jammu. These laboratories deal with examination of such samples for their storage life and fitness for human consumption. Samples must be taken under the supervision of an officer who should ensure that the following directions are carried out :

(a) A fair average sample should be taken e. g. both the crust and core of bread and cheese should be included; the milk should be well mixed by stirring before taking the sample and so on. The use of paper or other packing inside the receptacle, in which any of the samples except grains is forwarded, is prohibited, unless the sample is contained in its original wrapper.

(b) Canned articles should be sent in unopened containers. If this is impracticable, at least send the original container with the sample.

(c) Articles not packed in original containers should be packed in clean glass stoppered bottles of such a size that the sample completely fills the bottles; solids should be packed in clean tins; and semisolids should be packed either in bottles or tins, whichever is more suitable, or in clean glazed earthenware jars fitted with clean bungs.

| | |
|---|---|
| Milk | 180 ml |
| Condensed milk | 1 tin |
| Dried milk, milk food etc | 60 g |
| Butter, margarine, ghee etc | 120 g |
| Cheese | 120 g |
| Bread | 1 complete loaf |
| Biscuits | 240 g |
| Flour | 120 g |
| Oatmeal. | 60 g |
| Atta | 120 g |
| Rice. | 120 g |
| Tea. | 60 g |
| Coffee | 120 g |
| Cocoa | 60 g |
| Tinned meat, fish etc. | 1 tin |
| Sausages | 1 full tin |
| Dried or smoked meat or fish | 240 g |
| Lard or its manufacture substitutes | 120 g |
| Tinned or bottled fruits, vegetables etc | 1 tin or bottle |
| Sugar | 120 g |
| Jams/syrups | 1 tin/jar |
| Confectionery, sweets etc. | 120 g |
| Pepper, mustard, spices etc. | 60 g |
| Vinegar, sauces etc. | 150 g |
| Lime juice and other similar preparations | 150 g |
| Beer or stout. | 1 bottle |
| Spirits (whisky, gin, brandy, rum) | 1 bottle |
| Aerated water. | 1 bottle |

(d) Samples for bacteriological examination should be packed with aseptic precautions in sterile glass-stopper bottles. The material should be dispatched to reach the laboratory within three hours of collection, otherwise bacterial multiplication may alter initial picture. If delay is

inevitable the material should be preserved in a refrigerator or ice and then forwarded.

**Minimum Quantities**

The minimum quantities which should be sent for examination are as follows :

**Dispatching Particulars of Samples**

Each sample must be securely packed, labeled, and sealed by the officer taking the sample and forwarded so as to reach the laboratory expeditiously. The request should be signed by the officer taking the samples and may be countersigned by the officer at whose request the sample was taken. Full details of each sample sent should be dispatched separately by registered post on laboratory request. For more details, the nearest supply depot should be contacted. This information should include the nature and quantity of the sample, the source of the sample and the date of procuring it, the exact nature of the examination required, and the reasons for examination. In suspected poisoning, a clinical summary of the case must be sent. This summary should state the length of the time which elapsed between the consumption of the article and the onset of the symptoms observed in the order of their occurrence, the present condition of the patient or patients and the condition of other persons who have consumed the articles or similar articles from the same consignment as the sample. Reports of analysis carried out at the military food laboratory are sent to the unit sending the sample.

## Poisoning Specimens for Chemical Examination

**(a) Procedure**

Poisoning is sometimes obvious from the start but when it is uncertain or obscure or being considered because of lack of positive findings the alimentary tract and the organs of elimination deserve prime consideration. However, it must be remembered that except in corrosive poisons, the pathological findings are rarely conclusive, and appropriate viscera will have to be submitted for chemical analysis. It is therefore vital to collect and preserve the right material in the right way, quickly enough to avert failure and preferably in cold storage. The selection of viscera and materials to be preserved for chemical analysis is based on the course the poison takes in the body and its distribution in various organs and tissues. There is a common misconception that it is necessary to preserve only gastric contents in order to establish if poisoning has occurred in a given case. It should be pointed out that the gastrointestinal tract is not the only route of entry of poison into the body. Further more, if any significant period (4 to 6 hours) elapses from the time of ingestion until death or treatment, the poison will have passed out of the stomach. Poison could also have been introduced in the stomach after death to mask a homicidal act. The detection and distribution of a toxic agent in different body fluids and tissues is therefore of vital importance.

**(b) Specimens**

In non-fatal cases vomit, faeces, urine, blood, remnants of food consumed and any other article suspected to be the source of the poison should be sent. In fatal cases, kidney, liver, stomach contents, intestines and bladder should be sent in addition. At the time of postmortem, care must be taken that the contents of the hollow organs do not contaminate the solid organs. Details of material to be sent for chemical examination are given in Table - 6.

Table - 6 : Details of viscera to be sent for chemical Examination in fatal cases

| Material | Quantity |
|---|---|
| Stomach | Whole |
| Stomach contents | 300 ml. If less available, whole quantity |
| Small intestine | 90 cm in adults, 180 cm in children and whole in infants |
| Small intestine contents | 100 ml. If less available, whole quantity |
| Liver, preferably the portion containing gall | 500 gm. of liver in adults and whole in bladder along with its contents* children |
| Spleen + | Half in adults and whole in children |
| Kidneys | Half from each kidney in adults and both kidneys in children |
| Urine | 100-200 ml. If less available, whole quantity |

* The gall bladder and bile should be routinely preserved because examination of bile or, if the gall bladder was empty at postmortem, the gall bladder itself will show the presence of a large number of drugs including morphine (free and conjugated), cocaine, methadone and its metabolites, glutathione, many antibiotics and major tranquilizers or their metabolites.

\+ If septicaemia is suspected and the cause of it is not obvious, spleen tissue should be cultured. It may reveal an unsuspected terminal

**(c) Packing**

Specimens must be packed separately. Clean bottles or jars made of good quality glass with well fitting, clean and sound corks, or glass stoppers, and large enough to contain one and a half times the volume of the specimen should be used. In case of suspected poisoning by substances other than alcohol, all perishable material should be sent immersed in good quality rectified spirit or saturated solution of sodium chloride sufficient in quantity to cover the material in whatever position the vessel containing it may be held; a sample of spirit/preservative used should be sent for ready reference. In case of suspected alcohol poisoning the contents of the stomach and its washings in water are placed in a bottle with a sufficient quantity of salt to saturate the solution and leave a little salt undissolved.

The stomach itself and other materials are placed in rectified spirit as above. The stopper should be carefully tied down with a piece of cloth or leather and carefully sealed. A ring of beeswax or candle wax should be placed round the lip of the bottle so as to cover the shoulder of the bottle and sealed with the office seal of the officer in charge of the case. Each packing should be labeled giving name of the case, nature of the contents, preservative used and date of packing. The containers should be placed in a wooden or tin box, large enough to allow a layer of raw cotton (at least 2 cm thick) between the vessels as well as between the vessels and the box. The box itself is encased in cloth, which should be securely stitched and sealed. The seal should be at intervals not exceeding 7. 5 cm along each line of sewing.

**(d) Dispatch**

The specimens are sent with as little delay as possible to the nearest Government Chemical Examiner by registered post or courier together with all details, which will give him a clue. The forwarding letter should enumerate the specimens sent giving the exact date and means of dispatch. A specimen of the seal should also be enclosed.

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## Appendix A

Laboratory Investigation form during Epidemics

Date:_____

(To be filled by the clinician / epidemiologist)

Patient's name : _____ Patient's ID number : _____

Father's / Husband's name : _____ Age / Sex : _____

Address: _____

_____

Date of onset of illness : _____

_____

Date of hospitalization/ reporting to the MI Room : _____

_____

Clinical signs, symptoms (with duration) : _____

_____

Treatment history: _____

Results of previous investigations (if any) : _____

_____

Any other relevant information : _____

_____

Specimen details :

| Nature of specimen | Date of collection | Investigation required |
|---|---|---|
| | | |
| | | |
| | | |

**Details of sender:**

Name of sender: _____

Unit / Address : _____

Fax : _____ Mobile : _____

E-mail : _____

Signature

(All information has to be complete. Always send the sample in cold chain unless specified otherwise)

# Appendix B

**Outbreak investigation kit**

(To be kept ready in the laboratory. The lab should check the kit fortnightly)

- Disposable storage vials (5 ml, 3 ml) & holders
- Disposable sample collection vials
- Stool culture bottles (plastic screw capped)
- Throat swabs
- Blood culture bottles (to be placed fresh)
- Viral transport medium as required
- Cary Blair medium / Stuart medium (place fresh)
- Vacutainers (plain, EDTA) with needles & holder
- Disposable syringes with needle (5ml, 10 ml)
- Tourniquet
- Gloves assorted sizes
- Triple layer surgical mask
- Disposable gowns
- Autopipette 10 µl, 50 µl, sterile pipette tips in holder boxes
- Puncture proof discarding bags
- Vaccine carrier with ice-pack
- Spirit lamp / gas lighter
- Match box
- Test tube rack
- Centrifuge tubes
- Cleaned slides & cover slips in plenty
- A small portable centrifuge, if available
- Vaccine carrier
- Ice-box / Thermocol box
- Torch, cells
- Mosquito repellant cream
- Rubber bands
- Ziploc plastic bags (Assorted sizes)
- Absorbent material (Newspaper, tissue paper, absorbent cotton)
- Sterile Absorbent cotton-wool balls, packed
- Labels, self-sticking including Bio-hazard labels
- Glass marking pens
- Adhesive tape, cellotape
- Scissors
- Scalpel / sterile blades
- Spatula (wrapped in paper)
- Forceps
- Loop holder
- Pasteur pipettes (sterilized)
- Rapid diagnostic kits eg. $H_2S$ strip for water testing, latex agglutination for meningitis, card test for dengue, chikungunya, malaria
- Band-aid
- Sod hypochlorite concentrate (4%)
- Hand disinfectant
- Lab request forms
- Stationery (paper, pencil, eraser, calculator, sketch pens, ball pens)
- Lancets (packed)
- Coolant packs
- Cardboard containers (assorted sizes)

## Appendix C

**Form for submitting Sample of Water**

1. Sample of water collected from _____ (identity number mentioned on the label).
2. The reason for and exact nature of the examination required _____.
3. Date and hour of sampling _____.
4. Nature and location of source of water, the site of sampling _____.
5. Nature and distance of any source from which an inflow of pollution appears probable _____.
6. Geological strata likely to affect the water constituents _____.
7. If the source be a well: -
   i. Depth of the water surface
   ii. Depth of the water
   iii. Staining
   iv. Coping
   v. Covering
   vi. Strata penetrated
   vii. Method of raising water
8. If stored surface water, nature of collecting surface and conditions of storage
9. Meteorological conditions; heavy rainfall or drought
10. Any treatment the water has received: -
    (i) Clarification
    (ii) Chlorination
    (iii) Softening
    (iv) Boiling

Station:-

Date:-

Name, appointment and address
of Officer requesting analysis
(IN BLOCK LETTERS)

## Appendix D

Report on Water Sample

Received from _____

On _____

The sample was labeled _____

The results of the chemical analysis in parts per 100,000 were as follows: -

Colour in 60 cm tube _____

Odour _____

Insoluble matter _____

Reaction, pH value _____

Ammonia, free and saline _____

Ammonia, albuminoid _____

Oxygen absorbed from : ¼ hour _____ 4 hour _____

Permanganate _____

Nitrogen present as nitrites _____

Nitrogen present as nitrates _____

Chlorine present as chlorides _____

Hardness Total _____

Temporary _____

Permanent _____

Total solids _____

The result of bacteriological examinations is as follows :

_____

_____

_____

_____

Conclusions :

_____

_____

_____

_____

Date : _____

Place : _____ Signature of OIC Lab

## Appendix E

Constituents for preparation of VTM (Hanks Balanced Salt Solution)

| **10X Hank's A Solution** | |
|---|---|
| NaCl = 80 g; KCl = 4 g<br><br>Dissolve this in 1 Litre of Double Distilled water | |
| **10X Hank's B Solution**: | |
| $Na_2HPO_4$ | = 0.6 g |
| $KH_2PO_4$ | = 0.6 g |
| Glucose | = 10.0 g |
| Phenol red (1%) | = 16.0 ml |
| Dissolve this in 1 Litre of Double Distilled water. This is dispensed in 6 ml volume in 10 ml screw capped vials and autoclaved at 15 lb/in² X 15 min | |
| **Preparation of working solution 100ml VTM (Hank's)** | |
| Solution A | = 10.0 ml |
| Solution B | = 10.0 ml |
| Bovine serum albumin (BSA) | = 7.5 ml |
| Antibiotic solution (100X)<br>[contains streptopenicillin, Gentamicin & Mycostatin] | = 1.0 ml |
| Glutamine | = 1.0 ml |
| Double Distilled water | = 70.5 ml |

# Bio-Medical Sciences

## Medical Entomology


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# Introduction to Entomology

The word 'Entomology' is derived from the Greek words 'ENTOMON' meaning an insect and 'LOGOS' meaning science, thus making Entomology 'the branch of science which deals with the study of insects'. However, the scope of the subject has been broadened to include study of all Arthropods. The phylum has many important classes of which class Insecta is the largest. The other important classes are Arachnida, Crustacea and Myriapoda.

Arthropod borne diseases are one of the leading causes of morbidity and mortality the world over and pose a major public health challenge especially to the third world or developing countries. The Armed Forces personnel are at special risk due to their enhanced susceptibility to exposure to vectors due to exigencies of service. For this reason, Armed Forces Medical Officers should have a good working knowledge as regards arthropods of medical importance. An overview of the same is being presented in this chapter. Interested personnel are advised to refer to standard textbooks on Medical entomology and references cited at the end of the chapter for detailed information on vector biology and control (1,2,3,4).

## Modes of Disease Transmission

Arthropods transmit diseases to man through mechanical or biological (which includes propogative, cyclo-propogative and cyclo-developmental) modes of transmission the details of which have been already discussed in the section on Principles of Epidemiology. In addition, there are some **other specialized modes of disease transmission, often encountered** in ticks and mites, which are as follows:

### Trans-ovarian

The disease organism is transmitted to eggs through ovary of infected female, e.g. *Orientia tsutsugamushi*, the agent for Scrub typhus is transmitted by trombiculid mite-*Leptotrombidium deliense*.

### Trans-stadial

The disease causing organism is transmitted from one stage to another e.g. Tick typhus organism *Rickettsia conorii* is transmitted from infected larva to nymph to adult.

### Arthropod Borne Diseases

The important arthropod borne diseases are listed in Table 1 along with their vectors, causative organisms and their reservoir hosts.

Table - 1 : Important arthropod borne diseases

| | Disease | Vector | Causal organism | Reservoir |
|---|---|---|---|---|
| I | **Mosquito borne diseases** | | | |
| | Malaria | Anopheles species | Plasmodium species | Man |
| | Filariasis | Culex quinquefasciatus | W bancrofti (nocturnal, periodic) | Man |
| | | Aedes niveus group | W. bancrofti (diurnal sub-periodic) | Man |
| | | Mansonoides species | Brugia malayi infection | Man, Primate |
| | Chikungunya | Aedes species | Arbovirus group A | Man |
| | Dengue fever & DHF | Aedes species | Arbovirus group B | Man |
| | Yellow fever | *Aedes* species | Arbovirus group B | Man / Monkeys |
| | Japanese Encephalitis | Culex vishnui group (C tritaeniorhynchus) | Arbovirus group B | Mammals/ Birds |
| II | **Sandfly borne diseases** | | | |
| | Leishmaniasis | | | |
| | a) Visceral (Kala azar) | Phlebotomus argentipes | Leishmania donovani | Man/Man made |
| | b) Cutaneous (Oriental sore) | | P. papatasi | L. tropicaMan/Man made |
| | c) Espundia | P. sergenti | Virus | Man/Man made |
| | d) Sandfly fever | P. sergenti / P. papatasi | Virus | Man |
| | **Disease** | **Vector** | **Causal organism** | **Reservoir** |

| | | | | |
|---|---|---|---|---|
| III | **Fly borne diseases** | | | |
| | Bacillary dysentery | *M. domestica* | *Shigella* | Man |
| | Amoebic dysentery | M. domestica | E. histolytica | Man |
| | Gastroenteritis | M. domestica | Specific/Non specific organisms | Man /animals |
| | Typhoid | M. domestica | Salmonella typhi | Man |
| | Paratyphoid | M. domestica | Paratyphi A & B | Man |
| | Cholera | M. domestica | Vibrio cholera | Man |
| | Poliomyelitis | | Virus | Man |
| | Viral hepatitis (Type A) | M. domestica | HAV | Man |
| | Trachoma | M. domestica | C trachomatis | Man |
| | Yaws | *M. domestica* | *T pertenue* | Man |
| IV | **Flea borne diseases** | | | |
| | Plague (Bubonic) | Xenopsylla species | Yersinia pestis | Rodents |
| | Endemic/Murine Typhus | Xenopsylla species | R. typhi | Rodents / Domestic animal |
| | Chiggerosis (Jigger) | Tunga penetrans (chigoe) | -- | -- |
| | Dipylidium caninum | Ctenocephalides felis / canis | | Dipylidium caninum Dogs, cats, wild Carnivores |
| | Hymenolepis diminuta | X. cheopis / N. fasciatus | Hymenolepis diminuta | Carnivores |
| | H nana | X. cheopis / C. canis / Pulex irritans | H nana | Rats, mice |
| V | **Louse borne diseases** | | | |
| | Epidemic typhus | Pediculus humanus | R. prowazeki | Man |
| | Epidemic relapsing fever | Pediculus humanus | Borrelia recurrentis | Man |
| | Trench fever | Pediculus humanus | B quintana | Man/animals |
| | Dermatitis | Pediculus humanus / capitis | | Secondary organisms Man |
| VI | **Tick borne diseases** | | | |
| | Kyasanur Forest Disease (KFD) | Hard ticks species | Arbovirus group B | Monkeys/Birds |
| | Tularaemia | Hard ticks species | P tularensis | Rabbits/Rodents / cattle |
| | Indian Tick Typhus | Hard ticks species | *R. Conorii* | Dogs |
| | Relapsing fever | Soft Tick | B duttoni | Rats |
| VII | **Mite borne diseases** | | | |
| | Scrub typhus | L. deliense | Orientia tsutsugamushi | Rodents |
| | Rickettsial pox | - | R. akari | Rodents |
| | Scabies | S. scabei | - | Man |
| VIII | **Cyclops transmitted diseases** | | | |
| | Dracontiasis | Cyclops species | D. medinensis | Man |
| | Fish tape worm | Cyclops species | D. latum | Fish |
| IX | **Reduviid bugs** | | | |
| | Chagas disease | Reduviid/Cone-nosed | T. cruzi | Domestic animals / man |
| X | **Tsetse flies** | | | |
| | Trypanosomiasis | Glossina species | T. gambiense & T. rhodesiense | Wild animals / cattle / man |

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# Principles of Vector Control

Control of arthropods is one of the key strategies in the management of Vector borne diseases. We should have sound knowledge of the bionomics, distribution, seasonal prevalence, vectorial capacity, insecticide susceptibility status and role of arthropods in disease transmission coupled with the knowledge of identification features of the vectors incriminated for formulating effective control strategies. The various control options available are as follows:

(a) Environmental Control
(b) Biological Control
(c) Chemical Control
(d) Personal Protective measures
(e) Mechanical control
(f) Physical control
(g) Genetic control
(h) Legislative control

## Environmental Control

The important environmental control measures which are increasingly being used in the developed countries are described below (5, 6, 7) :

### Environmental Management

This has been defined as "The planning, organization, carrying out and monitoring of activities for the modification and/or manipulation of environmental factors or their interaction with man with a view to preventing or minimizing vector propagation and reducing man-vector-pathogen contact." This is a naturalistic approach which attempts to extend and intensify natural factors which limit vector breeding, survival and contact with man.

Environmental Modification

It is defined as "A form of environmental management consisting of any physical transformation that is permanent or long-lasting of land, water and vegetation, aimed at preventing, eliminating or reducing the habitats of vectors without causing unduly adverse effects on the quality of the human environment". Environmental modification includes drainage, filling, velocity alteration, land leveling and transformation of impoundment margins.

Environmental Manipulation

It is defined as "A form of environmental management consisting in any planned recurrent activity aimed at producing temporary conditions unfavourable to the breeding of vectors in their habitats". Examples of environmental manipulation activities are water salinity changes, stream flushing and regulation of the water level in reservoirs, vegetation removal, shading and exposure to sunlight.

Modification or Manipulation of Human Habitation or Behaviour

This means "A form of environmental management that reduces man - vector - pathogen contact". Examples of this approach are siting of settlements away from vector sources, mosquito/rodent proofing, personal protection and hygienic measures against vectors and provision of mechanical barriers, providing facilities for water supply, disposal of waste water and excreta, laundry, bathing and recreation to prevent or discourage human contact with infested water.

## Chemical control

The new era of control of vector borne disease began with the discovery of the insecticidal value of Dichlorodiphenytrichloroethane (DDT). DDT was first synthesized by Othmar Zeidler in 1874 at Strasbourg, Germany. In 1939, Paul Muller of the Geigy Company in Basle, Switzerland, discovered its remarkably long residual insecticidal property, earning him the Noble Prize in Medicine. The availability of several effective, safe and low cost pesticides, coupled with improvements in the techniques of their application, made it possible to embark upon extensive countrywide programmes for the control or eradication of such major vector borne diseases. However, development of resistance amongst vectors to insecticides as well as the growing concern about environmental contamination resulting from the use of persistent insecticides has become issues of concern. In view of this, research on newer and safer insecticides and promotion of their widespread use as well as better methods of application is being intensified throughout the world (8 -15).

### Classification if Insecticides

The most common classification used is based on chemical composition, as presented in Fig - 1.

### Natural Insecticides

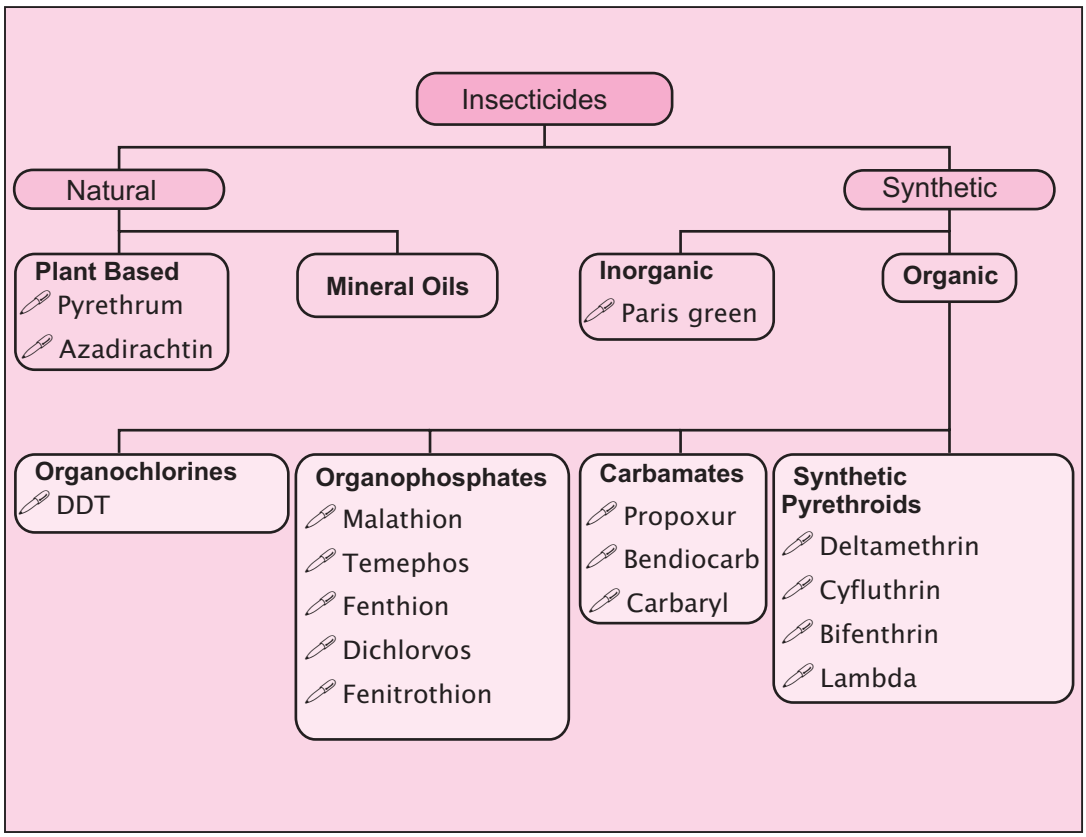
Plant based

### Pyrethrum

Pyrethrum extract is obtained from the dried heads of the flower *Chrysanthemum cinerariafolium* and contains the active ingredients pyrethrins I and II, constituting 1 to 2 percent of the total weight of the raw pyrethrum. Pyrethrum is characterized by rapid knockdown action on arthropods even when used in very low dilution. It has practically no residual effect, which makes repeated applications necessary. Pyrethrum is available as 2 percent extract. 1 litre of this extract is mixed with 19 litres of kerosene to get 0.1% solution. Using a 0.4 mm or lower calibre nozzle, 50 to 100 ml of pyrethrum solution in kerosene oil is sprayed per 100 $m^3$ of space. It is one of the main insecticidal constituents in aerosol dispensers

and also an insecticide of choice for ULV sprays. Synthetic pyrethroids.

Fig. 1: Classification of insecticides as per chemical composition




Pyrethrum is perhaps the most acceptable insecticide for use in cook houses, dining halls and other food preparation areas.

**Azadirachtin**

This is obtained from the seed kernels of Neem plant. It may have some insecticidal & fungicidal, including insect growth regulating qualities. It has been variously formulated for mosquito larval and adult control in the form of liquid and cream formulations. Neem products contain up to 3% Azadiractin. At present, its use is not fully evidence based.

**Mineral Oils**

Kerosene oil, diesel oil, petrol and crude engine oil have been successfully used as mosquito larvicides. The oil film cuts off the air supply, enters and blocks the trachea, may act as a stomach poison, and also lowers surface tension which prevents larvae from floating. Malariol is the best and easiest larvicidal oil to use for Anopheline and Culicine larvae. Malariol oil is used @ 10 litres per 500 linear mts.

**Synthetic insecticides**

These can be organic and inorganic. The only inorganic compound which was used as mosquito larvicide was Paris green (Copper-aceto-arsenite). It acted as stomach poison when ingested by mosquito larvae. However, it is not used any more for mosquito control.

The organic insecticides fall into four major groups, viz. Organochlorines, Organophosphates, Carbamates and

Organochlorine Compounds

These compounds are contact poisons and act on the nervous system. These or their degradation products are stored in body fat and may be excreted in milk, urine or sweat. They all have variable residual action for variable periods and are toxic to man and animals. The most important and the only member of this group used in Public Health is DDT (Dichlorodiphenyltrichloroethane). Currently DDT is being used for Indoor residual spray in North Eastern states only. A deposit of 1 g of DDT/$m^2$ of surface area of walls and ceiling up to a height of 3.5 m in all dwellings applied at 8 weeks' interval effectively controls majority of the mosquitoes and also other arthropods resting on the treated wall (Refer to Chapter on Mosquitoes for further details on use). As per Govt. of India Gazette notification number S.O. 378(E) dt. 26th May 1989, the use of DDT in Agriculture has been withdrawn and restricted to 10000 MT/ annum for Public Health programme except in case of North East as Insecticidal Residual Spray (IRS).

Organophosphorus Compounds

These insecticides are derivatives of phosphoric acid and act by inhibiting the activity of cholinesterase. Many of the insects, which have become resistant to Organochlorines are still susceptible to the members of this group. However, due to their extensive use in agricultural as well as public health field, more and more insects are developing resistance to Organophos-phorus compounds. Some of the common compounds are Malathion, Temephos, Fenthion, Dichlorovos (DDVP) and Fenitrothion and so on.

**Malathion**

It is one of the least toxic Organophosphorus compounds. It is available as Malathion Technical (95%) for use as space spray, 50 percent Water Dispersible Powder (WDP) and Emulsifiable Concentrate (EC) for residual control and 90% dust for use against fleas and lice. Malathion under the National Vector Borne Diseases Control Programme is being used as Indoor Residual Spray against mosquitoes in areas where the vectors have become resistant to DDT. The dosage of its application is 2 g/$m^2$ (Refer to Chapter on Mosquitoes for details). As ULV spray it has been very

widely used during outbreaks of DHF and JE as an anti adult mosquito measure. Development of resistance has been reported in a large number of vectors to Malathion.

**Temephos (Abate)**

It is available as 50% EC. It is the only insecticide approved for use in potable water. Because of its low toxicity, it has been successfully used for the control of *A. stephensi* breeding in wells and domestic containers at a dosage of 1ppm (Refer to Chapter on Mosquitoes for details). It has proved to be very successful in Guinea worm eradication programme in India.

**Fenthion (Baytex)**

It is formulated as 50 percent EC and as granules containing 2 percent toxicant. It is a good mosquito larvicide but can not be used in potable water bodies. It is highly effective as a larvicide against *C quinquefasciatus* or any other vector found breeding in non potable water bodies at a dosage of 1 ppm (Refer Chapter on Mosquitoes for further details). It can also be used for housefly control as a larvicide (Refer to Chapter on Houseflies for details).

**Pirimiphos methyl**

This insecticide is being considered as an alternative insecticide for Indoor residual spray. It is available as 25% WP; 2 kg is mixed in 10 litres of water and sprayed @ 10 litres/ 250 sq m area to give a deposit of 2g/sqm. Three rounds of spray are recommended as is followed in case of Malathion.

**Dichloro-dimethyl-dichlorvinyl-phosphate (DDVP or Dichlorvos)**

It differs from other Organophosphorus compounds in that it possesses a much greater vapour pressure at ordinary temperature which produces fatal insecticidal vapour. It is available as 72.6% EC and in aerosol formulations. It can be combined with solid substances like wax and used as tablets or bricks thus allowing it to evaporate slowly. It is one of the common insecticides used for disinsecting aircraft. It is an effective housefly larvicide.

**Fenitrothion**

It is available as Fenitrothion 40 percent water dispersible powder (WDP). The insecticide has shown promise as an effective insecticide for control of bedbugs; however toxicity constraints have limited its widespread use.

Carbamates

These compounds are derivatives of carbamic acid and resemble Organophosphorus compounds in their mode of action. Some of the preparations produce a rapid knockdown effect like that of pyrethrum. The inhibition is reversible with the Carbamates and hence these compounds are less toxic. Some of the compounds in common use are Propoxur (Baygon), Carbaryl and Bendiocarb.

**Propoxur (Baygon/Blattenex)**

It is formulated as WDP as well as EC. It is considered as the least toxic Carbamate compound for man and domestic animals. It has a flushing out effect and therefore is commonly used for cockroach and bedbug control. It is also used in bait formulations against houseflies and cockroaches.

**Bendiocarb**

Bendiocarb is an alternative insecticide for indoor residual spraying. It is available as 80% WP. For indoor residual spraying, it is recommended @ 200 mg/sq m. Two rounds of spray are recommended for effective control against Malaria.

Synthetic Pyrethroids

These are synthetic derivatives of natural Pyrethrum. These are highly potent with quick knock down action and long residual life. Synthetic pyrethroids are many times more effective than the previously available insecticides. Their relative safety to man and higher animals and efficient biodegradability makes them very attractive materials for integrated vector control. The commonly available products are Permethrin, Allethrin, Phenothrin, Cypermethrin, Cyfluthrin, Deltamethrin and Bifenthrin. The Synthetic pyrethroids are formulated as WDP, EC, SC, Flow, EW and ULV formulations. Being broad spectrum, these insecticides are being used as residual spray, space spray and topical applications as well as for treatment of clothing.

**Deltamethrin**

It is one of the most widely used Synthetic Pyrethroid molecule in the field of vector control. It is available in many formulations for various vector control strategies viz. SC 2.5% (Flow) formulation for treatment of bed net and routine household pest control activity; 2.5% WP formulation for indoor residual spray in Malathion resistant areas and 1.25 ULV for space spraying.

**Cyfluthrin**

Besides Deltamethrin, this is the next most widely used molecule. It is available as 05 EW formulation for treatment of bed nets; 5% EC for household use and 10% WP for use as indoor residual spray in Malathion resistant areas.

**Permethrin**

Widely used for control of lice, scabies and for treatment of clothing and bed nets. The product is formulated as Shampoo formulation for use as anti-lice treatment and 5% cream for use in scabies treatment. Bed nets treated with Permethrin at the manufacturing stage itself are available as Pretreated or Long Lasting Nets (LLN's).

**Newer group of insecticides**

Phenyl pyrazoles

Fipronil is the only member of this class of insecticide. Fipronil acts by antagonizing the effect of GABA. It is available as 0.3% Gel for use against cockroaches as a crack and crevice treatment. It has a unique action called 'cascade effect' which is possible due to coprophagy seen in cockroaches. When cockroaches consume the insecticide bait, they are killed. These dead cockroaches when consumed by other cockroaches, it results in their death and this goes on for about two months or so, thus

obviating the need to retreat the area at lesser intervals.

Neo Nicotinoids

Imidacloprid is the sole member from this class. It acts on the Central Nervous System of insects, causing irreversible blockage of Postsynaptic nicotinergic acetylcholine receptors. Imidacloprid is a systemic insecticide, having notable contact and stomach action. Imidacloprid is available as 2.15 % Gel for use against cockroaches and as Bait for use against Houseflies, where it is formulated with housefly pheromone Muscalure.

Biorational Insecticides

'Biorational' means any substance of natural origin that has a detrimental or lethal effect on specific target pest, e.g. insects. Possess a unique mode of action. These insecticides are non-toxic to man, plants and animals, and have little or no adverse effects on the environment. The biorational insecticides are presented in Fig - 2 :

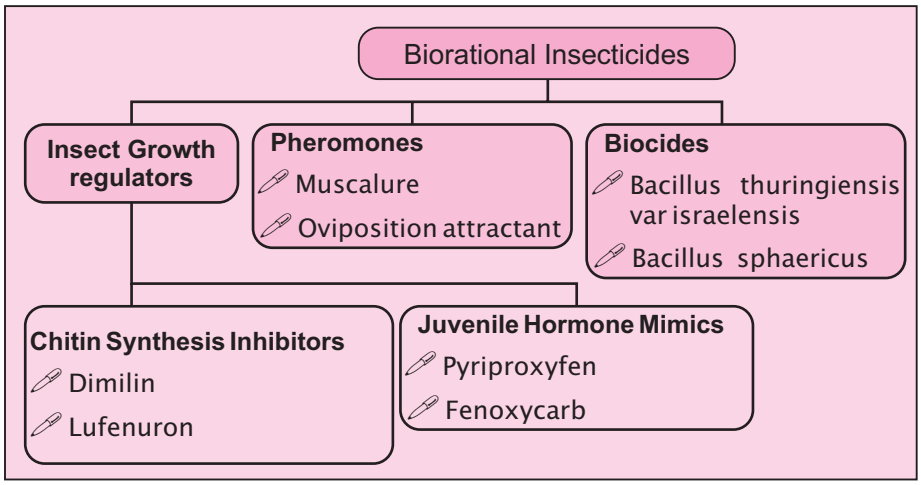
**Insect Growth Regulators**

A new approach to vector control is the use of substances that adversely affect insect growth and development. The enzymes and hormones that regulate developmental processes within an insect's body, often known as insect growth regulators (IGRs), can be used to stimulate development at inappropriate times or inhibit it at other times. They are quite selective in their mode of action and potentially act only on target species. The major groups of IGR compounds include:

**Chitin Synthesis Inhibitors**

They are most effective when used against the immature stages of a vector. Diflubenzuron, currently registered under the trade name Dimilin, is used for controlling mosquitoes, houseflies etc. Lufenuron is especially effective in flea and tick infestation control on animals. Novaluron is a recent addition to the list, which has been found effective against the mosquitoes. Dimilin is available as 25% EC, WP & 0.5% Granules and is used @ 1.0 g/ acre of surface water as mosquito larvicide. Novaluron is a contact larvicide and is available as 10% EC; it is used @ 20 µg a.i./ l and the efficacy lasts up to 3 months.

Fig - 2 : Biorational Insecticides used in Vector Control




**Juvenile Hormone Analogues or Mimics (JHMs)**

Juvenile Hormone Analogues or Mimics (JHMs) act by inhibiting the developmental changes associated with embryogenesis, morphogenesis, and reproduction. Several compounds (e.g., Pyriproxyfen, Fenoxycarb, Lufenuron, Triflumuron) have been successfully incorporated into vector management programmes especially Dengue and Malaria and in products used for controlling ants, fleas, and other household pests. Pyriproxyfen has a residual effect up to 3 to 6 month indoors and 30 days outdoors. It is widely used against mosquitoes @ 2gm a.i./ sq m.

Biocides

The two biocides used in the field of vector control are *Bacillus thuringiensis* var *israelensis* and *Bacillus sphaericus.* Both these products are widely used as larvicides in Mosquito control programmes and act as stomach poison (16-18).

***Bacillus thuringiensis var israelensis* (Bti)**

It has been found to be effective as Mosquito larvicide. It is a gram positive spore forming bacteria. The product is available as WP, Granules, AS & Briquette. Bti 12 AS is used @ 20ml/m³ and has been found to be effective up to 15 days (for details refer chapter on mosquito). Bti however, suffers from the disadvantage that it can not be used in polluted waters or where particulate matter is more; it also cannot recycle in nature. It is used in non potable water bodies.

***Bacillus sphaericus***

A naturally occurring bacterium used against mosquito larvae. It is more effective in polluted water and can recycle in nature. It is available in various formulations like Bti viz. pellets, briquettes, granules & WP. It is used @ 20ml/m³ and has been found to be effective up to three weeks.

**Fumigants**

Some of the fumigants used as pesticides are Carbon tetrachloride, Methyl bromide, Ethylene dibromide, Chloropicrin, Carbon disulphide and Dichlorvos (DDVP).

## Application Techniques

Control of arthropods in different habitats necessitates the use of different types of spraying equipment as well as a variety of formulations such as liquids, granules and dusts. For example, control may involve treatment of small domestic or peridomestic water collections which are ideal breeding places for *Aedes* mosquitoes; applications to stagnant waters in cesspools, ditches and drains where *Culex* mosquitoes breed, large bodies of standing water where certain *Anopheles* mosquito species may be breeding; or aerosol spraying of extensive areas to halt epidemics. To meet with diverse situations, significant progress has been made in improving the spraying

equipment. The ultra low volume (ULV) equipment for ground and aerial spray to control mosquitoes and other haematophagous arthropods has resulted in not only the elimination of several impediments like frequent mixing and reloading but helped in increasing the speed of application and reducing the dosages and costs. It is specially recommended for control of an outbreak of vector borne disease (19, 20).

### Types of formulations

Formulations essentially are of three types: Solid or dry, liquid and gaseous formulations.

Solid or dry formulations

#### Dusts

Dusts are normally ready-to-use formulations with a low percentage of active ingredient (usually 1 - 10%) plus a very fine inert carrier such as talc, chalk, diatomaceous earth, clay or volcanic ash. Dusts are always used dry and can easily drift into non-target areas if they are not applied carefully. For this reason, they are only used for outdoor applications when the wind is calm. A common use for dusts is in crack and crevice or spot treatments indoors in out-of-sight areas (behind equipment, in wall voids, and so on) which remain dry. The residual pesticidal activity of dust is normally fairly long, provided the dust stays dry. Dusts are used on people during mass delousing operations to control outbreaks of lice. Dusts are also used for flea control during Plague outbreak. Dusts aren't generally absorbed through the skin, but may be dangerous if inhaled into the respiratory tract.

#### Granules

These are basically the same as dust formulation, except the carrier particles are larger. Granules are also available in timed-release formulations that release a dosage of the pesticide over an extended period of time. Granules have the advantage of providing longer lasting effects and less drift than generally occurs with liquids or dusts.

The percentage of insecticide in granules and pellets varies from 1 to 5 percent. These can be used in irrigation channels, irrigated or flooded lands, paddy fields, and particularly where there is vegetation on the water surface. These can be effectively used also in small water collections such as ornamental tanks and earthen pots, tree holes and other domestic or peridomestic breeding places of *Aedes* mosquitoes.

#### Wettable powder

This formulation consists of the technical grade pesticide, an inert carrier and a wetting agent (usually a synthetic detergent) that helps it mix with water. These usually contain 50 to 75 percent of the toxicant. Most of these can be put directly into water and require only slight agitation to make suspension while others may require mixing with a small amount of water to form a paste or slurry. The required volume of water is then added to paste or slurry followed by thorough agitation of the mixture, to make a suspension. A great advantage of a suspension is that the pesticide stays on porous surfaces like concrete, plaster or unpainted wood. Water penetrates these surfaces, leaving the carrier and the maximum amount of the pesticide on the surface available to kill pests. Suspensions have other advantages, too. They have no solvent odor, and they don't tend to irritate or penetrate skin. However, they generally need agitation to keep pesticidal particles from settling down. Also, they tend to clog sprayer nozzles and strainers, especially when the wettable powder is stored for long periods in humid areas.

Liquid formulations

#### Emulsifiable concentrates

Emulsifiable concentrates consist of the technical grade pesticide (typically 45% to 75%), a solvent, and an emulsifying agent, usually a synthetic detergent. This agent allows the concentrate to be diluted in water, resulting in an emulsion.

Emulsifiable concentrates are usually clear but emulsions look similar to milk. Finished sprays are emulsions or solutions diluted to field strength. Unlike solutions, most emulsions need a little periodic agitation to keep the concentrate from separating out of the water. Emulsions are used for residual treatments. Pests that contact these surfaces are killed by the pesticidal residue. Emulsions may damage aluminum, varnish, and painted surfaces, due to the action of solvents such as xylene. Emulsions may also be corrosive to metal sprayers and their fittings.

#### Oil solutions

These formulations consist of a technical grade pesticide dissolved in a solvent such as kerosene or diesel oil. Solutions are available as ready-to-use formulations (for example ordinary household fly and mosquito sprays with a low percentage of pesticide) and as solution concentrates. These concentrates should be diluted in oil or another suitable solvent. Some concentrates are used without dilution in Ultra low volume (ULV) applications. Oil solutions applied as finished sprays often kill insects on contact, since the oil helps the pesticide penetrate the insect's waxy body wall.

Gaseous formulations

Gases are primarily used in fumigation operations. They may be prepared as liquefied gases and packaged in pressure containers or in a material form that reacts with the moisture in the air to form a gas. Gases are the most dangerous pesticides used and hence special safety equipment and training are necessary when using gases. One of the common gaseous formulations viz. Calcium cyanide (powder) and Aluminium phosphide (tablet) are used for rodent control.

Special formulations

#### Resin strips

Pesticide-impregnated resin strips release vapor when they are heated or exposed to normal room temperatures. The use of resin strips in rooms occupied by the young, the elderly or in food preparation and food serving areas should be prohibited.

#### Baits

Baits are commonly used to manage scavenging pests such as rodents, ants, flies, and cockroaches, which are

particularly difficult to manage with standard techniques. Baits consist of the toxicant mixed with a food attractive to the target pest or with water. Thus, baits made with local foods are normally more effective than premixed formulations. Recent development is the use of pheromone Muscalure with Imidacloprid as bait for houseflies.

**Gel**

Gels comprise of some food attractant mixed with the toxicant and some stabilizing agents. Examples are Fipronil and Imidacloprid Gels marketed for use against cockroaches.

**Shampoo**

It is used against head lice infestation. Permethrin is available as Shampoo formulation under the trade name "Mediker".

**Beads/ Pellets/ Briquettes**

Small, floating beads, pellets or briquettes incorporating biocides-Bti and *B. sphaericus* are sometimes used against Anopheline larvae. These formulations can be made into controlled release formulations as well.

**Paints and Lacquers**

These can be used for incorporation of insecticides for certain situations like control of pests on ships. They are effective for long periods. The new insecticide, Imidacloprid is also available as a paint formulation against houseflies.

**Mats/ Coils**

These are special formulations which have been developed as controlled release formulation for indoor use against mosquitoes. These have Synthetic pyrethroids, usually Allethrin, as the toxicant which knocks down the mosquitoes when used indoors.

**Aerosols**

Aerosols are pressurized cans containing a small amount of pesticide driven through a small nozzle. They are commonly used as space sprays for flying insects viz. Mosquitoes and Houseflies and as residual sprays (Mites / ticks) depending on the formulation. Care should be taken since they can explode if punctured or overheated, even after the pesticide has been dispensed. Common insecticides used are Pyrethroids, Malathion, DDVP and repellents like DEET and DEPA. These are used for disinsecting aircrafts, tents, rooms, other small enclosures, uniforms and for topical application. An emission of nearly 15 seconds is enough for a 100 $m^3$ space.

**Equipment**

Equipment used for vector control can be broadly classified as ground equipment and equipment used for aerial applications (19, 21).

The Ground Equipment

Includes sprayers for production of fine or coarse spray which may be either manually operated or power operated; or, sprayers for the production of mist which may be either with gaseous energy nozzles (manual operated or power operated) or with centrifugal nozzles. These also include devices for the production of aerosols which may be mechanical, thermal or gaseous energy aerosol generators. Other type of ground equipment includes dusting equipment which may be manually operated or power operated, and applicators for granules and pellets, manually or power operated.

The Aerial Equipment

Includes equipment for aerial sprays (boom and nozzle system).

The equipment commonly used for spraying various insecticidal formulations are the hand operated sprayers, power operated sprayers, aerosol dispensers, fog generators and dusters.

Hand Operated Equipment

These are hand sprayers, knapsack sprayer and compression sprayer.

**Hand Sprayer**

The hand sprayer is used for space spraying of small apartments. It is provided with a small can for holding ½ - 1½ L of spray fluid and a cylindrical plunger type air pump. The nozzle size is less than 0.4 mm, in order to produce a fine spray. The simplest form is the familiar 'flit gun' producing intermittent spray. A number of other light hand sprayers have been designed which can be pressurized in the manner of compression sprayers and are used to produce a mist or fine droplet spray.

**Knapsack Sprayer**

This is designed to fit on to the back of the operator and usually has a capacity of 15 to 20 L. It incorporates a light but powerful diaphragm pump actuated by a lever carried forward to the operator's hand where it is worked by an up-and-down movement. These sprayers are used both for larviciding and residual spraying. The nozzle size used for residual spraying varies between 0.78 to 1.0 mm so as to produce a coarse spray.

**Compression Pneumatic Sprayer**

This is the commonest type of equipment used in National Vector Borne Diseases Control Programme (NVBDCP) and in the Armed Forces for the application of insecticides. It has a hand operated pump incorporated to build up adequate pressure. When the pressure is released by a trigger on the lance, the liquid is forced out from the tank to the nozzle by the compressed air and continuous spray of the insecticide formulation is produced. It is slung over the shoulder with one strap or may be carried on the back with two straps. It is operated by one person.

Power Operated Sprayers

These are useful for application of insecticides over large areas. These are hydraulic sprayers in which the spray liquid is expelled to the nozzle by positive displacement by the plunger pump. Insecticide tanks built into a truck or mounted over a hand trolley are connected directly to a power operated compressor.

**Insecticidal Fog Generators**

Several types are now available for the production of

insecticidal fogs in the open on a large scale. In these fogging machines the oily solution of the insecticide is finely atomized by the powerful blast of hot exhaust gases from a petrol engine.

Aerosol Dispensers

These are used for disinsectisation of aircrafts, tents, rooms and similar small enclosures. It contains insecticide and a propellant. Common aerosols contain Synthetic pyrethroids, often used for mosquito and fly control.

Dust Gun

Insecticidal dusts are applied against lice, fleas in rat burrows or on water surfaces as dry powders diluted with inert dusts. Small light weight guns are used for mass delousing of infested people.

**Residual Spraying**

This is the application of insecticides to surfaces so that the insecticide particles remain on the surface in the form, size and quantity suitable for insects to pick up on contact and sufficient to exert a lethal effect over a long period. Organochlorine, Organophosphorus, Synthetic pyrethroids and Carbamate compounds can thus be applied on the inside walls of houses and also on thick bushes in forests. The type of surface to which an insecticide is applied influences its toxicity against insects and its persistence. Solutions and emulsions quickly get soaked in the absorbent surfaces of soft bricks and mud walls which take in a large portion of insecticidal material deposited on them; but when suspended in water it remains over the surface after the water evaporates or gets absorbed. The nozzles of sprayers used for residual spraying must conform to the need of having a droplet size which is neither too large nor too small. Similarly, safety precautions should be observed, as follows, while spraying (22):

(a) Do not eat, drink or smoke while working.

(b) Wash your hands and face with soap and water after spraying and before eating, smoking or drinking.

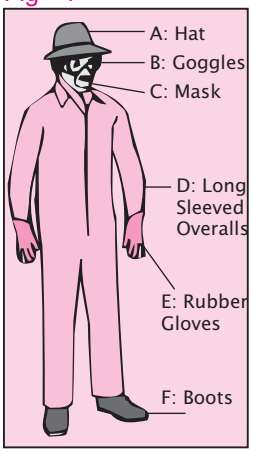
(c) Shower or bathe at the end of every day's work and change into clean clothes.

(d) Wash your overalls and other protective clothing at the end of each working day in soap and water and keep them separate from the rest of the family's clothes.

(e) If the insecticide gets on your skin, wash off immediately with soap and water.

(f) Change your clothes immediately if they become contaminated with insecticides.

Fig - 4




(g) Inform your supervisor immediately, if you do not feel well. Wear protective clothing as shown in Fig - 4

(i) Broad rim hat (protects head, face and neck from spray droplets)

(ii) Goggles or face shield (protects face and eyes against spray fall-out.)

(iii) Face mask (protects nose and mouth from airborne particles of the spray fall-out.)

(iv) Long sleeved overalls. (Keep overalls outside of boots.)

(v) Rubber gloves.

(vi) Boots.

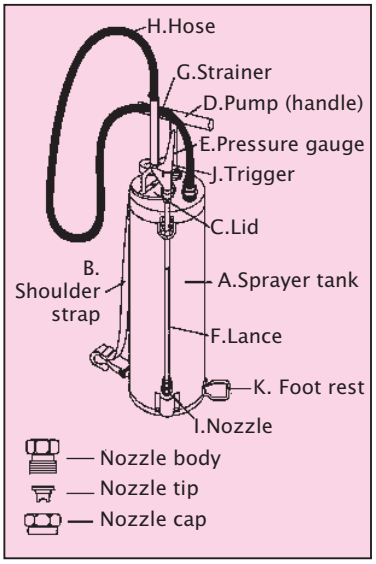
**Preparations**

**The household** - Inform the householder of the spraying schedule and the purpose of spraying, giving them time to prepare and vacate the house. Occupants, including pet animals, MUST leave houses before spraying. Rooms occupied by sick people who cannot be moved must NOT be sprayed. Remove all household items, including water, food, cooking utensils and toys from the house. Move and cover, or take out the furniture to allow easy access for spraying walls. Items that can not be removed should be well covered.

**Equipment**

Indoor residual spraying of insecticides is normally done using hand-operated compression sprayers. Before starting a spray operation, the equipment must be checked. Faulty sprayers may result in poor control or over-treatment. Examine the sprayer visually to ensure that all parts are present, assembled correctly and are in good condition (Fig - 5).

Fig - 5

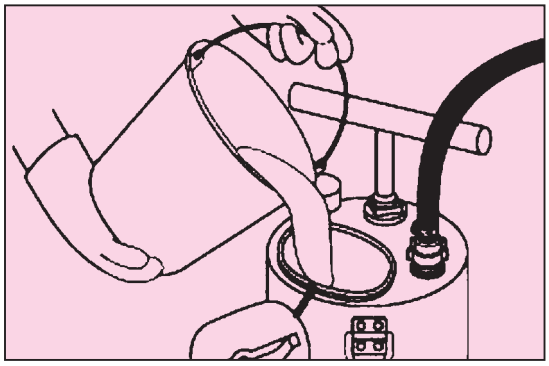



A. Sprayer tank
B. Shoulder strap
C. Lid
D. Pump (handle)
E. Pressure gauge
F. Lance
G. Strainer
H. Hose

I. Nozzle - check correct type of nozzle is fitted and is not damaged or worn (flat fan nozzle with 55 to 60º swath and 0.75 l/min flow rate at 700 g/ sq cm).

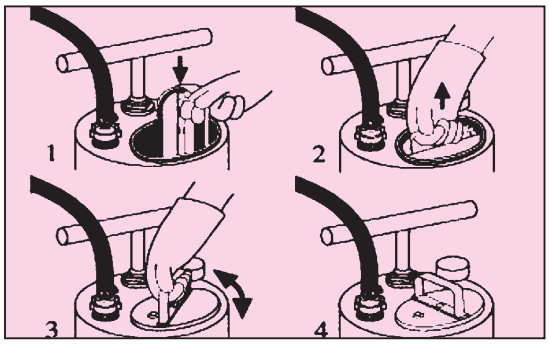
J. Trigger on/off valve. Is the strainer inside valve handle clean?

Fig - 6



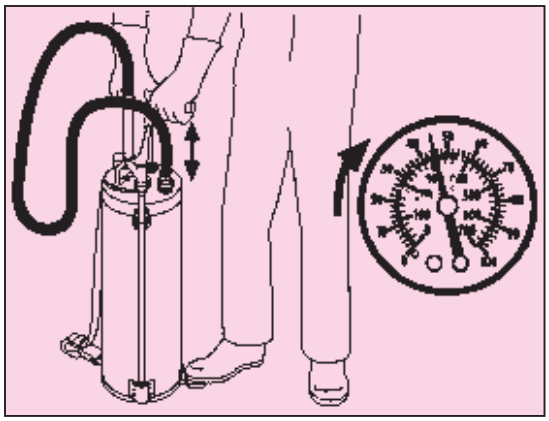
K Foot rest

Fig - 7




Before using an insecticide use clean water to ensure that the equipment operates properly and does not leak. Wear protective clothing. To check, follow the steps below:

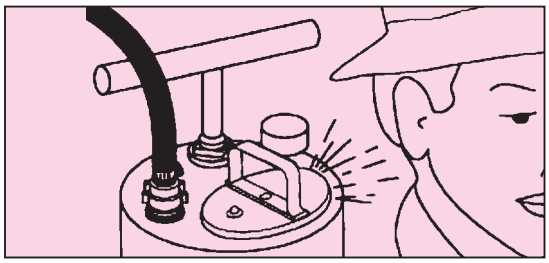
Fig - 8



(a) Pour clean water into the tank (never fill tank more than 3/4 full) (Fig - 6).

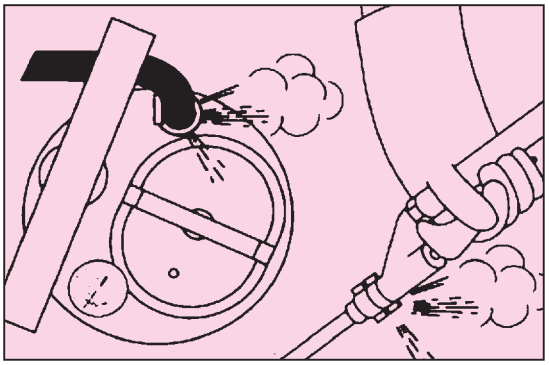
(b) Fit the lid. Turn the handle to lock the lid in position (Fig - 7).

Fig - 9



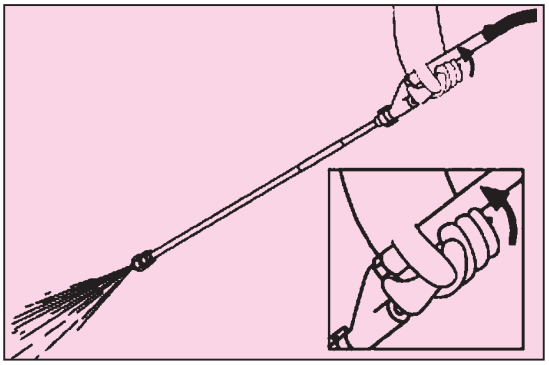
(c) Operate the pump using both hands and with foot on the footrest. Pump to the working pressure 55 psi (Fig - 8).

Fig - 10



(d) Check tank is holding pressure. Listen for hissing sound of escaping air (Fig - 9).

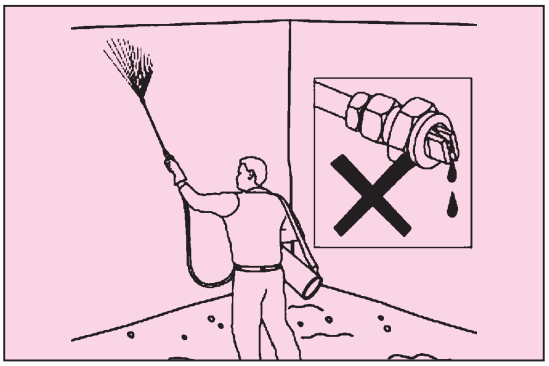
Fig - 11



(e) Check to make sure there are no leaks along lance and hose, especially where hose joins tank and trigger on/off valve (Fig - 10).

(f) Operate trigger on/off valve to make sure that spray is emitted from the nozzle (Fig - 11).

Fig - 12



(g) Check the spray pattern from the nozzle by spraying a dry wall surface. Look to see that the pattern is even and without streaks. Ensure nozzle does not drip when trigger on-off valve is released (Fig - 12).

(h) Calibrate the nozzle with water in the tank. Pump to 55 psi (700 g / sq cm). Open the trigger on-off valve for one minute, collect the discharge and measure the

amount in a measuring jug. Empty the jug. Discharge for a further one minute and measure the amount. Repeat for a 3rd discharge. Calculate the average of the three, one-minute measurements.

(j) With the above procedure, the average discharge of an 8002 nozzle is about 750 ml per minute. If the discharge is incorrect, check the nozzle and the screen filters to ensure they are not clogged. If necessary replace nozzle. Repeat the calibration.

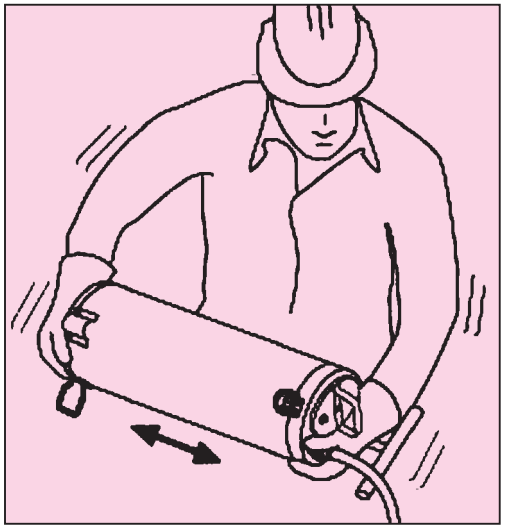
**If the nozzle is clogged**

The opening in a nozzle is very small and must not be damaged. Clogged nozzles should be put in a container with water for several hours before the blockage is removed by a very soft toothbrush. Nozzle should never be cleaned with a hard pin or a piece of wire.

Mixing, handling and spray techniques

Prepare the insecticide spray according to the manufacturer's instructions. The insecticide may be mixed separately in a bucket and poured into the sprayer. Water soluble sachets, tablets and insecticides granules are added directly to the water filled tank. These formulations mix readily with water and reduce the hazards associated with handling and mixing in a separate container. When the sprayer has been filled with water to the maximum level indicated on the tank, the lid of the tank is fitted and the sprayer pumped to a pressure

Fig - 13

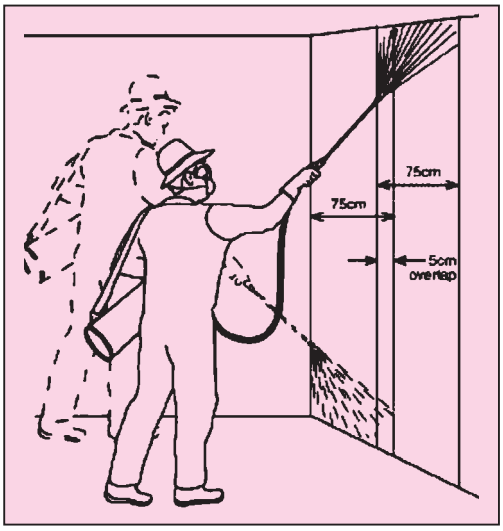


of 55 psi by pumping 55 times (700 g/sq cm). The contents of the tank should be thoroughly mixed by shaking the tank before starting to spray (Fig - 13).

Spraying in a room should commence from the backside of a door clockwise completing the plain surfaces of walls. Then the crevices on the walls and inside portion of windows etc. should be sprayed. Then the pillars, under surfaces of furniture and lastly the ceilings should be taken for spray.

Spray is done from roof to floor, using downward motion, to complete one swath; then stepping sideways and spraying upwards from floor to roof. Spray is applied in vertical swaths 52-56 cm wide. Swaths should overlap by 5 cm and spraying should be undertaken as shown in Fig - 14. Normal swath coverage will take 2.7 sec and hence in one minute 22-23 swaths will be required to cover a wall of

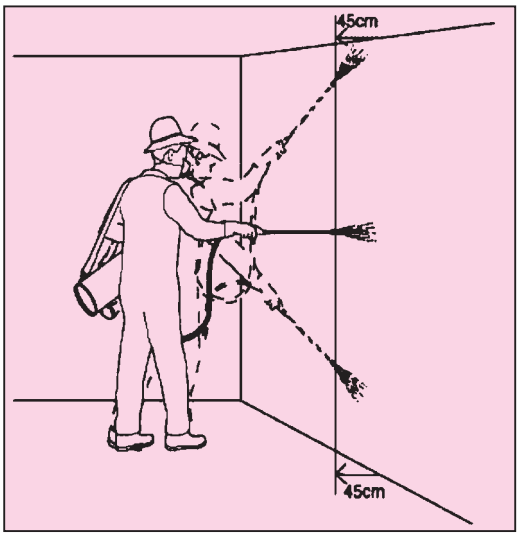
Fig - 14




10-11 metres length and 3 metres height i.e. 30-33 sq m. It takes about 5 minutes to spray a house with an average surface area of 150 sq. metres.

To ensure the correct swath width, keep the spray tip

Fig - 15

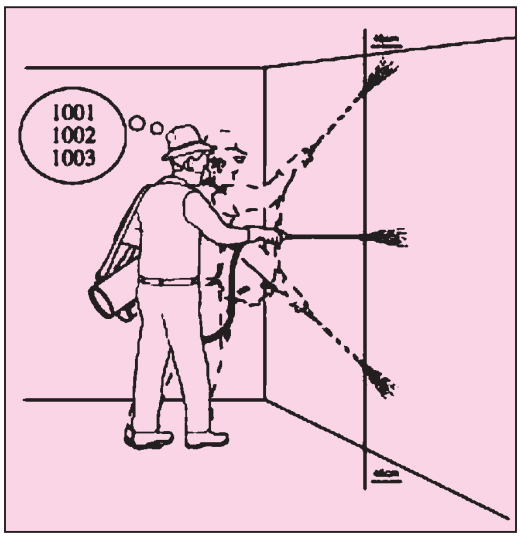



about 45 cm from the wall. Lean forwards as you spray from top of the wall & move back as you bring the nozzle downwards (Fig - 15)

The flow of liquid from the nozzle tip at 700 g/sq cm pressure is 750 ml/minute. Hence 30 sq m surface will be covered with 750 ml of the insecticide solution. Time your spray speed to cover one swath every 3 seconds, for a 3 m high wall. Timing may be aided by mentally counting “one thousand and one, one thousand and two, one thousand and three -...”. Adjust the mental counting procedure according to the local language (Fig - 16).

If spray stops due to a blockage in nozzle, unscrew the nozzle cap, remove blocked nozzle and replace with a new

Fig - 16




one. The blocked nozzle should be cleaned as explained above. Do not let spray drip on the floor. Re-pressurize the tank when the pressure falls.

Procedures after spraying

(a) Advise the occupants to stay outside until the spray is dry.

(b) Instruct the householder to sweep or mop the floor before children or pets are allowed to re-enter.

(c) Instruct the householder not to clean the sprayed surfaces

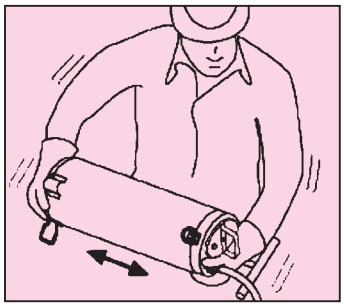
**Disposal of remains of insecticides and empty packaging**

At the end of the day's work, put the washings from the sprayer into pit latrines, if available, or into pits dug especially for this purpose and away from sources of drinking water. Dilute any insecticide with more water before putting into pits. It is advisable to prepare only sufficient insecticide to avoid disposal of remaining. Never pour the remaining insecticide into rivers, pools or drinking water sources. All empty packaging should be returned to the supervisor for SAFE disposal. Never re-use empty insecticide containers. Empty insecticide containers should NOT be burned or buried.

Maintenance of equipment

After completing the day's work, de-pressurize the tank and empty any remaining insecticide, following the instructions given in the previous section. Clean the tank as explained below: Fig- 17

Fig - 17



(a) De-pressurize the tank.

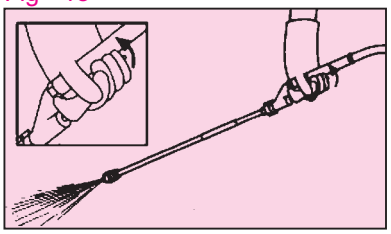
(b) Fill the tank half-full with clean water.

(c) Replace the lid.

(d) Shake the tank so that all inside surfaces are washed (Fig - 17).

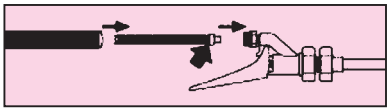
(e) Pump up to 700 g/ sq cm pressure. Spray water through nozzle (Fig - 18).

Fig - 18



(f) De-pressurize the tank and pour out any remaining water into pit latrines or into a pit away from sources of water.

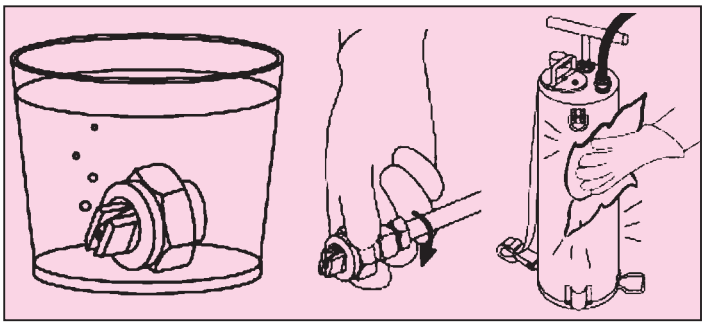
Fig - 19



(g) Unscrew trigger on/off valve handle and check and clean the strainer.

(h) Reassemble the trigger on/off valve (Fig - 19).

Fig - 20 (j)Remove the nozzle tip and wash



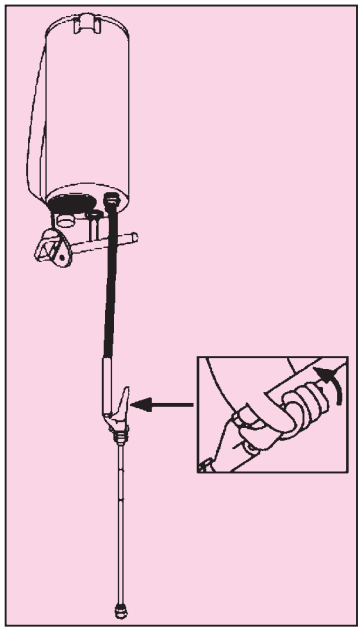
(k) Refit the nozzle (Fig - 20).

(l) Clean outside of tank.

(m)With lid open, turn tank upside down, open the on/off valve and let all the water drain out of the hose and lance (Fig - 21)

(n) Ensure the lance is parked to protect nozzle when not in use.

Fig. - 21



(o) When storing the sprayer for a long period, hang it upside down with lid open to allow air circulation. Allow lance to hang from D-ring on the tank with the trigger valve kept open (Fig - 21).

Insecticides used for residual spraying and anti-larval activities (8, 19, 23, 24, 25, 26)

The insecticides used for anti-larval and anti-adult activities with special reference to mosquitoes are presented in Table 1 and 2. The insecticides used for the other vectors with their dosages are

Table - 1 : Insecticides used for indoor residual spray with dosage and residual efficacy (ai = active ingredient)

| Insecticide | Preparation of suspension in water | Dosage of a.i. / sq m | Residual effect in weeks | No. of spray rounds / annum | Area to be sprayed by 10 lit of suspension | Remarks |
|---|---|---|---|---|---|---|
| DDT 50% WP | 1 kg/ 10 lit | 1 g | 10 – 12 | 2 | 500 sq m | In North East only |
| Malathion 50% EC | 1 lit/ 10 lit | 2 g | 6 – 8 | 3 | 250 sq m | In DDT resistant areas |
| Deltamethrin 2.5% WP | 400 g/ 10 lit | 20 mg | 10 – 12 | 2 | 500 sq m | In Malathion resistant areas |
| Cyfluthrin 10% WP | 125 g/ 10 lit | 25 mg | 10 – 12 | 2 | 500 sq m | In Malathion resistant areas |

Table - 2 : Insecticides used for mosquito larval control

| Insecticide | Dilution rate | Dosage /sq m | Area in linear metre to be sprayed by 10 ltr of solution/ suspension | Frequency of application | Remarks |
|---|---|---|---|---|---|
| MLO | As it is | 20 ml | 500 | weekly | Applied along shore of water |
| Temephos (Abate) 50% EC | | 20 ml | 500 | weekly | Applied in all water bodies |
| Fenthion 82.5% EC (Baytex 1000 EC) | 5 ml in 10 ltr for water depth up to 10 cm. 25 ml in 10 ltr for depth up to 50 cm | 20 ml | 500 | weekly | Not used in potable water |
| Fenthion 2% G - | - | 5 Kg per hectare for water depth up to 10 cm. 25 Kg per ha depth up to 50 cm | - | - | Used for larval control in water with organic pollutants |
| *Bacillus thuringiensis var israelensis* (Bti) (12 AS) | 250 g in 10 ltr | 20 ml | 500 | Bi weekly | Not used in potable water |
| *Bacillus sphaericus* | 500 g in 10 ltr | 20 ml | 500 | Tri-weekly | Not used in potable water |

**Note:** dose of each of the formulation is 20 ml of final solution per sq mtr of the water surface (10 ltrs of the prepared solution per 500 sq mtrs or 500 linear mtrs).

presented in chapters referring to those vectors/ pests.

### Space Spraying

It is an ideal method for bringing about rapid control of vectors in emergency or epidemic situations and may also be used for seasonal control of flying insect pests or vectors. An additional objective may be to reduce or interrupt the transmission cycle of insect-borne diseases. However, it may not be ideal for all vectors or situations and as such may not be an economical method of control. Among the disease vectors affecting public health, the most important and widespread are mosquitoes, houseflies, sand-flies and other biting flies; some of these may be targeted for space treatment (19, 27).

Immediate killing of actively flying insects requires a cloud of insecticide droplets that they will encounter in flight. To be cost-effective and obtain good biological efficacy, space spraying requires:

(a) Knowledge of the behaviour and biology of the target species to understand where and when space treatments will be effective.

(b) Knowledge of insecticides and formulations most suitable for space spraying.

(c) Knowledge of pesticide application technology to know which equipment is needed and how to use it.

(d) Monitoring and surveillance of the target species and vector-borne disease problem, to evaluate the efficacy of the programme.

A space spray, technically a fog (sometimes referred to as an aerosol) is a liquid insecticide dispersed into the air in the form of hundreds of millions of tiny droplets less than 50 µm in diameter with a view to cause by contact, immediate knock down of the flying or resting insects in confined spaces. Space sprays, even when they settle on surfaces do not have much residual action. It is only effective while the droplets remain airborne. Therefore, they have to be repeated at frequent intervals. Space sprays are applied mainly as thermal fogs or cold fogs.

Thermal fog

Thermal fog is produced by special devices known as thermal foggers that use heat to break up the chemical into very small droplets (usually in 5-30 micron diameter range) which then disperse in the air. When the chemical (usually diluted with oil-based carrier) is heated, it is vaporized in a combustion chamber and then expelled via an outlet tube to form a dense fog cloud when it condenses on contact with cool ambient air.

The insecticide used in thermal fogs is diluted in a carrier liquid, which is usually oil-based. Hot gas is used to heat the pesticide spray, decreasing the viscosity of the oil carrier, and vaporizing it. When it leaves the nozzle, the vapour hits colder air and condenses to form a dense white cloud of fog. Most of the droplets are smaller than 20 µm. The droplet size is affected by the interaction between the formulation, the flow rate and the temperature at the nozzle (usually > 500°C). The volume of spray mixture applied in vector control is usually 5-10 litres per hectare, with an absolute maximum of 50 litres per hectare. The hot emission gas is obtained from engine exhaust, friction plate/engine exhaust or from a pulse jet engine.

**Advantages**

(a) Easily visible fog, so dispersal and penetration can be readily observed and monitored.

(b) Good public relations in some circumstances as people can see something being done about the problem.

(c) Low concentration of active ingredient in the spray mixture and reduced operator exposure.

**Disadvantages**

(a) Large volumes of organic solvents are used as diluents, which may have bad odour and result in staining;

(b) High cost of diluents and spray application;

(c) Householders may object and obstruct penetration of fog into houses by closing windows and doors;

(d) Fire risk from machinery operating at very high temperatures with flammable solvents; and

(e) Can cause traffic hazards in urban areas.

Cold fog

The cold fog is produced by a special device (cold fogger) that breaks up the chemical into microscopic droplets by mechanical means, basically with a high-pressure pump and an extreme fine nozzle. The spray droplets are generated without any external heat. With cold fogs, the volume of spray is kept to a minimum. Ultra - low - volume insecticide formulations are commonly used for such applications. The cold fogger may dispense formulations in a very concentrated form and generate the droplets (usually in the 5-30 micron diameter range) in a precise manner. However, its ability to penetrate dense foliage or obstacles is not as good as that of the thermal fogging. Cold fogging is sometimes called Ultra Low Volume (ULV) treatment as it allows the utilization of only a very small amount of chemical for coverage of a large area.

Like thermal fogging, cold fogging also does not have lasting residual effects. It is, therefore, essential to carry out fogging at the time when the vectors are most active to hit them directly.

**Advantages**

(a) The amount of diluents is kept to a minimum, resulting in lower application cost and increased acceptability. Some formulations are ready to use, thereby reducing operator exposure.

(b) Water-based and water-diluted formulations, may be used which pose a low fire hazard and are more environmentally friendly.

(c) Because a lower volume of liquid is applied, application is more efficient.

(d) No traffic hazard as the spray cloud is nearly invisible.

**Disadvantages**

(a) Dispersal of the spray cloud is difficult to observe

(b) Higher technical skills and regular calibration are required for efficient operation of equipment.

Space spray equipment

Selection of appropriate equipment for space spraying depends on the size and accessibility of the target area as well as the human resources and operational capacity of the programme. Sometimes smaller machines may be needed in conjunction with vehicle-mounted equipment to treat narrow pathways and other areas inaccessible to vehicles or sheltered from prevailing air movements. Cold fog equipment is recommended where thermal fogs may cause a traffic hazard. Aerial application of space sprays may be justified where access with ground equipment is difficult and/or extensive areas need to be treated very quickly.

Equipment for thermal fogging

**Hand-carried thermal foggers**

These are used for treating houses and certain outdoor areas of limited size or accessibility, e.g. markets, hotel

Fig - 22: Hand held Thermal Fogger

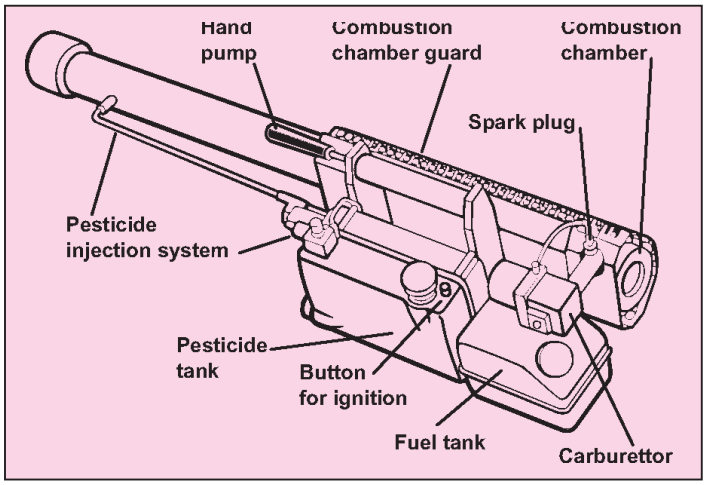
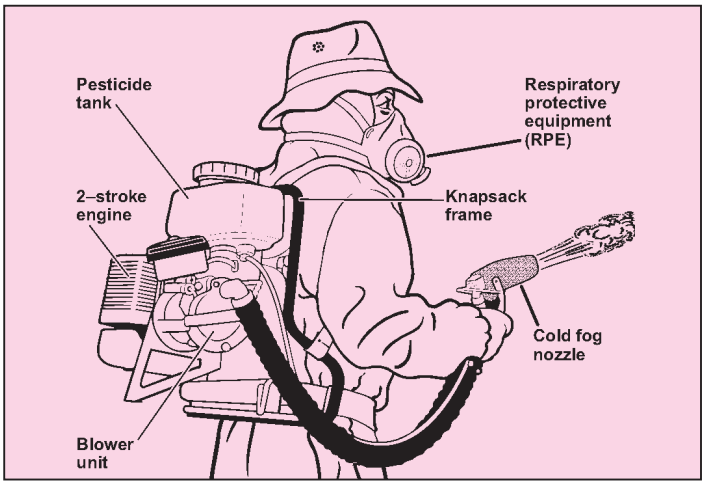



Fig - 23: Hand carried cold fogger




grounds and parks. There are two types of hand-carried thermal foggers; pulse jet and friction plate (Fig - 22).

**Vehicle-mounted thermal foggers**

Large thermal fog generators use an air-cooled motor to run an air blower, fuel pump and insecticide pump. Air from the "roots type air blower" is delivered into the combustion chamber. There it is mixed with gasoline vapour and ignited, so that temperatures reach 426-648 °C. The diluted insecticide liquid is pumped via a simple flow delivery valve and injected into a cup in the fog head or directly into the nozzle. The insecticide liquid is vaporized by the blast of hot gases. Despite this high temperature, insecticides show very little degradation of active ingredient. This is because the time spent at that temperature is only a fraction of a second, which is not long enough to cause serious degradation. The hot gases then pass out of the machine. As the hot oil vapour is discharged through a relatively large nozzle into the cooler outside air, it condenses to form very small droplets of thick white fog. Delivery rates of up to 10 litres per minute can be achieved with larger machines.

**Aircraft application of thermal fogs**

For aircraft application of thermal fogs, the diluted insecticide formulation is fed into the aircraft exhaust. The exhaust is adapted with vanes to swirl the fog droplets as they are formed. The application of thermal fogs by aircraft has been very limited.

Equipment for cold fog application

**Hand-carried cold foggers**

Most of these machines have gasoline engine or electric operated which drives a blower unit to discharge air through the nozzle. Air may also slightly pressurize the insecticide formulation tank so that the liquid is fed via a restrictor to the nozzle. However, negative pressure generated by the air flow passing through the nozzle allows liquid to flow from the tank. In addition to hand-carried units, knapsack cold fogging units are also available (Fig - 23), as are several electrically driven models.

**Vehicle-mounted cold foggers**

A high volume air blower, forces air at a rate of approximately 6 $m^3$ per minute at low pressure to nozzle. The pesticide container may be pressurized to force the formulation to the nozzle, or positive-displacement pumps may be used.

Alternatively a high-pressure, low-volume air source is used with an air compressor, rather than a blower. On these machines, nozzles ranging from the standard industry "paint gun nozzle" to proprietary nozzles that atomize well up to a flow rate of 0.5 litre per minute are available. Another design uses a rotary nozzle coupled with an electric motor which operates at a very high speed.

**Aircraft application of cold fogs**

Both fixed-wing aircraft and helicopters have been used to apply cold fogs. Conventional low-volume nozzles (e.g. flat fan) have been used on fixed wing aircraft to create fine sprays, using moderate or high pressures. However, the droplet spectrum is generally poor so preference is given to the use of rotary atomizers or very-high-pressure systems.

Insecticide products for space spraying

Space-spraying formulations are generally oil-based. The oil carrier inhibits evaporation of small fog droplets. Only insecticide products with high flash points are used for thermal fogging. Diesel is used as a carrier for thermal fogging, but creates a thick smoke and oily deposits, which may lead to public rejection. For environmental reasons, water-based formulations have been made available in recent years. These formulations may also contain substances that prevent rapid evaporation. Table 3 lists selected insecticides suitable for space spraying against mosquitoes. These insecticides may also be used against other insect pests and vectors, but different dosages may be required.

Space spray treatments : General considerations

**Optimum droplet size**

Table - 3 : Insecticides used for space spraying

| Sr. No. | Insecticide | Dilution | Equipment required | Remarks |
|---|---|---|---|---|
| 1 | Pyrethrum 2% Extract | 1 ltr in 19 ltr Diesel or Kerosene | Flit gun / Thermal Fogging machine | For space spray indoors (Keep rooms closed for 30 |
| 2 | Pyrethrum 2% EC | 1 ltr in 19 ltr Water | ULV Fogging machine | For space spray indoors |
| 3 | Malathion Tech | 5 ltr in 95 ltr Diesel (5%) | Thermal Fogging machine | For space spray outdoors |
| 4 | Deltamethrin 1.25 ULV | 1 ltr in 199 ltr Diesel | Thermal Fogging machine | For space spray outdoors |
| 5 | Deltamethrin 1.25 ULV | 1 ltr in 19 ltr Water | ULV Fogging machine | For space spray indoors |

Space treatments are only effective while the droplets remain airborne. Droplets fall by gravity and some are deposited on horizontal surfaces while the majority is lost to the atmosphere especially in outdoor spraying. Droplets bigger than 30 µm in diameter are less effective as they do not remain airborne for sufficient time. Droplets smaller than 5 µm in diameter do not readily come in contact with flying insects, as the movement of the smallest droplets is affected by the air turbulence created by the insect's flight. It is generally accepted that droplets should be generated at 10-30 µm so that, even with some evaporation and after some time, they remain in the correct range for optimal airborne suspension and insect impact. The optimum droplet size for space spraying against mosquitoes is 10-20 µm.

**Spray concentration**

For a flying insect to be killed, it must acquire a lethal dose of insecticide in the droplets that impact on it. The lower the concentration of active ingredient, the larger the number of droplets of a given size required to achieve a lethal dose. Ultra-low-volume spraying aims, largely for operational reasons, to minimize the total volume of diluted insecticide applied (usually < 2 litres per hectare).

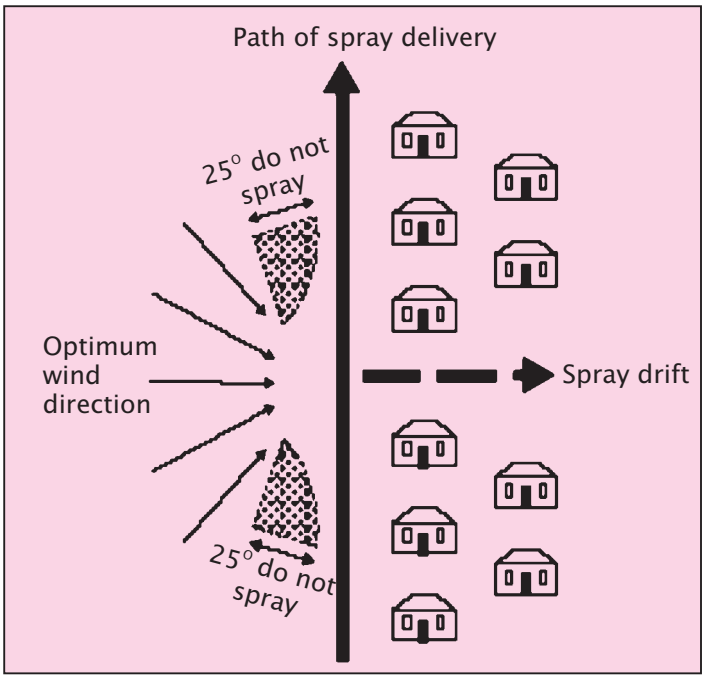
**Wind speed**

Wind speed has a profound effect on droplet distribution and impingement on insects. Spraying should not take place when wind speed exceeds 15 km/hour. The type of terrain and vegetation affects air movement and hence the distribution of the droplets. In open terrain with relatively sparse vegetation, wider effective swaths can be obtained than in urban areas where the obstruction of buildings alters the flow of air.

**Wind direction**

With vehicle-mounted and aerial spraying the spray route must take account of the wind direction to maximize the distribution of the spray throughout the target area. Fig - 24 illustrates the spray application route relative to wind direction.

Fig - 24 : Spray application route relative to wind direction




**Temperature effects**

In direct sunlight the ground is heated. This causes air to rise. In the middle of the day outdoor space spraying will largely be wasted as the spray droplets will tend to rise upwards rather than drift horizontally. Ideally an inversion is needed, i.e. colder air closer to the ground. This generally occurs early in the morning after the ground temperature has fallen during the night, but can also occur in the evening when the sun has set and ground temperatures begin to fall.

**Time of treatment**

Knowledge of the time of peak flight activity of the target species is crucial to ensure that space treatments are planned to coincide, as far as possible, with these times. Fortunately, peak flight activity of many vectors is around dusk and/or dawn, when weather conditions are often favourable for space treatment. *Aedes aegypti* and *Aedes albopictus,* mosquito vectors of Dengue fever and Chikungunya, are active during daytime, with peak flight activity in the morning and afternoon. With these species a compromise is usually made outdoors by spraying in the early morning or late afternoon. The timing is less important if indoor spraying is conducted.

Indoor fogging

Personnel conducting this work require training on the safety measures to be followed. Several rules apply:

(a) Protect all water containers and foodstuffs.

(b) Remove fish or cover fish tanks.

(c) Ensure all occupants and animals remain outside the house during spraying and stay outside for 30 minutes after spraying. Ensure that the building is ventilated before reoccupation.

(d) Close all doors and windows before spraying and keep them closed for 30 minutes after spraying to ensure maximum efficacy.

(e) Spray operators should work backwards and away from the fog to minimize exposure.

(f) For small single-storey houses, the spray can be delivered from the front door or through an open window without having to enter every room of the house, provided that adequate dispersal of the insecticide droplets can be achieved.

(g) For large single-storey buildings, it may be necessary to apply the spray room by room, beginning at the back of the building and working towards the front.

(h) For multi-storey buildings, spraying is carried out from top floor to the ground floor and from the back of the building to the front. This ensures that the operator has good visibility at all times.

Outdoor ground fogging

Advanced route planning should precede outdoor ground fogging operations and may require a combination of vehicle-mounted and hand carried or knapsack equipment in areas with difficult or limited vehicle access. Consideration must also be given to the following:

(a) Spraying should not be undertaken when it is raining, when winds exceed 15 km/hour, or in the heat of the day.

(b) Doors and windows of houses and other buildings should be open to allow penetration of the spray cloud for improved efficacy.

(c) For vehicle-mounted equipment, in areas where the roads are narrow and the houses are close to the roadside, the spray should be directed backwards from the vehicle. In areas where the roads are wide, with buildings far from the roadside, the vehicle should be driven close to the roadside and the spray should be directed at an angle (downwind) to the road rather than directly behind the vehicle.

(d) The nozzle of vehicle-mounted cold fog machines may be directed upwards at an angle when there are barriers that impede airflow, e.g. boundary walls and fences; for vehicle-mounted thermal foggers, the nozzle should be directed horizontally.

(e) A track spacing of 50 metres is generally recommended, with the vehicle moving upwind so that the fog drifts downwind away from it and the operators.

Aerial application of fogs

Suppression of vector populations over large areas can be carried out using space sprays released from aircraft, especially over areas where access with ground equipment is difficult and extensive areas need to be treated very rapidly.

Evaluation

Evaluation of the efficacy of spray operations is carried out using techniques that are largely specific to the target insect. Space sprays are transient and only insects flying at the time of the application are affected.

Area Spraying

This is carried out for treatment of land against mites and ticks and also as an anti-larval measure over vast water surfaces. Against mites and ticks, suspensions are used on land and vegetation; WDP is used for anti-larval treatment of lakes and swamps. Aerial spraying is resorted to for agricultural purposes and sometimes for veterinary and rarely medical purposes. Dusts are applied to manure yards and dry refuse yards to control flies and other pests. For all such uses power driven sprayers and dust guns are used. The larvicidal oils are applied by spraying it on the surface of water by means of a knap-sack sprayer or hand pumps or by a mop stick.

**Resistance of vectors to insecticides**

Ever since the introduction of the potent synthetic insecticides into public health programmes at the close of the Second World War, the main problem has been the development of resistance to them by the arthropods they formerly controlled. In 1947, DDT resistance was discovered in the housefly and *Culex molestus* in Italy. In 1951, DDT resistance was noticed in body louse in Korea and in *Anopheles sacharovi* in Greece. In 1955, Dieldrin resistance was discovered in *Anopheles gambiae* in Northern Nigeria. In 1959, in Western India the oriental rat flea was found to have developed resistance to DDT. The number of arthropods showing resistance is on the increase (28)

Definition

Resistance is defined as "The development of an ability in a strain of insects to tolerate doses of toxicants which would prove lethal to the majority of individuals in a normal population of the same species". The word tolerance is normally used when the increase in $LC_{50}$ is less than the indicated minimum for the tests, but is nevertheless statistically significant. Vigour tolerance is a term, which has been applied to enhanced insecticidal tolerance resulting from extra vigour of the strain rather than from any specific defence mechanism.

Types

Resistance is of two types i.e. physiological and behaviouristic. Physiological resistance is the one described above. Behaviouristic resistance means the development of ability to avoid a lethal dose. This term is applied most often to mosquitoes in relation to DDT.

Nature and Cause

**Genetic**

Resistance develops in arthropods after a long period of insecticidal pressure. It is brought about by the accumulation of the contributing genes through

successive selection with a number of insecticides, each of which confers some cross-resistance. This is called polygenic resistance. In contrast, the resistance may be due to a single gene and bear no similarity to the complexities involved in the polygenic resistance. Monogenic resistant strains are more vulnerable to counter measures such as addition of synergists; hence the importance of distinction between the two types.

**Biochemical**

Many causes of resistance have been defined although several defy explanation in biochemical terms. Resistance to DDT and Dieldrin due to the gene Kdr does not involve detoxification, and is thought to be due to an altered site of action. On the other hand, an altered site of action as a cause of resistance has been definitely established with cholinesterase inhibitors. In these cases a mutant cholinesterase is produced that is inhibited more slowly than the normal enzyme in susceptible strains. This produces resistance against a large number of compounds and the resultant extensive cross-resistance makes it a serious type of resistance.

**Increased Detoxification**

Detoxification enzymes in resistant strains are generally more efficient and are not necessarily produced in higher amounts; oxidases are particularly important as they affect a wide variety of insecticides. The following enzymes or classes of enzymes are known to be of importance: -

(a) DDT dehydrochlorinase or DDTase which affects DDT and several analogues.

(b) Hydrolases which affects phosphate esters or carboxylic ester groups in OP compounds and in some pyrethroids.

(c) Glutathion S transferase affects OP compounds.

(d) Oxidases affect Carbamates, OP compounds, DDT and its analogues, as well as pyrethroids

**Dynamics**

(a) If the genetic potentiality to development of resistance to a given insecticide is present, the rate of development of resistance will depend upon factors such as the frequency of resistant genes and their dominance, the selection pressure, previous history of exposure to insecticides, isolation, inbreeding and reproductive potential of the arthropod population.

(b) The rate of development of resistance in previously unselected populations is normally very low at first. During the period when the frequency of major genes for resistance is gradually increased and the genetic background is progressively organized towards greater fitness in the contaminated environment, the rate of development of resistance accelerates rapidly, often leading to failure of control measures.

## Biological Control

Intentional manipulation of populations of living beneficial organisms, called natural enemies, in order to reduce the numbers of pests or amount of damage is called Biological Control (29-32).

Natural control strategies that employ biological agents for pest suppression are classified as biological control tactics. In conventional usage, this term usually refers to the practice of rearing and releasing natural enemies: parasites, predators, or pathogens. Biological control is a particularly appealing pest control alternative because, unlike most other tactics, it does not always have to be reapplied each time a pest outbreak occurs. However, Biological control is not a "quick fix" for most pest problems. Natural enemies usually take longer to suppress a pest population than other forms of pest control and therefore often regarded as a disadvantage or limitation of biological control. It also may be difficult to "integrate" natural enemies when pesticides are still in use. Beneficial insects are often highly sensitive to pesticides and their resurgence (recovery to pre-spray densities) is usually much slower than that of pest populations. Rapid pest resurgence often leads to a vicious cycle of continued chemical usage that prevents natural enemies from ever becoming reestablished.

The biological agents are broadly classified as Predators, Parasites and Pathogens.

**Predators**

Predators are insects or other insectivorous animals, each of which consumes much insect prey during its lifetime. Predators are often large, active, and/or conspicuous in their behavior, and are therefore more readily recognized than are parasites and pathogens. Most commonly used predators are the larvivorous fishes for the control of mosquitoes.

**Larvivorous Fish**

There are areas and habitats where larvivorous fish, such as *Gambusia affinis* (Fig - 25) and *Poecilia reticulata* (Fig - 26), can make considerable contribution to vector control. The larvivorous efficiency of *Gambusia* is due to the fact that a single full grown fish eats about 100 to 300 mosquito larvae per day, is a surface feeder, hence it is suitable for feeding on both Anophelines and Culicines, is small and inedible and can tolerate salinity. Poecilia's larvivorous efficiency is due to its capability to negotiate margins of ponds more easily, tolerate handling and transportation very well, survives and reproduces when introduced into new water bodies, survives in new places (water bodies) and multiplies easily and can survive in good numbers for years and does not require constant care.

Fig - 25

Fig - 26

Release of fishes is done at the rate of 5-10 fish per linear

meter. If the larval density is high, up to 20 fishes can be released. Fishes should be released in the morning hours or in the evening.

Criteria for selecting a water body for a fish hatchery are

(a) It should be a permanent water body.
(b) Depth of water should be at least 1.5 metre or more.
(c) Water should be confined and without big natural outlet.
(d) The minimum size of water body should be at least 5 m X 4 m. The water body of 10 m X 5 m can support 50000 fish.
(e) It should be free from other carnivorous fish.
(f) Water should not be contaminated by chemical or other harmful substances.
(g) Easily accessible for daily or periodic inspection and for collection of fish.
(h) De-weeding in ponds and shallow water bodies and cleaning of margins should be carried out periodically.

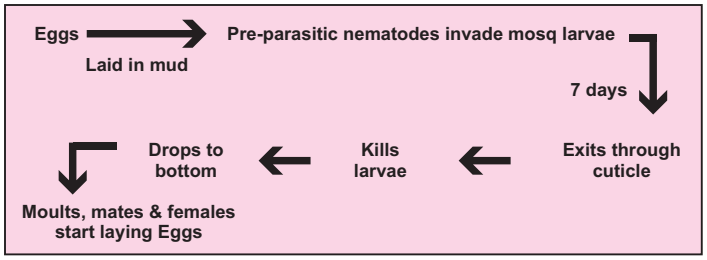
### Parasites

Parasites are those organisms which depend on their host for shelter or food. Many parasites are very specific to the type of host insect they can attack, and they are not harmful to humans. Although insect parasites are very common, they are not well known because of their small size. Some of the categories of Parasites are as follows:

Nematodes

Nematode *Romanomermis culicivorax* and *R iyengari* have been evaluated and have been found to give variable

Fig - 27




control of mosquitoes. The mode of action of the nematodes is presented in Fig - 27.

Fungi

Fungal agents *Laegenidium* and *Culicinomyces* have shown immense potential as mosquito larval control agents and can be exploited for use against mosquitoes.

### Pathogens

The pathogens which have been found promising are the Bacterial agent's *Bacillus thuringiensis* var *israelensis* and *Bacillus sphaericus* in mosquito larval control. However, these have been classified as Biocides or Microbial insecticides and have been discussed earlier. Viruses like Nuclear Polyhedrosis virus and Irido virus have also shown promise against mosquito larvae.

## Genetic Control

This is defined as "the use of any condition or treatment that can reduce the reproductive potential of noxious forms by altering or replacing the hereditary material". The various methods of genetic control fall into two general groups: those leading to population control, reduction, or elimination through the release of partially or completely sterile insects in sufficient numbers to overcome the reproductive capability of the natural population; and those leading to population control or population replacement through the release of partially sterile or fully fertile genetically altered insects (33).

New genetic control methods, such as those involving sex distortion mechanisms or the selection and release of strains refractory to pathogens, sensitive to selected ecological factors, or susceptible to insecticides, are being tested under field conditions. However, unless some new and revolutionary ideas emerge, the genetic control measures so far known are capable of achieving only "management" or "manipulation" of insect population rather than complete suppression or reduction in densities.

## Personal Protective Measures

The role of personal protective measures in arthropod-borne disease control is to prevent the arthropod vector from biting and feeding on its host, whether susceptible or already infected, thereby blocking the chain of transmission of disease from one host to another. Biting can be prevented either by protective clothing or chemically by using appropriate repellents (34 - 38).

### Protective Clothing

Individual personal protection against bites of arthropods can be achieved by use of mosquito net, wearing of long trousers, rolled down sleeves of shirts, socks, shoes and anklets, particularly when going out on patrols and exercises in areas heavily infested with arthropods. These measures will vary according to the nature of problem faced in a particular locality. Specific personal protective measures have been described as part of control measures in chapters dealing with those vectors.

### Repellents

Insect repellents are chemicals which repel insects when applied to body surfaces or clothing. The suitability of substances for use as repellents is dependent primarily on their inherent repellency and duration of effectiveness. The important factors are the ease of application on the skin; odour, appearance or feel on the skin e.g. oily or greasy; the likelihood of being rubbed off, or absorbed by the skin; irritant effect or toxicity if absorbed; and its stability under high humidity, high temperature, rain and perspiration. The efficacy may also be influenced by the amount of sweating, rubbing and the avidity of the insect itself. Moreover as is the case with insecticides, repellents exhibit specificity of action so that some species of insects are more sensitive to one and some to other repellents.

Common Repellents

The following compounds are among the most effective when used alone as repellents against one or more groups

of arthropods: benzyl benzoate, DEET (N, N-diethyl-m-tolumide), dibutyl phthalate, DEPA (di ethyl phenyl acetamide) and Neem oil. Repellents are formulated as liquids, gels, creams and in pressurized containers. Some of the common compounds are discussed below:

**(a) N, N-diethyl m-toluamide (DEET)**

DEET has been reported to be an outstanding all-purpose repellent. It provides 6-8 h of protection against mosquitoes, 2-3 hour against Chrysops, 9 hour against Culicoids. It feels less oily on the skin than the other repellents. DEET can also be used very effectively for impregnation of clothing. In experiments conducted at AFMC it has been shown to provide repellence up to two launderings of the clothing. As a skin application DEET may be used for protection against mosquitoes, sand flies, fleas and other biting Diptera. It is a good repellent against all haematophagous arthropods and also against leeches.

**(b) Dibutyl Phthalate (D.B.P.)**

It is more persistent but somewhat less rapid repellent. When smeared on clothing, its effect lasts up to 2-4 washes Ironing destroys it. It is specifically useful against ticks and mites as it is acaricidal as well as a repellent. DBP is a good repellent against leeches and Dimdam flies.

**(c) Benzyl Benzoate**

The oily liquid has a faintly pleasant aromatic odour and sharp bitter taste. It has been applied in 5 percent emulsion to skin as repellent for many arthropods. Clothing impregnated with benzyl benzoate show repellence to fleas, chiggers and other arthropods. A mixture of equal parts of Diethyltoluamide and Benzyl benzoate with the addition of an emulisifier acts as a good impregnant for clothing against trombiculid mites.

**(d) Diethyl phenyl acetamide (DEPA)**

This product has been indigenously developed by DRDE Gwalior. It is a colourless oily liquid. This repellent has been specially formulated for the Armed Forces and is available as lotion, cream and sprays (20%). It is a broad spectrum repellent and can be used for topical application against mosquitoes, ticks & mites or any other haematophagous arthropod and leeches. It can also be applied on clothing/uniform as repellent. It can withstand 2-3 launderings and ironing. It matches DEET in its spectrum and efficacy.

Application Procedures

**Skin Application**

Repellents like DEET and DEPA are applied to the skin either undiluted or diluted in various solvents, ointments, creams, etc. The vehicles should be suitable for smearing over the exposed skin surface. These are generally effective against such pests as midges, mosquitoes, sand-flies, and so on. A good repellent applied in this way will give protection from insect bites for about five to seven hours.

Impregnation of Clothing

Application to clothing is carried out when longer protection against insects is required. Application of DBP, DEET or DEPA to clothing to protect one self from mites and ticks is much more persistent than skin treatment and remains effective for a period up to a month

**Hand Application (Repellent Drill)**

Hand Application of repellent is the simplest way to treat the clothing. The fingers of one hand are dipped into the chemical in an open container or a few drops of the chemical are poured into one hand, both the hands are rubbed together and then they are wiped lightly on the inside and also on the outside of all the openings of all garments to produce a thin layer of the chemical on them. The chemical should be applied more particularly to the opening such as inside the neckband of shirts and the fly and turn ups of trousers and tops of socks turned inside out. 60 ml per man per fortnight of DBP is enough to impregnate two shirts, two pairs of trousers, 2 pairs of socks, anklets and two sets of underclothing. The application should be started a fortnight before the mite borne disease (like scrub typhus) season in any area begins, and repeated every fortnight thereafter until the season lasts. This should be done on a parade as a drill supervised by a JCO or an NCO who has had training and experience of the procedure. The repellents DEET, DEPA require lesser quantities for impregnation

**Spraying**

The chemical can be applied to the entire clothing by spraying or the clothing can be impregnated with a solution or emulsion of the repellent when large quantities of clothing are treated at formation levels. Clothing should be soaked in the solution, then wrung out lightly and dried. DEPA is now available as spray formulation for treatment of uniform.

**Barrier Application**

Considerable protection may also be obtained by treating only the openings of the clothes inside the neckband and cuffs of shirts, inside the waistband, fly and turn ups of trousers and on the socks above and inside the shoes and below its tongue. These methods, called the barrier application, are particularly useful when troops have to move at very short notice during an emergency and there is no time for regular repellent drill or when sufficient supplies of repellents are not available.

**Mosquito nets**

Mosquito nets are very effective means of protection against the bites of haematophagous arthropods. Untreated or insecticide treated nets may be used as per the availability. Insecticide treated bednets may be manually treated with Synthetic pyrethroids like Deltamethrin 2.5% SC or Cyfluthrin 05 EW. These nets have to be treated every six months. The newer concept of Long Lasting Nets (LLN's) has been launched. These nets may also be treated manually or may be pretreated with insecticide Permethrin or Deltamethrin for such

**Steps for treatment of bednets**

(a) Measure the total area of the net in $m^2$.

(2 x length x height + 2 breadth x height + length x breadth) in metres.

Average area of a single net is 10 sq m

(b) Measure the absorption capacity

(i) Measure 1 litre of water and take in a tub.

(ii) Immerse the dry net, when completely wet, take it out by gently wringing the net to prevent dripping of water.

(iii) Measure the remaining water in the tub. 1 litre minus the remaining water gives us the absorption capacity of the net.

(c) Wash the net to be treated and dry it.

(d) Calculate the dosage of the insecticide required

(i) Deltamethrin 2.5% SC - dosage required 25 mg a.i. per sq m. 1 ml of the 2.5% insecticide contains 25 mg; therefore the dosage will be 1ml per sq m to give the dosage of 25 mg a.i. /sqm. So if the net is of 10 sq m and the absorption capacity is say 500 ml then we need to add 10 ml of insecticide in 500 ml of water to give the required dosage.

(ii) Cyfluthrin 05% EW- dosages required 50 mg a.i. / sq m. 1 ml of the 05% insecticide contains 50 mg; therefore the dosage will be 1ml per sq m to give the dosage of 50 mg a.i. /sqm. So if the net is of 10 sq m and the absorption capacity is say 500 ml then we need to add 10 ml of insecticide in 500 ml of water to give the required dosage.

(e) Put the net in the insecticide solution prepared as per the procedure given above and knead it well to ensure the net is completely soaked in soln.

Take out the net and spread it in shade, once semi dry it can be hung for drying.

treatment. The shelf life of these nets is 5 years. Steps of treatment of bed nets is given in the box

## Integrated Vector Management

Development of resistance, effects on non-target organisms, and damage to the environment can all be minimized with selective and judicious use of multi-faceted control tactics. This approach, commonly known as **integrated control**, requires an understanding of ecological principles as well as a thorough knowledge of the pest's life history and population dynamics. Today, integrated pest control forms the foundation of Integrated Vector Management programs (IVM) that take a comprehensive and multi-disciplinary approach to solving pest problems. These programs emphasize management rather than eradication. They take a broad ecological approach to pest problems, focusing on all members of a pest complex in an effort to identify the optimum combination of control tactics that will reduce vector populations below economic thresholds and maintain these levels with the least possible impact on the rest of the environment(32, 39).

IVM is a dynamic approach which requires a broad knowledge of vector biology, ecology and behaviour on the one hand and that of system analysis approach on the other so that a variety of control measures, such as environmental, chemical, biological, genetic and personal protective measures can be integrated with a view to achieve the ultimate aim of combating human disease. Whereas, chemical and biological methods may provide temporary control of vectors, environmental control measures may lead to permanent control. In this approach initial costs may be high and programmes may require years for implementation, but commanders at all levels should be advised to include environmental changes and improvements relating to vector control in all long term planning. However, these methods require elaborate organization, longer time and liberal finances. Species control and vector control are the two modifications circumscribing the wider concept of vector management.

## Future Policy

The aim of future vector control by use of insecticides should be to reduce the intensity of chemical selection by reducing the frequency and coverage of insecticide sprays in public health programmes, minimizing the agricultural use of persistent chemicals as far as possible and by supplementing the chemical control methods by other methods whenever feasible. There is a need to strengthen existing surveillance methods and incorporating the benefits of the newer methods like Remote sensing, Geographical Information System, Global Positioning System, etc whenever and wherever feasible. There is a continued effort to evolve safer alternatives for vector control coupled with the intensive research using molecular biology tools to address the problems of vector control.

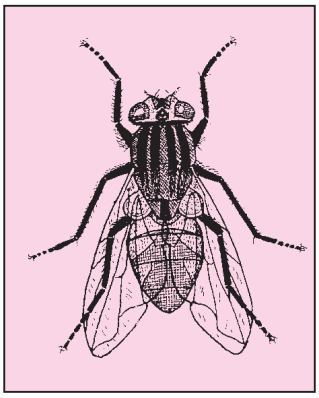
Dr (Mrs) Rina Tilak

# Housefly

Houseflies live in close association with man. Despite the best and most extensive efforts taken to control it, housefly control has remained a challenge. The important genera include Musca, Fannia and the biting flies, Stomoxys, Sarcophaga and the various blowflies viz. Chrysomya, Calliphora and Lucilia. However, the most abundant and widely distributed is the Housefly (1-4, 8, 40).

## Morphology

Fig - 1

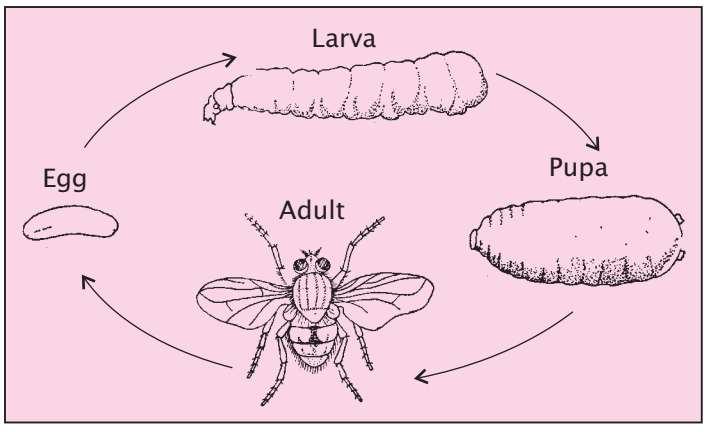


Adult houseflies are 6-9 mm in length, grayish in colour, with 4 distinct longitudinal black stripes on the thorax. The head bears a pair of compound eyes which are close together in males but are widely separated in females. The mouth parts, collectively known as the proboscis are capable of considerable extension and retraction. The thorax bears a pair of clear transparent wings, three pairs of legs - each terminating in five segments of tarsus; the last segment bears a pair of claws and pair of pad-like 'pulvilli' provided with a large number of glandular hairs. These secrete a substance which keeps the pads wet and sticky for clinging to vertical and smooth surfaces. The abdomen is short, broadly oval with five visible segments and is studded with ochre coloured bands or patches (Fig - . 1).

## Life History

The life cycle of housefly undergoes complete metamorphosis with egg, larva, pupa and adult stages (Fig - 2). Houseflies breed in decaying organic matter of animal or plant origin. The eggs are pearly white, oval in shape and measure about 1 mm in length. They are laid in cracks & crevices in moist manure heaps or any decaying animal or vegetable matter. A female fly may lay 300 to 900 or more eggs in 3 to 10 batches during her life time. In summer, the eggs hatch after 8-12 h, whereas in winter it may take 2 to 3 days. There are three larval stages or instars in the life of a fly. The larvae are photophobic and thus are found in the deeper layers of the manure. After 3-5 days, the third stage larvae moves from deep moist burrows to the neighboring dry soil and contracts to form a dark brown barrel shaped pupa about 6 mm in length. The pupa neither feeds nor grows. Within 2-5 days, the adult fly emerges out of the pupal case. Under favourable conditions of temperature and food supply, the whole life cycle from egg to adult may be completed in about less than a week's time. During winter it may take as many as 20 to 22 days.

Fig - 2




## Bionomics

The housefly has a remarkable capacity to reproduce. It is estimated that at an average of 7 day's developmental cycle for each generation, one female housefly, laying about 120 eggs, could produce a progeny of 5,598,72000,000 adult flies by the end of 5 months in summer. A high percentage of flies remain near the breeding places. Depending on the prevailing wind and availability of food, some of them may migrate up to 20 km from breeding places. High temperature is lethal to larvae and so the heat generated in tightly packed manure heap quickly kills them. The adult houseflies are attracted to light. The housefly is omnivorous and a voracious feeder. It is particularly partial to faecal matter, sputum, discharges from wounds and open sores. It is also easily attracted to sugars, milk and other articles of food meant for human consumption. The solid or semi-solid foods are softened by extrusion of a vomit drop and then sucked up. Well fed fly defaecates every 5 min, particularly while feeding and vomits every 2-3 minutes.

## Vector Potential

Immediately after visiting a dirty place, the fly may rest on any foodstuff or drink meant for human consumption or an exposed part of body e.g. mouth, eyes or a wound, and deposit the disease producing organisms. The housefly is thus a mechanical carrier of the causative organisms of diarrhoeas, dysenteries, gastroenteritis, cholera, enteric group of fevers, intestinal worms, poliomyelitis, viral hepatitis A, other entero viruses, trachoma, conjunctivitis, anthrax, yaws and tuberculosis. At times, the housefly may cause conditions known as internal and external myiasis in which the flies breed in sloughing wound, intestinal contents and suppurating cavities.

## Fly Control (41-47)

### Environmental Control

The best control of houseflies is to eliminate their breeding places and to maintain a high standard of environmental sanitation, especially by proper disposal of human and animal excreta, swill and garbage and all other decaying organic rubbish, offal and carcasses. Access of

flies to faeces should be prevented by fly proofing the latrines and latrine pans and prompt removal of faeces. Their access to food is prevented by fly-proofing cook houses and messing blocks and by use of fly-proof cupboards and containers. The doors of all entrances and windows should open outwards and preferably should have vacuum levers especially in cookhouses. Constant vigilance is necessary to destroy all flies that gain entrance otherwise the fly-proofed rooms become large fly-traps. In pantries and mess rooms, fly-proof cupboards for food storage and wire guaze, weighted with beads, afford protection to food in jugs or bowls, but their repair and cleanliness require constant supervision. When the table is being laid, cups should be inverted in saucers, and bowls should be kept either upside down or under cover when not in use.

Insecticidal Control

**(a) Space Spray**

For immediate destruction of flies and especially for suppression of fly borne epidemics, pyrethrum (0.1%) spray is useful, mainly in cook houses and dining rooms before meal times and in canteens. Certain combinations of space sprays containing Pyrethrum or Synthetic pyrethroids and/or Organophosphorus / Carbamate compounds are available commercially.

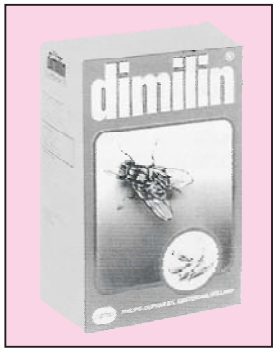
**(b) Baits**


Propoxur baits have in use since long for fly control. Recent introduction in this concept is Imadacloprid baits containing Imidacloprid as the toxicant with Pheromone Muscalure, which helps in attracting the flies to the bait. This bait ( Quickbayt ® ) has been evaluated at AFMC and found to be effective for use in areas with low to moderate fly infestation. However, while using these baits in cookhouses/ dining areas, care should be taken that they are not placed close to cooking or serving place.

**(c) Cord and Ribbons**

During the night, houseflies prefer to rest on strings and hanging wires or any object; this fact is utilized for killing them by use of insecticide treated cords and strips which are hung from ceilings in kitchens, dining halls, store rooms, diary farms and poultry houses to provide effective control during the fly season. Dark coloured material is preferred for treatment @ 1m cord or strip for each square metre of floor space. The period of effectiveness ranges from 1 to 6 months. For this any insecticide with high vapour pressure and quick knock down effect should be used. These treated materials should not be hung over food containers, watering troughs or within reach of animals or pets. Curtains treated with Synthetic pyrethroids will be of additional benefit.

**(d) Larvicides**




Insecticides such as DDVP (0.5%), Fenthion (4%) have been used as larvicides to control fly breeding but the use of larvicides may favour the development of resistance, the choice should therefore be made carefully. Insecticides like Dimilin (IGR) may be used to retard development of resistance. Larvicides should be applied at a rate sufficient to wet the upper 10-15 cm of the breeding medium thouroughly i.e. 0.5 - 5 l/$m^2$.

**(e) Paints**

The concept of using insecticidal paint for housefly is catching up. Imidacloprid baits wetted with water may be used as paint on housefly resting places.

**(vi) Residual Spray**

The housefly has developed resistance to most of the Organochlorine as well as Organophosphorus and Carbamate group of insecticides routinely used in public health. Residual sprays are ideally not recommended for fly control.

Mechanical Control

**(a) Fly Traps**


Various types of fly traps such as the cage trap and the kerosene tin trap were used in the past with fairly good results. These are no longer in use because of the availability of more potent and convenient methods mentioned above. Newer mechanical fly catching devices have been developed which have bags with attractants inside which attract the houseflies and on entry inside the bag, they get trapped and eventually are killed.

**(b) Swatting**

It is used in situations where infestation is so low that routine fly control measures are either not indicated or feasible. However, it is important to remember that fly population of a cook house or dining room cannot be greatly reduced by persistent swatting. A good swat is the one, which is resistant enough to affect a rapid hit. The flaps should be perforated and washable.

**(c) Fly Paper**

Commercially available fly papers may be used or alternately sticky fly papers can be prepared by mixing 8 parts of powdered resin and 5 parts by weight of crude

castor oil and heating the same in a water bath while stirring constantly. The paste mixture is spread on glazed paper. The latter can be prepared by coating an ordinary paper with a hot solution of 1 g of glue in 3ml of water and allowing it to dry. The


fly papers do not give lasting results and hence are not much in use. They are best used for monitoring fly density.

Physical Control

Use of light traps (electrocutors) is very useful in the dining areas & other public eating places. The light traps should be placed away from dining tables & food.

| Insecticide | Formulation | Dosage | Area to be sprayed |
|---|---|---|---|
| Cyphenothrin | Gokilaht-S 5EC | 10ml + 990 ml of water | 500ml/sq m |
| Diflubenzuron | Dimilin 2.5%WP | 8 g in 1 l water | 500ml/sq m |
| Diflubenzuron | Dimilin 5% G | As it is | 50 g/sq m |
| Imidacloprid | Quick bayt | As it is | 20 g / bait station |
| Propoxur bait | Baygon bait 2% | As it is | Moisten and keep in bait stations |

Dr (Mrs) Rina Tilak

# Mosquitoes

Mosquitoes belong to phylum Arthropoda, class Insecta, order Diptera and family Culicidae. The family culicidae is divided into sub-families - the Culicinae, the Chaoborinae and the Dixinae. Of these only the sub-family Culicinae, which comprises all the true mosquitoes, is of medical importance. Amongst the mosquito genera, only *Anopheles, Culex, Aedes* and *Mansonia* are of importance in India. The mosquitoes are further classified as 'Anophelines', which comprises only one important genera - *Anopheles* and 'Culicines' comprising three important genera viz. *Culex, Aedes* and *Mansonia.*

## Morphology

Mosquitoes are about a centimetre long and grayish black in colour. The division of the body into the head, thorax and abdomen is sharply defined. The head bears two large compound eyes, a pair of antennae and the mouthparts which are collectively called 'proboscis'. The mandibles and maxillae of only the female are developed for cutting the human skin; therefore only the female mosquitoes can suck the blood and transmit diseases (1-4, 48).

Males can be identified by their antennae, which are densely haired and look like moustache, whereas, in females the antennae is sparsely haired. The abdomen of mosquitoes consists of 10 segments of which 7 or 8 are clearly marked out and the terminal ones form the male and female external genitalia.

## Life History

Mosquitoes undergo complete metamorphosis through the stages of egg, larva, pupa and adult. Water is required for egg laying. The number of eggs laid at each oviposition varies between 50 and 150. The eggs hatch into larvae in one to two days, but in cold weather the hatching may be delayed. Mosquito larvae feed voraciously on microorganisms, water algae or other organic matter, and breathe through spiracles. They move actively with wriggling motion, hence are known as "wrigglers'. Larvae pass through four stages or “instars” in five days depending on the species, the temperature of the water and availability of food supply. At the end of the fourth instar, the fully grown larva casts its skin and becomes a pupa. During this stage it undergoes transformation to the adult usually within 1-2 days. The adult mosquito wriggles out of the pupal skin. The total duration of the life cycle varies between seven days to one month; however it could be up to a maximum of 6 months in the temperate zones, but in the tropics they seldom survive for more than a month.

## Bionomics

The females of all the medically important mosquitoes are normally bloodsuckers, as they require a blood meal for maturation of eggs. Females are fertilized during swarming (nuptial dance) at dusk. Those feeding on human blood are called anthropophilic and those feeding on animals are called zoophilic. Majority of species are nocturnal in their feeding habits, some are diurnal while others feed indiscriminately by day or night. Some are outdoor biters (exophagous) and some are indoor biters (endophagous). After blood meal, female goes in search of a quiet place indoors (endophilic) or outdoors (exophilic) to rest for a variable period, usually 2 days and matures her eggs, which are thereafter laid in water collections. Male mosquitoes feed on flower-nectar and plant-juices and do not survive long after fertilizing the female mosquito.

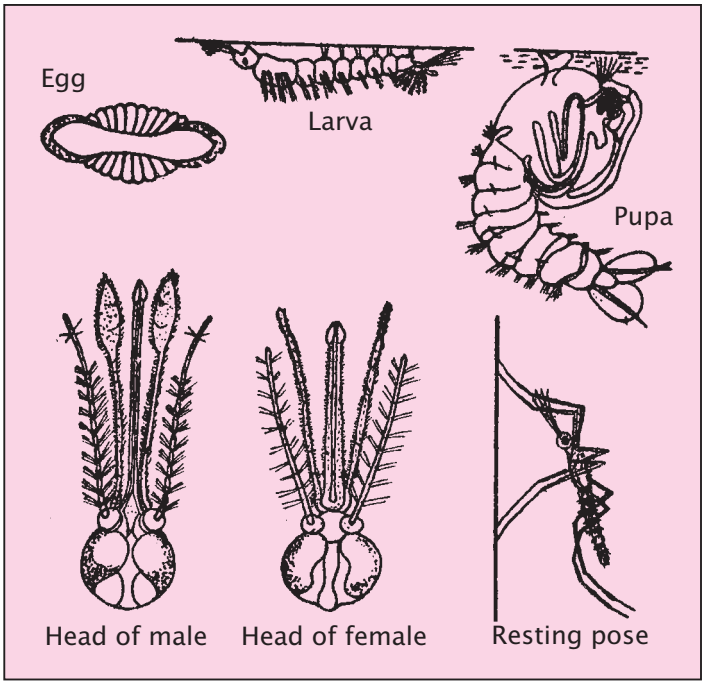
## Vector Potential

Certain species of Anopheline mosquitoes are vectors of Plasmodia causing human malaria. Some species of Culicine and Mansonoides mosquitoes cause human filariasis. Aedes mosquitoes cause yellow fever, dengue, dengue haemorrhagic fever and chikungunya. Many species of mosquitoes belonging to the genera Culex and Aedes are the vectors of a number of viral encephalitides. Vector potential is posessed only by certain species of a particular genus and for specific infection only. All species are not efficient in spreading the particular infection. The potential generally depends upon the feeding, breeding and resting habits and the biological capability of serving as a host to an aetiological agent. A short description of the important genera is given below.

### Genus Anopheles

Members of this genus have 58 species in India. Females of only nine species of Anopheline mosquitoes are the vectors of human Plasmodia in India. In certain parts of the world, some species of Anopheline mosquitoes are the

Fig - 1 : Genus Anopheles



vectors of *W bancrofti* and *B malayi* infections as well. Anophelines mostly breed in fresh, unpolluted and oxygenated water. The larvae of a few species like *A subpictus* may be found in polluted water.

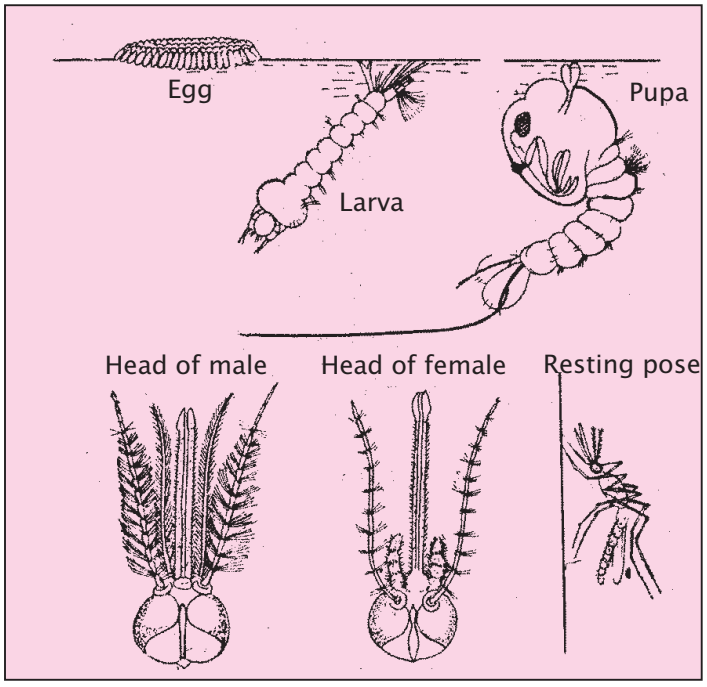
An identification kit for common Anophelines of India is presented at the end of the chapter.

**Genus Culex**

Members of this genus are found in temperate and tropical zones throughout the world. There are 240 Indian species in this Genus. Adult mosquitoes of this genus are generally dull in colour and inconspicuous due to unspotted wings. Their breeding sites vary from clear water, such as wells and springs, to collections of muddy, brackish or polluted water; but unlike Anopheline mosquitoes these mosquitoes generally prefer stagnant and muddy pools. *C quinquefasciatus* is prevalent universally. It is a night biting mosquito and is the most important vector of *W bancrofti.*

**Genus Aedes**

Fig - 2: Culex Mosquito

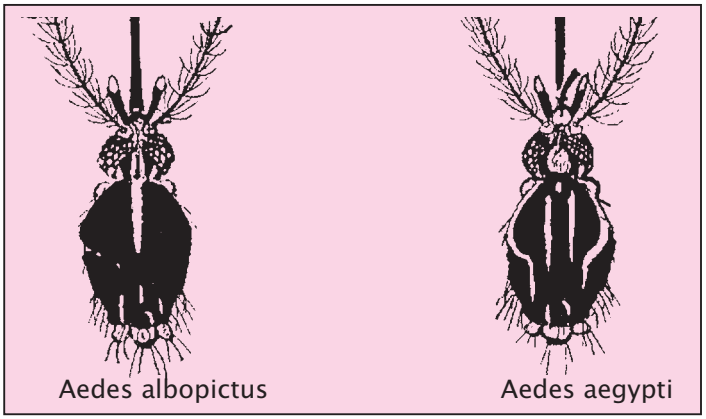



Some members of the genus *Aedes* have almost worldwide distribution while others have restricted habitats. The chief species in India are *Aedes aegypti, Ae albopictus* and *Ae vittatus.* They are black or dense brown and medium sized mosquitoes with silvery white scales forming patterns on the thorax, bands on the legs and rings around each abdominal segment (49).

These are container breeders. The cigar shaped eggs are laid singly on damp surfaces on stagnant water. These mosquitoes are mostly anthropophilic and are adapted to domestic or semi-domestic environments. During the pre-monsoon period the breeding is restricted to water collections meant for domestic use. Communities or sections of the cities with water scarcity, which leads to water storage practices, are mostly harassed by *Ae aegypti.* In the shore areas, barges and country crafts provide ample places for *Aedes* breeding. They are well adapted for breeding in small collections of water in a wide variety of natural and artificial containers such as masonary tanks, earthenware pots, small and large tins, barrel drums, coconut shells, stored or discarded motor car tyres, discarded polythene packs, junk and hardware, flower pots, fire buckets, depressions in tree trunks, axils of leaves and so on. They may breed in tree holes if these are within about 20 m of houses. The eggs after maturing may remain viable for considerable periods even after drying-up of the breeding sites, and hatch out during rains. Such surviving eggs rapidly build up the adult mosquito population when rains come. Their capacity to complete life cycle indoors enables them to breed in urban areas throughout the year, irrespective of the prevailing external climate. They are generally diurnal feeders. They may feed indoors or outdoors and rest near the breeding places in dark, shady corners and such places as behind cupboards, hanging clothes, inside shoes, umbrellas, below the furniture, and in containers providing breeding sites. *Aedes* mosquitoes are the vectors of urban and rural yellow fever, dengue, dengue haemorrhagic fever and chikungunya. *Ae niveus* has been reported as vector of *W bancrofti* (diurnally sub periodic) infection in Nicobar Islands.

*Ae aegypti,* and *Ae albopictus,* the two important vector species can be easily distinguished by their thoracic pattern. *Ae aegypti* has sickle or lyre shaped pattern on the thorax, whereas *Ae albopictus* has a single central mark present on the thorax (Fig - 3).

Fig - 3 : Thoracic pattern of *Ae aegypti* and *albopictus*

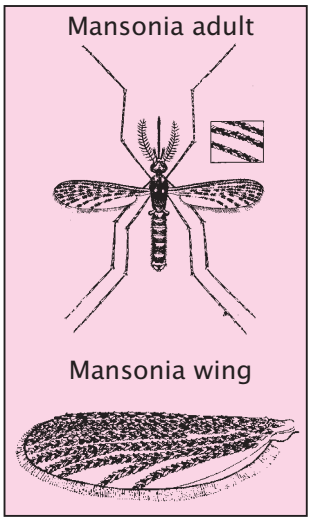



**Genus Mansonia**

This has wide distribution in tropical countries. In India, M annulifera, M uniformis and M indiana are the prevalent species in Kerala. The adult mosquitoes are robust and yellowish brown. The wings are covered with flat, broad scales, which give the wings a speckled appearance as if dusted with mixed salt and pepper. The female lays eggs in cluster anchored to the under surface of the leaves of aquatic plants such as Pistia straitiotes, Lemna, Eichornia, Salvinia and so on. On hatching out, the larvae obtain oxygen from the plant cells through their modified siphon

tubes by attaching themselves to the rootlets of these plants. The pupae are similarly attached to the plant stems by the modified breathing trumpets. When matured they detach themselves and come to the water surface. The adults then emerge and fly away. They are persistent biters, particularly during darkness. Mansonia mosquitoes are the vectors of B malayi infection of filariasis in several pockets in rural areas of Kerala, Tamil Nadu, Andhra Pradesh, Madhya Pradesh, Assam and West Bengal. (Fig - 4)

Fig - 4 : Genus Mansonia




Some of the important differences between Anopheline and Culicine mosquitoes are shown in Table-1

## Mosquito Control (8, 12-15, 19, 23-25)

Anti-adult measures and anti-larval measures are the two most important mosquito control measures. Personal protection against their bites aids these measures in control of disease. Methods related to environmental management by way of minor manipulations or major engineering steps should always be an important consideration in overall anti-malaria plan.

### Anti-adult Measures

Residual Insecticides

Indoor residual spray is considered to be the most important tool for controlling mosquito borne diseases. As per National Policy, indoor residual spray is to be carried out in all rural areas during malaria transmission season. This is a more practicable and simpler method of interruption of transmission of disease. For the limited objective of disease control it is not necessary to carry out the work throughout the year or in the entire territory but only in houses and shelters in endemic zones during the transmission season. However, there are certain conditions under which the absolute efficacy of this procedure may be doubted, for instance, where vector is exophilic though biting indoors or where the surfaces sprayed are subject to frequent mud plastering or white washing. Even when local conditions do not appear to be absolutely favourable, the application of residual insecticide gives relative success in disease control. DDT, Malathion and the members of synthetic pyrethroids like Cyfluthrin, Deltamethrin etc are the residual insecticides of choice depending upon the susceptibility of the vectors. The different insecticides used for indoor residual spray are presented in chapter on principles of vector control in this section.

Space Sprays

Space treatments are usually designed to provide a rapid knock-down and mortality with little or no residual effect. Such treatments must be considered in conjunction with other control methods as part of an integrated vector management programme. There are two types of fogging viz. Thermal and Cold fogging which are routinely used in the field of mosquito control; the details are given in chapter on principles of vector control in this section.

Table - 1 : Important differences in anopheline and culicine mosquitoes

| Stage | Anopheline | Culicine |
|---|---|---|
| Egg | Boat shaped; laid singly with lateral floats. | Elongated. Aggregation occurs into rafts of hundreds of eggs in Culex. Aedes eggs are laid singly, Mansonia eggs are laid on undersurface of leaves of aquatic plants in star shaped clusters. |
| Larva | No siphon tube but only apertures on 8th abdominal segment. Larvae rest parallel to the surface of water and swim with swift wriggling movements. Palmate hairs for floatation arranged in pairs on all abdominal segments. | Single siphon tube on 8th abdominal segment. In Culex, siphon tube is long and narrow whereas, in Aedes it is short and broad. Mansonia larvae are attached to roots of aquatic plants. Culicine larvae rest at an angle to surface and swim with slow snail or worm like movements. No palmate hairs for floatation. |
| Pupa | Mosquito pupa is comma shaped. In Anophelines, spiracles are longer, spiracle is short stumpy and funnel shaped. | In Culicines, slender and trumpet shaped. |
| Adult | Wings usually spotted. Rests at an angle to | Wings usually not spotted. Rests parallel to the surface. |

Thermal fogging is a space treatment against adult mosquitoes. It can even reach air spaces in areas obstructed by dense vegetation or other objects. When the mosquitoes in flight come into contact with the droplets, they will be knocked down and killed. Thermal fogging can quickly reduce the number of biting mosquitoes but does not have lasting residual effects. As adult mosquitoes must come into contact with the pesticide, the timing of application is critical. While different mosquito species are active during different periods of the day, it is essential to fog at the right time to get effective control of the target species.

Thermal fogging is very susceptible to wind and thermal air currents. If applied during unfavorable conditions, such as during a hot day, the fog may be carried up and over the target places and the application will become ineffective. If applied in a very windy day, the fog will drift out of the area that you want to treat. Application should therefore be carried out when the air is calm and the temperature is not too high, such as during the evening or early in the morning when the fog is more likely to be held close to the ground.

Cold fogging is also very effective in bringing down the infective vector population and is considered more environment friendly as compared to Thermal fogging. Details on space spraying and the insecticides with their dosage are given in chapter on principles of vector control in this section.

Genetic Control

The control of adult mosquitoes by means of 'Sterile Male Release' (SMR) technique and other genetic methods such as cytoplasmic incompatibility, chromosomal translocations, sex distortion and gene replacement have been attempted in the past. However, all these methods have still to prove their worth and utility in the field. The scope of recombinant DNA technology is immense and research is being carried out to use this tool for vector control.

### Anti-larval Measures

Larval control is the only effective method of radical mosquito control. In urban areas, like cantonments, garrison stations and base areas, this method complements the adult mosquito control. Anti-larval work is carried out by preventing breeding and destruction of larvae and pupae.

Vector Engineering

Avoidance of man-made mosquitogenic conditions is of primary importance. Mosquito breeding prevention should be deliberately incorporated in the planning and execution of all engineering constructions and town planning schemes like River valley projects, dams and barrage constructions, road and railways, railway constructions and irrigation systems. Besides these, indiscriminate digging, disposal of discarded tins, containers and water collections, overhead storage tanks and septic tanks without covers are potential mosquito breeding places in urban areas. Clean edging and water de-weeding, channelling, filling or draining, exposing to sunlight, shading or covering are the usual methods adopted. Underground drainage constitutes the best method of bio-engineering for control of mosquito breeding.

Dry Day

Intermittent drying once a week is an effective method of prevention of breeding by observance of a weekly 'dry day'. It should ideally fall on the day when the anti-mosquito staff is due to visit that area for anti-larval work. All fire fighting tanks, ornamental ponds or water storage tanks, fire buckets, and all domestic water containers should be emptied and allowed to remain dry for a few hours on the weekly 'dry day'.

Larvicidal Measures

Destruction of larvae is achieved by application of larvicidal oils, Organophosphorus insecticides, use of Insect Growth Regulators, biocides and use of larvivorous fish. The list of anti-larval chemicals along with their dosages is presented in Table in chapter on principles of vector control in this section.

**Larvicidal Oils**

Oiling of the breeding places with larvicidal mineral oils like 'malariol' has been the mainstay of the antilarval measures in all sorts of mosquito breeding places, except those which are used for drinking, agricultural, horticultural and piscicultural purposes or in the ornamental, fire fighting and overhead water storage tanks. Oils act primarily by suffocating and poisoning the larvae and denying them the surface tension required for floatation. 10 ltr of oil is required to treat 500 linear metres. Oil is applied once a week with a broom or a mop tied at the end of a long handle. The drawback of this method is that the oil film may be broken by wind or raindrops. It is also not very effective in the presence of excessive weeds and other vegetation.

**Insecticides**

Organophosphorus compounds viz. Temephos (Abate) and Fenthion (Baytex liquid and Baytex granules) are routinely used for antilarval activity in India. Biocides (Bti) are the recent introduction as larvicides in the National programme as well as in the Indian Armed Forces. Insect growth regulators (IGR's) viz. the chitin synthesis inhibitors (Dimilin, Novaluron) and the juvenile hormone mimics (Pyriproxyfen) are being proposed and being promoted as safer alternatives besides Temephos and Biocides for use as larvicides.

**Biological Control**

Various predators, parasites and pathogens have been evaluated for mosquito control. Larvivorous fishes like *Gambusia affinis, Poecelia reticulata* and *Aplocheilus lineatus* have been found effective and are being used for mosquito larval control in India. Various other fungal agents' e.g *Lagenidium, Coelomomyces, Culicinomyces* along with nematodes *Romanomermis culicivorax* and *R iyengari* are promising bioagents. Protozoans- Nosema, Thelohania and viruses like Cytoplasmic polyhedrosis

virus and Iridovirus also hold great promise.

**Personal Protection**

Individual personal protection against mosquito bites is achieved by use of mosquito nets, repellents and protective clothing. Screening the houses and hospital wards has been practiced on a restricted scale.

Mosquito Nets

The use of mosquito nets is one of the most effective personal protective measures. Net should be put up before dusk and tucked all round under the bedding. They should always be maintained in a good state of repairs by patching holes and tears and not by stitching or knotting. Mosquito net inspection should be held regularly as a drill. Definite arrangements should be made to fix the nets in barracks, huts and tents.

One of the latest strategies for prevention against mosquito borne diseases is use of treated nets called Insecticide Treated Bed Nets or ITN's. The nets are manually treated with synthetic pyrethroids like Deltamethrin, Cyfluthrin etc. These ITN's provide an irritant and excito-repellent effect besides contact action. An additional collateral benefit is also provided against pests like bed bugs, houseflies, sandflies etc. These nets are safe for use by pregnant women, the infirmed & small children.

Advancement in ITN technology has come in the form of **Long Lasting Nets** or LLN's. A LLN is a ready-to-use pretreated mosquito net, which requires no further treatment during its expected life span (average 4 to 5 years). This advancement has obviated the need to treat the nets every six months. Of the available LLNs, "Olyset Net" is made of polyethylene with 2% Permethrin incorporated, while "Perma Net" is a regular polyester net treated with Deltamethrin 50 mg / sq mtr.

Repellents

Repellents should be applied by all on exposed parts of the body during evenings and when not under mosquito net during night. Repellent application is also advised during daytime, in areas where Dengue/ Chikungunya outbreak has occurred or threat exists. Repellents available for application are Diethyl toluamide (DEET), available as brand name Mosfree and Odomos and DEPA (Diethyl phenyl acetamide), which has been indigenously developed by DRDE, Gwalior and found at par with DEET in efficacy and spectrum, in the trials conducted at AFMC and in the field. DEET & DEPA have been found to be very effective when applied on uniform as lotion or sprays against all haematophagous arthropods as well as leeches.

Protective Clothing

The wearing of long trousers and shirts with rolled down sleeves after dusk should be enforced in all malarious areas and when personnel move by rail or road. Added protection is given by wearing web anklets. Implementation of barrier clothing in daytime is also advised in Dengue sensitive areas.

Screening of Houses and Barracks

This measure is effective only when all doors, windows and ventilators in the building are screened by wire mesh of proper gauge and size (1.2 to 1.5mm).

## Vectors of Malaria (23, 25, 50)

Table - 2 : List of malaria vectors of india and the vectors of local importance

| S No. | Name of Species | Role in transmission |
|---|---|---|
| 1 | *A stephensi* | Primary urban vector in most of India except North-East and in Rajasthan |
| 2 | *A culicifacies* | Primary rural vector all over India except North-East |
| 3 | *A fluviatilis* | Primary rural vector in foothill areas of the country |
| 4 | *A minimus* | Primary vector in North Eastern regions, West Bengal |
| 5 | *A phillippinensis* | Primary vector in rice field ecosystem of North Eastern regions |
| 6 | *A dirus* | Primary vector in regions of evergreen forests in the North East |
| 7 | *A sundaicus* | Primary vector in Andaman & Nicobar Islands |
| 8 | *A varuna* | Eastern ghats (Andhra Pradesh), Singbhum hills (Bihar) & Kerala |
| 9 | *A annularis* | Secondary vector in rice field ecosystem in Uttar Pradesh and coastal areas of Orissa |
| **Vectors of local importance** | | |
| 1 | *A aconitus* | Orissa, Assam |
| 2 | *A jeyporiensis (var candidiensis)* | In certain localities in Kerala, Karnataka and Assam |
| 3 | *A maculates* | In certain localities in Assam & Meghalaya |
| 4 | *A tesselatus* | Lakshadweep Islands (on epidemiological grounds) |

There are 58 species of anopheline mosquitoes in India but only 9 are incriminated as vectors and another 5 species have been found to be of local importance in transmission of malaria. The list of these vectors is presented in Table - 2. The following characteristics of vector mosquitoes play an important role in the epidemiology of malaria.

| | |
|---|---|
| (a) Slow moving water, seepages, terraced rice fields | A fluviatilis |
| (b) Brackish waters | A sundaicus |
| (c) Wells, cisterns and over head tanks | A stephensi |
| (d) Tanks, pools, burrow pits and ditches | A philippinensis<br>A annularis |
| (e) Forest pools, streams and slit trenches | A dirus |

Breeding Habits

The breeding habits of mosquitoes show a lot of variation. Hence, vector mosquitoes tend to be confined to certain geographical areas only. A few examples are given in a box below.

Density

For effective transmission of malaria in a locality, the mosquito vector must attain and maintain a certain density. This is called critical density and it varies from one mosquito to another and also under different environmental conditions. A culicifacies needs a very high density for transmission of malaria.

Longevity

A mosquito, after an infective blood meal, must live for at least 10 days to complete the development of malaria parasites.

Tropism

Some mosquitoes like *A fluviatilis* prefer human blood and are called anthropophilic. Others like *A culicifacies* preferably feed on animal blood and are called zoophilic. This preferential feeding habit is called tropism. It has obvious bearing on the transmission of malaria.

Biting behaviour

Some vector mosquitoes bite at or soon after dusk, others either during late night or early hours of the morning. However, some species may be active at two different periods during the same night.

Resting Habits

A female mosquito after a blood meal rests either indoors (endophilic) or outdoors (exophilic) for maturation of its eggs. Knowledge of these habits is necessary for organizing antiadult measures. The common resting places are either human dwellings, cattle sheds or mixed dwellings.

Flight Range

The range of flight and dispersion varies from one vector to another. Some have a short flight range e.g. *A dirus, A annularis* and *A fluviatilis* upto 1 km distance; *A culicifacies* and *A stephensi* up to 2 km; and A sundaicus up to 8 or 10 km.

Resistance to Insecticides

When a vector mosquito in a locality becomes resistant to a particular insecticide, use of an alternative insecticide is recommended.

## Vectors of Filariasis

*Culex quinquefasciatus*

This species is the main vector of bancroftian filariasis in India. It preferentially breeds in dirty water collections such as in drains, cesspools, soakwells and septic tanks. When denied such opportunities, it can also breed in clean water.

Mansonoides

Mansonoides species are the vectors of *B malayi* infection in India. In Kerala, *M. annulifera* and *M. uniformis* are the major vector species. These mosquitoes are associated with aquatic plants like *Pistia stratiotes, Eichornia speciosa* and *Salvinia auriculata.*

*Aedes niveus*

This species has been incriminated as a vector of diurnally subperiodic form of Bancroftian filariasis in Nicobar group of islands.

## Vector Control

The best and permanent method of vector control is to prevent breeding of vector mosquitoes by underground drainage schemes. Because of financial constraints in a developing country like India, this may not be feasible in the near future. The temporary measures anti-adult and anti-larval measures which are on the same lines as have already been outlined under anopheles control measures.

## Mosquito Surveillance (51, 52)

Places which are endemic for mosquito borne diseases or outbreak prone, it is deemed mandatory that mosquito surveillance system be established. The aim of the surveillance should be to forecast an impending outbreak and to recommend appropriate strategies for mosquito control which would prevent outbreak.

### Steps for establishing mosquito surveillance system: Guidelines for Specialists in Preventive medicine (SHOs / DADsH)

It needs no emphasis that all specialists in Preventive Medicine in Armed Forces (SHOs / DADsH) develop an ongoing, simple, practicable but regular surveillance on disease vectors, especially mosquitoes. The guidelines for planning, organizing and implementing the same are being suggested in the succeeding paragraphs. It is also desirable that Sr Advisors in PSM check the records (Entomological adult and larval surveillance registers) and the practical implementation, as and when they visit the

Table - 3 : Adult Mosquito Surveillance Register

| Date | Sector No. | Species | Fixed Catching Station | | | Random Catching Station | | | Total | | | | Density per Man hour |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Time Spent | No. Collected | | Time Spent | No. Collected | | Time Spent | No. Collected | | | |
| | | | | M | F | | M | F | | M | F | Total | |
| | | Anopheles | | | | | | | | | | | |
| | | Culex | | | | | | | | | | | |
| | | Aedes | | | | | | | | | | | |
| | | Anopheles | | | | | | | | | | | |
| | | Culex | | | | | | | | | | | |
| | | Aedes | | | | | | | | | | | |

Table - 4 : Mosquito Larval Surveillance Register

| Sector No. | Date | Anopheles | | | Culex | | | Aedes | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | No. of dips | Total Larvae & Pupae | Larvae/ dip & Pupae /dip | No. of dips | Total Larvae & Pupae | Larvae/dip & Pupae/dip | Type of container | No. of containers positive for | Remarks (*) |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

* Remarks to include details of House index, Container and Breteau index for Aedes if situation warrants.

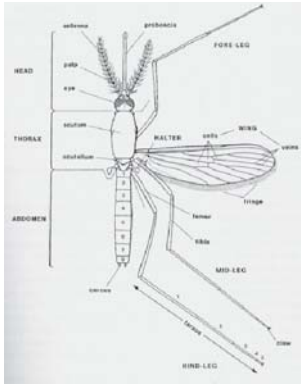
PSM specialists in their jurisdiction. The proposed format of these two registers are given in Table - 3 & Tabe - 4.

**Basic steps in identification**

Acquaint yourself with basics of mosquito identification both larval and adult mosquitoes up to genera level (*Culex, Anopheles* and *Aedes*) and mosquito bionomics.

Adult

Fig - 5



**Identification of mosquito**

Mosquitoes are identified from other such flies by the presence of forward projecting mouthparts or proboscis, wing veins (veins 2, 4 and 5 are branched) and a fringe of scales along the posterior margin of wings (Fig - 5).

**Identification of male & female mosquito**

The mosquito sexes can be identified by their antennae. It's bushy in males and not so bushy in females.

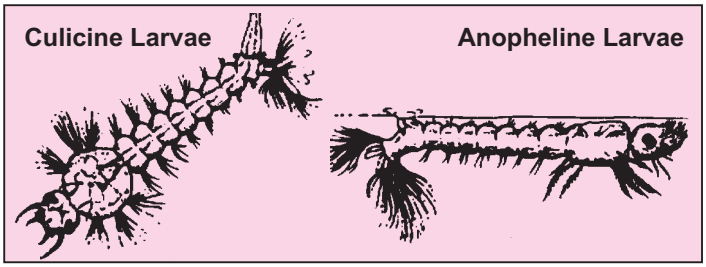
**Identification of *Anopheles, Culex* and *Aedes***

If the wings are spotted, it is an anopheline vector species; whereas, if the legs are striped it is *Aedes* and if there are no spots on the wings or stripes on legs, it is *Culex* adult.

Larvae

If the larvae have siphon tube it belongs to Culicine group and could be *Culex* or *Aedes*. If the siphon tube is long and narrow, it is *Culex* species, whereas short and broad siphon tube indicates it is *Aedes*. It is also important to remember that *Aedes* is essentially a container breeder and will be found only in artificial or natural containers. The culicine larvae float at an angle to the water surface. Anopheles in contrast will have no siphon tube and will be floating parallel on the surface of water as shown in Fig - 6.

Fig - 6




Sector allocation and mapping

Once armed with the basic information, start by dividing the entire Cantonment into five sectors and make a map of the sector. Each sector should be covered every fortnight or at least once a month for surveillance.

Conduct a preliminary survey

First a baseline survey (larval and adult) is conducted to determine the prevalence, abundance and distribution of the vector species.

Data compilation and preparation of spot map

The data collected in step one is compiled and analyzed to determine the above mentioned variables and a spot map is prepared with clearly marked out areas where density is high, medium or low or where potential of breeding exists.

Establish monitoring/ catching stations

In each of the five sectors, establish four fixed stations (min two if manpower is less) with preferably two from the high density and two from medium density spots and an equal number of random stations (2 each from high density and medium density areas). Poor or worst ventilated houses located close to breeding places, discarded bathrooms, abandoned buildings are considered ideal for room selection, the room which has fewer openings is selected.

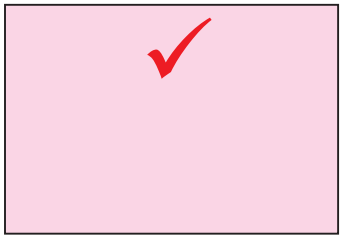
Conduct fortnightly surveys

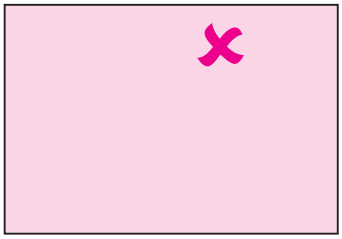
Conduct surveys in the fixed and random stations and record your data in the adult and larval surveillance registers as per format given earlier.

Larval sampling procedure

The mosquito larval sampling will be done by standard larval ladles available with all SHOs. The method is as follows :

(a) **Dip the ladle sideways** : A minimum of five dips may be taken for calculation of larval density.





(b) **Transfer the larvae in enamel bowl** : count the total number of larvae and pupae in the bowl after five dips.

(c) **Calculate larval density** : it is done by the following method:

Total number of larvae counted - 50

Total no. of dips taken - 5

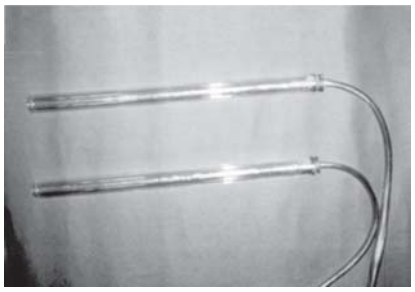
Larval density (Total no. of larvae / no. of dips) -50/5 = 10

Other larval sampling procedures like larval nets (when the water body has vegetation) or well nets (when mosquito breeding is noticed in wells) may be used in specific situations. The density is calculated in the same way and given as larvae/ larval net or well net.

Adult sampling procedure

It is done by various methods viz. aspirators, total catch, light trap, window traps, direct bait collection, whole night collection or use of magoon trap or drop net traps.

**Aspirators / Suction tube**



This is the most common method of sampling adult mosquitoes. It is normally undertaken in the mornings. Before using suction tube ensure that muslin cloth or gauge piece is placed between the glass tube and the rubber tubing to prevent mosquitoes being sucked inside your mouth.

(a) With the aid of a torch look for resting mosquitoes on the walls, ceilings (when it's low), behind and under furniture/ wall hangings etc.

(b) For practical purposes, while undertaking mosquito surveillance, one insect collector should spend at least 15 min in each of the 4 fixed and each of the 4 random stations. Thus, 2 insect catchers should be deputed, one for the 4 random stations and one for the fixed stations ( 15 mts at each station) on the day surveillance is being conducted in that sector.

(c) While using suction tube, keep the end of rubber tubing in your mouth and place the opening of the glass tube 1-2 cm from the resting mosquito. Move the end closer to the mosquito by applying gentle suction to draw the mosquito inside the tube, now place your finger over the tube to keep the mosquito from flying away.

(d) Do not collect more than five mosquitoes in one tube. After collection, transfer the mosquitoes in transport cages by gentle blowing.

$$\text{Density (Per Man hour)} = \frac{\text{Total No. of mosquitoes collected}}{\text{Man Hour spent in collection}}$$

(e) Density of mosquitoes is calculated by the following formula:

(f) If 2 persons have collected 18 mosquitoes and each man has spent 1 hr each (15 mts per station), the density is calculated by the following method:

2 Persons X 1 hr= 2 Man Hour

Total mosquitoes collected in 2 Man Hour - 18

Mosquitoes collected Per Man hour (PMH) - 18/2 = 9

Density = 9 PMH

Total Catch or spray sheet collection

Involves the use of Pyrethrum for collection of mosquitoes resting indoors. This is a more efficient method of sampling as it can also collect those mosquitoes which are hiding under furniture or resting on high ceilings or where the density of mosquitoes resting is low. However, this method is tedious and is recommended for use by SHOs / DADsH under supervision of a splt in PSM, when an outbreak is impending. For routine surveillance by SHOs / DADsH, the method of suction tube and larval dip is the most practical.

**Total Catch Method**

- Remove all animals, small items of furniture, food items. Close all windows and doors and close / cover all openings with cloth.
- Spread white cotton bed sheets to cover the entire surface area (no. of sheets will depend on the size of the room). Ensure that sheets have been placed under furniture also. Sheets placed on furniture should not touch the floor as it will prevent the insecticide from reaching underneath.
- Prepare the Pyrethrum solution from 2% Pyrethrum extract available to a workable strength of 0.2% by mixing 100 ml of Pyrethrum with 900 ml of Kerosene to make a total volume of 1 ltr of prepared soln. of 0.2%.
- Use a hand sprayer (Flit gun) for spraying. The person after entering the room should first close the door of the room and then start spraying in open spaces and holes in the wall and thereafter proceed to apply spray towards the ceiling until the room is filled with fine mist; always taking care to move in a clockwise direction. After spraying he should close the door and come out and keep the room closed for at least 10 min.
- After 10 mins, open the door, move gradually from the doorway picking up the mosquitoes by forceps in a

Other types of mosquito sampling devices

The other sampling tools are the window traps, magoon traps, direct bait collection and light traps.

### Surveillance of Aedes mosquitoes (53-56)

Larval survey

Three indices are commonly used to record Ae aegypti and Ae albopictus density levels.

**House index (HI)**

$$HI = \frac{\text{No of houses positive for Aedes larvae}}{\text{No of houses inspected}} \times 100$$

Percentage of houses or premises positive for Aedes larvae. The HI is calculated as follows :

$$CI = \frac{\text{No of positive containers}}{\text{No.of containers inspected}} \times 100$$

**Container Index (CI)** : Percentage of water-holding containers positive for Aedes larvae. CI is calculated as follows :

$$BI = \frac{\text{No of positive containers}}{\text{No.of houses inspected}} \times 100$$

**Breteau Index (BI)** : Number of positive containers per 100 houses in a specific location. BI is calculated as follows :

(A HI > 5% &/or a BI > 20 for any locality is an indication that the locality is dengue sensitive and therefore adequate preventive measures should be taken).

Adult surveys

Human bare-leg catches (landing catches) of *Aedes* adults (both males and females) or indoor resting collections of adults are normally used to assess adult *Aedes* populations. The data collected are calculated to reflect the number of female *Aedes* mosquitoes landing / biting on single human bait per hour (e.g. number per man hour). The collectors should move from house to house and not collect in one place for more than 15 or 20 minutes. In a similar manner, indoor resting collections can be made and the data expressed as numbers collected per man-hour or per house.

Oviposition traps

"Ovitraps" provide a sensitive and economical method for detecting the presence of *Ae. aegypti* and *Ae. albopictus* in situations where the *Aedes* density is low and general larval surveys produce unsatisfactory results (e.g. when the Breteau Index is < 5). The standard ovitrap is a wide-mouthed glass jar of approximately 250 ml which is painted black on the outside to attract the *Aedes* females to oviposit. A piece of hardboard/ wooden paddle or filter paper is placed diagonally inside the glass as an oviposition substrate. In addition, the jar is partially filled with clean water for oviposition.

**Aedes Prevention & Control**

The only effective method of preventing dengue is the control of the vector mosquito *Aedes aegypti* and *Aedes albopictus*.

- Temephos is very effective as a larvicide. Oviposition attractant developed by DRDE has been found to be successful in initial trials at many places.
- Thermal fogging with Malathion or Deltamethrin/ Ultra low volume (ULV) fogging with Deltamethrin or Pyrethrum has been found to be highly successful in interrupting transmission.
- Insect growth regulators are increasingly being used against *Aedes* for prevention of Dengue & Chikungunya.
- Use of personal protective measures like barrier clothing and applying mosquito repellents are helpful during outbreaks.
- People should sleep under net, preferably treated net, especially infants and pregnant women.
- The patient should be treated under a mosquito net

Dr (Mrs) Rina Tilak

# Other Biting Pests

## Fleas

Fleas are one of the few important vectors which have been historically linked with the Armed Forces the world over. Plague, transmitted by rat flea, was one of the vector borne diseases which played an important role in redefining geographical boundaries post World War I and II.

### Classification and Distribution

Fleas are distributed all over the world and belong to the order siphonaptera comprising about twenty five hundred species and sub-species. Fleas can be classified into two main groups, 'combless' fleas and the 'combed' fleas. The combless fleas contain the important genus *Xenopsylla* which has about sixty species and sub-species including the well known vectors of plague viz, *X cheopis, X astia* and *X.braziliensis*. The oriental rat flea, *X cheopis,* is widely distributed in the tropics and is the principal plague flea in India. The combed fleas are the cat-fleas-*Ctenocephalides felis*, the dog flea, *C canis*, and the rat fleas of temperate zones, *Nosopsyllus fasciatus*. These fleas serve as intermediate host of certain veterinary cestodes (dog-tapeworm) but are more of a biting nuisance to man. The other important combless flea is *Pulex irritans,* which occurs only in the hills of the tropical countries of the Eastern Hemisphere. *Tunga penetrans*, a sandflea is found in tropical and sub-tropical regions of North and South Americas and Africa and occasionally in Western India.

### Morphology

Adult fleas are small, bilaterally compressed, highly chitinised, wingless, 6 legged, blood sucking ectoparasites of many warm blooded vertebrates (Fig - 1). The size varies from 1.5 to 6 mm in length and the colour from light amber to dark brown (57-58).

They have a compact appearance without a sharp division between the head, thorax and abdomen. The head is roughly triangular and bears a pair of three segmented antennae, the mouth parts and in a number of species, a row of powerful teeth like spines collectively known as the genal comb, arranged on the lower border of the head, and a set of pronotal combs on the thorax. However, the rat fleas are devoid of both these combs. The mouth parts are adapted for biting, piercing and sucking blood, which forms the only food for both sexes. The thorax of the flea is compact and consists of the pro, meso, and meta-thorax without any wings. The legs are long and powerful and are adapted for the purpose of hopping and jumping. The abdomen consists of 10 segments, the 9$^{th}$ and 10$^{th}$ being modified for sexual functions. The 7$^{th}$ segment in both sexes bears a pair of setae known as the antepygidial bristles, so named because the 9$^{th}$ segment bears the pygidium which is a pin-cushion like structure with a sensory function. In the female, the abdomen has a rounded terminal outline whereas in the male it has a rather cocked up appearance. The body and the legs are provided with stiff setae, which give the insect a bristly appearance. The tapering pharynx continues into the oesophagus leading into the conical proventriculus. This is lined with closely set, backwardly directed rods converging towards the centre. These rods are pressed together during the act of sucking blood to prevent regurgitation of the stomach contents. This is an important structure involved in the transmission of the plague bacilli.

### Life History

The flea undergoes a complete metamorphosis through the successive stages of egg, larva, pupa and adult (Fig - 2). When the female is ready to lay eggs it leaves the body of the vertebrate host and lays eggs in dark place in the host's nest, lair, rubbish, debris, accumulation of dust, in cracks or crevices in the floor of granaries etc. or under carpets in dwelling houses. During her lifetime of 6 months or a year, the female lays 300 to 500 eggs in small batches of about a dozen at a time. A temperature between 18° and 27°C and humidity about 70 percent favour egg laying. However, most of them complete their life cycle in one to two months. The eggs are just visible to

Fig - 1 : Adult rat flea

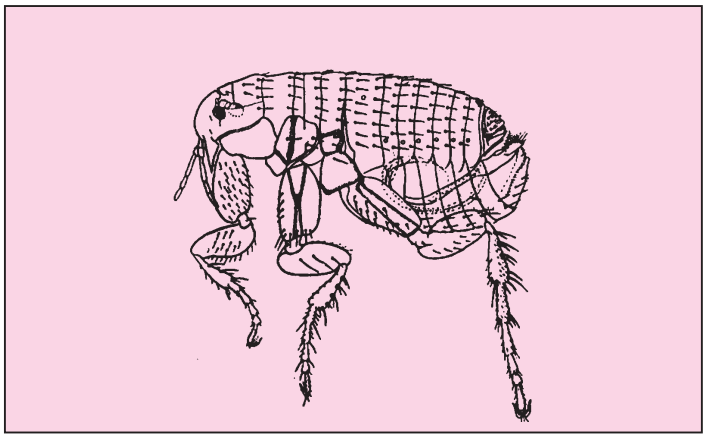
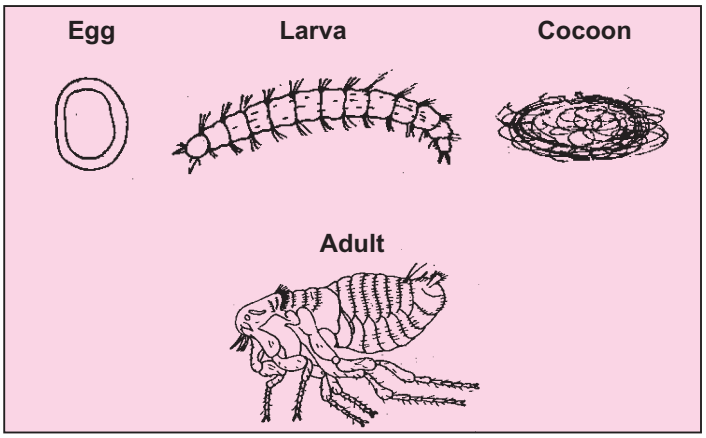


Fig - 2 : Rat Flea life cycle



the naked eye. They hatch in 2-10 days depending on temperature and humidity. The larvae are very active, slender, 13 segmented and yellowish white with a number of bristles. They feed on the excreta of rodents and on partially digested blood discharged from the faeces of adult fleas. Larvae complete their development in a week or two and enter quiescent stage, spin cocoons which are whitish, translucent and so loosely spun that the pupae can be seen within them. Hence the pupa closely resembles the adult which usually emerges within a week. The whole metamorphosis takes two to four weeks, but may need several months under less favourable conditions.

### Bionomics

The fleas are temporarily parasitic on their host as their immature forms are free living and even the adults frequently leave it between blood feeds which, however, are obligatory for both sexes. After the death of the host its body becomes cold and then the flea seeks a new host. Fleas feed frequently and much more than their actual requirements, as a result of which much of the ingested blood is passed out in a semi-digested state. Fleas are not strictly host specific and may attack unusual hosts when hungry or with rise of ambient temperature, when they feed more frequently. They are very sensitive to light and air currents. They always hide under dark objects and when blown up they at once get agitated. They are able to jump up to 16 cm and hop 30 cm.

### Vector Potential

The flea transmits mainly the zoonoses to man, chiefly from rodents and also from the dog and cats. The most important microorganism that is conveyed to man from rat is the *Yersinia pestis* causing bubonic plague. The most important vector species i.e. *X cheopis, X astia* and *X braziliensis* are also effective vectors. *Rickettsia typhi* is also transmitted from its rodent reservoir to man by the same rat fleas. Cat and dog tapeworms use fleas as their intermediate hosts for their development of cysticercoid stages. Cats and dogs become infected by the ingestion of infected fleas. Children also get the infection similarly due to accidental ingestion of the infected fleas. The South American and African flea, *Tunga penetrans* burrows under the soft skin in between toes and under the nail bed and causes a disease called 'chigger', 'jigger' or 'chigoe' in endemic areas.

### Flea Control

Chemical control of fleas is one of the best methods of flea control. These are effective against both adult as well as larval fleas. The areas or places generally frequented by fleas are treated like rodent burrows and rat runs. The insecticidal treatment is either done in the form of residual sprays, dusting or treatment of rodent burrows. Dusting is done by applying a patch of insecticide dust of about 20-25 cm wide and 0.5cm thick in all infested areas. For rodent burrows, 30g of insecticidal dust is used. In Plague susceptible areas, treatment is undertaken when flea index exceeds 1. However, during an outbreak no rodent control activity is undertaken. In the event of a Plague case occurring, immediate treatment of the patients dwelling and of other dwellings within 200 m is undertaken (59-66).

#### Vector Control

Due to development of insecticide resistance, prior susceptibility tests should be carried out to find out the most effective insecticide. Indoor residual spraying at the lower one metre of the wall surface and adjacent floor area is effective. Patch dusting also brings about marked reduction in flea density. For this, dusts of Propoxur (1%), Malathion (5%) or Carbaryl (5%) may be applied at a dosage of 2 to 3 g per $m^2$ of surface area under grain bins, on rat runs, furniture, upholstery, rugs and bedding. The dust of Deltamethrin (0.05%) may also be used for dusting in rodent infested area.

#### Disinfestations

Disinfestations of pet animals like dogs and cats along with good environmental sanitation of the household and public places help in flea control. Pet animals may be treated with dusts, sprays or dips of Malathion, Propoxur, Permethrin or Pyriproxyfen. Animal premises may be sprayed with insecticides (Malathion, Deltamethrin, Pyrethrum etc) @ 4-8 l/100 $m^2$. Insecticidal treatment of animals and their premises should be carried out simultaneously.

#### Rodent control

It is an indirect method of flea control. Though a radically effective method during non-epidemic period, it is dangerous during epidemics, because the fleas leave dead rats quickly and start attacking human beings. However, a constantly sustained campaign keeps the rodent population down and aids significantly in keeping the flea index constantly low. In general, during control of urban plague, insecticides to kill rat fleas should be applied a few days earlier or at least at same time (and not after) when rat poison baits are being applied.

#### Personal Protection

This is achieved by the use of protective clothing such as wearing long trousers, socks and shoes. Use of a high charpoy with the net, and application of repellents DEET are necessary precautions while in endemic or epidemic areas of flea borne disease. Using flea collars for pets are effective means of keeping them free from infestation.

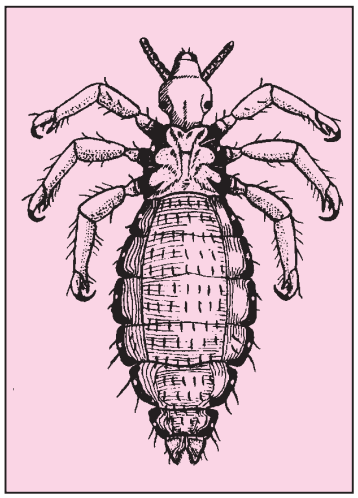
## Human Lice

Human lice are true ecto-parasites of man. There are three species of human lice viz. *Pediculus capitis* (head lice), *Pediculus humanus* (body louse) and *Phthirus pubis* (crab or pubic). All stages, females as well as males are haematophagous, however, only body louse has been incriminated as vector. The head louse infests the hair on the head and may be found in the neck region and behind the ears. The body louse infests the hairs of chest and axilla, seams of clothing in contact with the body, and sometimes linen. The crab louse infests the hair of the pubic region and occasionally invades eyelashes and eyebrows.

### Morphology

Lice are small, dorso-ventrally flattened, wingless insects with simple metamorphosis (Fig -3). They are permanent obligatory ecto-parasites living entirely on mammals. The mouthparts are of a sucking and piercing type. They have no eyes. The legs are short, stout, and thick with claws for grasping hairs and fibres. In the female the last abdominal segment is bilobed and in the male it is pointed from which the aedeagus (penis) projects. *Phthirus* resembles *Pediculus* in its general morphology, but its body is almost circular, all the three pairs of legs of *Pediculus* are equal whereas in *Phthirus* the first pair is less developed; *P capitis* has a smaller and deeply pigmented body, while that of *P humanus* is larger and non-pigmented. Abdominal segments of *P humanus* are rounded with shallower inter segmental indentations while those of *P capitis* are clearly marked and deeper. Antennae and legs of *P humanus* are longer and thinner than those of *P capitis* (67).

Fig - 3 : Head Louse



**Life History**

The life histories of all the three varieties are similar. After fertilization, the female lays eggs either on the hairs or under clothing chiefly along the seams of the vests, pants and shirts etc. They are firmly cemented to the hair or seams of the clothing, singly or in groups. Under optimum favourable conditions the louse lays 4 to 9 eggs in each batch. Total number of eggs laid during the life span of 4 to 5 weeks may be 300 in a body louse, 150 in a head louse, and 50 in a crab louse. The immature stages called nymphs begin sucking blood at once and throughout their development feed frequently during the day and night, mostly when the host is quiet. There are three nymphal stages and the young ones resemble the adults except in size. It takes about 18 days between hatching of the eggs and appearance of the adults.

**Bionomics**

Lice like warm and moist environments; 38° C is the optimum temperature. Higher temperature and death of the host are detrimental and make lice leave the body of the host. The average life of a louse is 30 to 50 days. Females live longer than the males. Once lice are acquired by a human host, their multiplication depends on the neglect of personal hygiene. Following factors are responsible for the dissemination of lice.

(a) Close contact with lousy persons; sharing the same bed and clothing in the household, barracks, underground shelters etc. In fact any prolonged crowding of human beings in unsanitary surroundings will spread lousiness. Hence lice and louse borne diseases are closely associated with wars and disasters among prisoners and refugees.

(b) Indirect contact - for example exchange of beddings, clothing, blankets, towels, hats, combs and brushes.

(c) Hair bearing eggs from lousy persons scattered in public conveyance are picked up from the seats and cushions of railways carriages and buses etc.

(d) Head lice easily pass from one child to another in school by close contact while playing and use of common combs.

(e) The pubic or crab lice spread through sexual contact and sometimes from toilet seats, beds and by close personal contact. Small children may become infested with crab lice on their eyebrows and eyelashes from their mothers or other close contact.

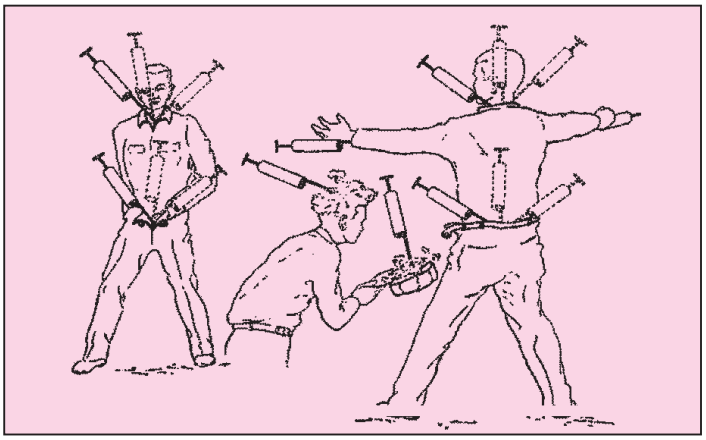
**Vector Potential**

Body lice are responsible for the transmission of *Rickettsia prowazeki,* causing Epidemic typhus, *Bartonella quintana* causing Trench fever, and *Borrelia recurrentis* causing Relapsing fever. The presence of lice on any part of the body is termed 'pediculosis' which causes irritation with loss of sleep and scratching which may lead to secondary infections. The skin of a heavily louse infested person becomes hardened and deeply pigmented and a condition known as 'Vagabonds' disease or melanoderma is developed.

**Prevention and Control**

Louse infestation should never occur among troops under static conditions where ample facilities for bathing and washing are provided and their regular use ensured. In mobile operations, however, when it may be difficult to provide these facilities adequately, the danger of louse infestation becomes imminent, particularly when contact with local civilians, refugees and P.O.W. is unavoidable. In order to prevent lousiness amongst troops, their contacts with refugees and local civilians should be reduced to the minimum. Regular hot baths and washing of clothes should be ensured. For this purpose field bath and laundry

Fig - 4 : Insecticidal dust application against body louse



units may be required.

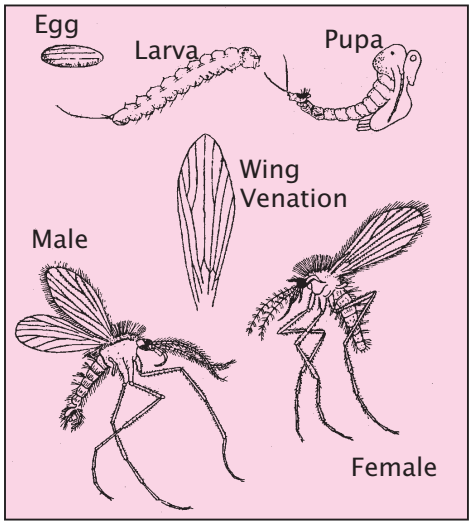
In the past, during mobile operations use of anti louse powder which has 10 percent DDT was used for reduction of infestation in a controlled community, by dusting the lousy individuals and garments. Currently, the insecticides of choice are Permethrin dust (0.5%), Propoxur dust (1.0%) for body louse and shampoo formulations like Phenothrin (0.2-0.4%), and Permethrin (1%) for head lice infestation. For mass treatments against body louse, dusts should be applied through neck openings, up sleeves and from all sides of the loosened waist of trousers (Fig - 4). Socks, head coverings, the inner surfaces of extra garments and bedding should also be treated.

For application on hair, the hair of the infested persons should be wetted thoroughly before application. Massage the shampoo thoroughly on the head and leave for 10 min. Thereafter rinse the shampoo from the hair, towel dry hair and use lice comb for removing dead lice. Treated uniforms with pyrethroids may be helpful against body lice in Armed Forces settings (68-71).

## Sand flies

The sand-flies belong to the subfamily Phlebotominae of the family Psychodidae. Species of three genera *Phlebotomus, Lutzomyia and Sergentomyia* are only haematophagous, whereas the former two are important as they are vectors of many diseases. The medically important vector species in India include *P argentipes, P papatasii, P sergenti and P braziliensis.*

Fig - 5 : Sand fly




### Morphology

The adult sand-fly is a small, greyish yellow to brown insect about 1.5 to 4.0 mm in size (Fig - 5). The insect is typically characterized by large conspicuous eyes and stilt like legs. The entire body is densely covered with hair. The antennae are long filamentous and give a beaded appearance. The mouth parts are very short and are adapted for biting and piercing in the females. The thorax is markedly humped and bears a pair of lanceolate wings held erect over the body when the fly is at rest. The wings are densely hairy and the second vein branches twice, the first branching in the centre of the wing and second at the margin. Legs are long, slender and used for hopping as sand-flies are poor fliers. The abdomen consists of 10 segments; the last two are modified for sexual functions. The abdomen of a female is rounded posteriorly; in the males it is modified and bears claspers (1-4, 8).

### Life History

The sand-flies prefer to breed in dark places rich in organic matter and moisture. Sand-flies lay torpedo shaped eggs in small batches which hatch out in one or two weeks under optimum favourable conditions. The larvae feed on organic excrement of lizards and mammals and other decaying material. Its life span is from 2 to 6 weeks, depending on the temperature and humidity. The larva bears two anal spines. The pupa is naked and requires about 10 days for development, after which the adult emerges. The total period required from egg to the adult stage is about 4 weeks under favourable conditions. In the tropics the breeding goes on throughout the year. In north India, they appear about the middle of March and persist until November, with their maximum density in March and April.

### Bionomics

The female has piercing mouth parts and is a blood sucker. Some species feed on cold blooded animals such as lizards and snakes; others feed on warm blooded animals including man. The males live entirely on plant juices or similar fluids from other available sources. The adults are weak fliers and generally confine themselves up to 50 yds from their breeding place and are not found resting beyond 3 ft on the wall. After fertilization and a blood meal the female lays eggs in shady, damp and warm places with sufficient supply of organic matter such as insect remnants and faeces, and excrements of tiny animals which form the future larval food. Such conditions are found under stones, in stables and poultry houses, around soakage pits, grease traps and water sinks, in hollowed trees and rodent burrows, bases of walls and embankments.

### Vector Potential

Sand-flies are responsible for the transmission of various species of Leishmania causing Kala-azar or Visceral leishmaniasis, Oriental sore or Cutaneous leishmaniasis, and Espundia or Mucocutaneous leishmniasis (naso-oral). Sand-flies also transmit the virus of sand-fly fever, also known as papatasi or Phlebotomus fever and the re-emerging viral disease Chandipura disease. It also transmits *Bartonella bacilliformis* or Oraya fever also known as Bartonellosis or Carrion's disease. In addition, the sand-flies have biting nuisance causing skin reactions (Herara) in sensitized persons(72-74).

### Phlebotomus Control

(a) Prevention of Breeding

This is primarily achieved by extremely good environmental tidiness. Places providing humidity, darkness and organic matter should be dealt with by removing all collections of rubble and heaps of rubbish; obliterating all cracks and fissures in the floors of buildings and indoor constructions, sides of culverts, gutters, nullahs, cattle sheds and poultry houses which

are common breeding places for sand-flies. Cracks and holes in the walls up to a metre from the ground should be sealed by plastering; the earthen floor of cattle sheds should be rammed down and made hard to make it difficult for the larvae to burrow. Empty buildings should be kept in good repairs; soak pits and grease traps should be well maintained.

(b) Antilarval measures

Anti larval measures are generally difficult to undertake as identification of larval breeding sites is difficult. Even if insecticidal control is planned, it has been found to be of little importance in the control of sand flies.

(c) Anti-adult Measures

Anti adult measures are based on the principle that sand-flies make short flights with relatively long pauses on entering or leaving any place or shelter. Therefore, any surface treated with residual insecticide on which the flies rest will have a lethal impact. The anti adult measures are the same as followed under the National Programme for Indoor residual spraying against mosquitoes; this strategy has proved to have a dramatic impact on the density of sand-flies in the area. If outdoor resting sites have been identified, they can also be sprayed with residual insecticides. Outdoor fogging may provide additional benefit in reduction of Sand-fly density.

d) Personal Protection

Use of repellents viz. DEET is one of the most efficient methods of preventing bites from sand-flies; the repellents may be applied topically or sprayed on the uniforms. A sand-fly net is useful, but it reduces air movements and causes great discomfort. Use of insecticide treated mosquito nets has been found very effective in protecting against bites of sand-flies. Personal protection may also be achieved by wearing shirts with sleeves rolled down and buttoned at the cuffs, and long trousers with socks tops drawn over the trouser cuffs and or anklets worn over them during evenings and nights.

e) Other Measures

**Strategies for control of sand-flies**

**Indoor Residual spraying**

As followed under National Programme for Mosquito Indoor Residual spray in sync with insecticide susceptibility status in the particular state or area.

**Personal protective measures**

Use of repellent DEET as topical application or as sprays on clothing/ uniform. Use of other insecticide treated material like bednets, curtains and insecticide treatment of clothes.

**Treatment of animals**

Earlier practice of culling of dogs or killing of rodents is no more undertaken. Dogs are treated by dipping in insecticide solution (Deltamethrin 50ppm) or applying insecticide solution (1-2 ml of 65% Permethrin or Imidacloprid 10%). Even insecticide treated dog collars and treatment of non-reservoir animals reduces transmission of Leishmaniasis.

**Space spraying**

Thermal and cold fogs can be undertaken as done in

These include encouragement of gardening (cultivation of ground) and planning of embankments with native aromatic plants. Free cross ventilation and ingress of sunlight keeps the sand-fly out of barracks, bashas and bunkers. Electric fans are useful as the air current drives them away. Electric light shades smeared with vaseline traps a large number of sand-flies. Siting of human habitation beyond 50 yards of the breeding place is an effective method of preventing transmission of sand-fly

Dr (Mrs) Rina Tilak

# Ticks and Mites

Ticks and mites belong to class Arachnida, which are characterized by the presence of two distinct body parts - cephalothorax and abdomen and four pairs of legs. Antennae are absent and eyes may or may not be present. There are two pairs of mouth appendages, the chelicerae and the pedipalps. The palps are sensory organs and the chelicerae are the actual cutting organs. Metamorphosis is incomplete and the adults resemble the nymphs except for the fact that nymphs lack genital aperture while in the adult the sexes are distinct. The larvae are morphologically distinct with three pairs of legs.

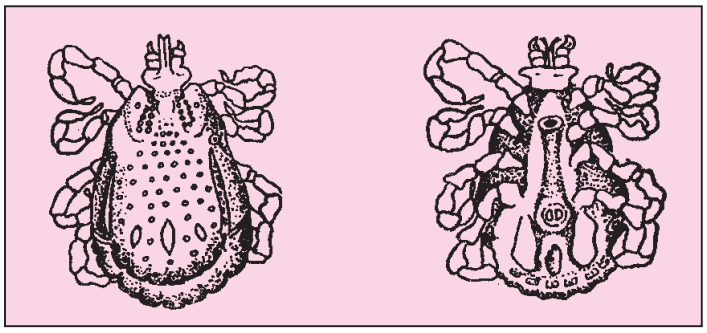
## Ticks

Ticks belong to the super-family Ixodoidea having more than 500 species of World wide distribution.

### Morphology

They are distinguished from other acarines by their relatively large size and absence of prominent hairs on the body. They are oval in shape and of varying colours, dorsoventrally compressed and slow in their movements. Females are larger than males and are capable of great distention. Both sexes thrive on blood alone and lead an intermittent parasitic life during a major part of their life cycle. The wide host range includes the cold blooded as well as the warm blooded animals. They are free living on the ground in between various moults during development. There are two families, Family Ixodidae which is the hard tick and Family Argasidae which is the soft tick. The hard tick is the jungle tick while the soft tick

Fig - 1 : Hard tick



is a domestic or household tick like a bedbug (1-4, 75-80).

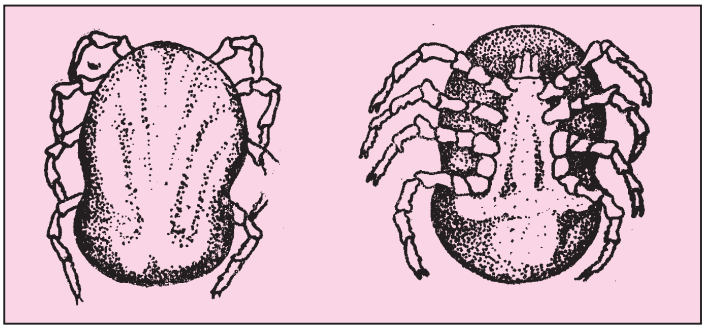
Ixodidae or Hard Ticks

The dorsum of the adult male is covered by a dark shield, like that of the tortoise, called the scutum. This may be ornate with grey or white 'patterns'. In females and immature males it covers only the anterior part behind 'the capitulum' which is the false head actually formed by the mouthparts anteriorly and, therefore, visible from above (Fig - 1).

Argasidae or Soft Ticks

These are oval with leathery cuticle, devoid of scutum.

Fig - 2 : Soft tick



Their mouth parts are placed ventrally and hence not visible from above and they possess no festoons (Fig - 2).

### Life History

All species of ticks pass through four stages during their development viz., egg, larva, nymph and adult. The total period required for full development of a tick is from six weeks to 2 years. Fully engorged fertilized female drops off to the ground and lays eggs in cracks and crevices in the soil under stones, or among roots of shrubs and grass and such other sheltered spots. Number of eggs laid varies from a few hundred in some species to several thousand in others. Hard ticks deposit all their eggs in a single act of oviposition after which they die. Eggs take a few weeks to several months to hatch. Larvae are six legged and do not feed for about a week after emergence. Thereafter, they become hungry and active and get attached to their animal hosts. They feed for some days and drop off when engorged and remain quiescent for digestion of blood. After the first moulting the nymphs emerge with their fourth pair of legs and seek a new host, feed and again drop off. They again moult and become sexually mature. Hard ticks have only one nymphal stage but soft ticks may have as many as five. Copulation takes place after the last moult; the male dies after fertilizing the female. The female engorges and then deposits eggs.

### Bionomics

A few species of hard ticks, mostly members of the genus *Boophilus,* spend the whole of their life cycle on the same host and are known as 'one host ticks'. Ticks of the Genera *Hyalomma* remain on the same host during the larval and nymphal stages but the adult form seeks a new host and is known as 'two-host ticks'. Ticks which feed on different animal hosts in the larval, nymphal and adult stages are known as 'three host ticks'. Medically important hard ticks of the genera *Ixodes, Haemaphysalis, Rhipicephalus* and *Dermacentor* are all three-host ticks. In soft ticks of the genus *Ornithodorus,* each stage of the five moults is completed on a different host; and adults may also feed intermittently on different hosts. Such ticks are known as 'multiple-host ticks'. Hard ticks are open jungle dwellers and thrive on animal hosts; hence they do not attach themselves to human beings voluntarily, except when a

person comes across them accidentally. Argasidae, although preferentially parasitic on animals and birds attack man voluntarily. These are found in human dwellings and cattle sheds and attack man and animals during their sleep. They however, live away from their hosts, like bedbugs, in cracks and crevices and only emerge at night to feed on the host. They all can survive starvation for long time even for 2 or 3 years in case of Argasidae.

### Vector Potential

Ticks produce diseases in man by transmitting viruses, rickettsiae, spirochaetes and bacilli of infectious diseases and through toxin present in their saliva. Some of the factors which account for high vector potential are that they feed entirely on blood and are persistent blood suckers; while feeding they attach firmly and cannot be easily removed. They are resistant to varying environmental conditions as nymphs and adults are sclerotized and thus relatively protected from natural enemies. A wide host range always ensures certainty of enough supply of blood; high production potential and long life. The transstadial and transovarian transmission of infection helps in maintaining infection for several years. Ticks have the power to regenerate lost parts such as amputated legs and also the ability to repair mutilated mouth parts, which conserves them for long.

#### Soft Ticks

Soft ticks of the genus *Ornithodorus* transmit various types of spirochaetae causing relapsing fevers in certain parts of the world. *O moubata* is the vector of *Borrelia duttoni* in Africa; *O hermsi* and *O turicata* are the vectors in America. *O tholozani* has a very wide distribution over a large area from Iran to Central Asia. *O lahorensis* has a very wide distribution in Central Asia and North West India. In India they are found in Kashmir and are known as *O crossi.*

#### Hard Ticks

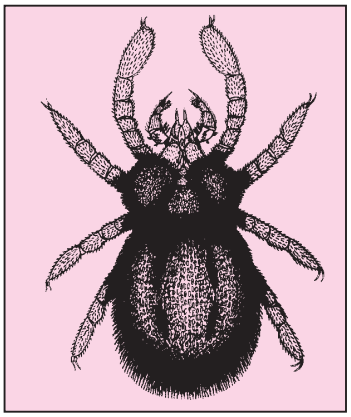
These are much more ubiquitous and produce larger varieties of human diseases. The most important of all are the various rickettsial infections transmitted by the hard ticks of the genera *Ixodes, Dermacentor, Amblyomma, Haemaphysalis, Rhipicephalus, Hylomma* and *Boophilus.* Viruses causing Kyasanur Forest Disease, Colorado tick fever and other Haemorrhagic fevers and Encephalitides are transmitted. These also transmit *P tularensis,* the causative organism of Tularaemia. Tick paralysis is an acute ascending flaccid paralysis due to an unknown toxin the ticks' saliva introduces through the bite of certain species of ticks of the genera *Dermacentor, Ixodes and Amblyomma.* It affects mostly children and young domestic animals in Australia, South Africa, North America, Southern U.S.A. and N.W. Pacific. Even a single tick bite may cause fatal paralysis. In certain cases, reaction from improper or partial removal of ticks or due to the bite itself may cause itching, swelling and ulceration at the site of the bite. Otoacarisis is an invasion of the auditory canal by ticks.

## Mites

Mites belong to the order Acarina and family Trombiculidae which comprises many hundreds of species of world wide distribution. They are found in great abundance in areas with hot, humid climate, thick vegetation and presence of small vertebrates like rodents. The foothills in subtropical and temperate regions offer them ideal conditions. In the tropics they are found even at heights in mountain valleys. These have also been found in the Alpine-subarctic terrain in the Himalayas as well as at the level of coniferous forest-glacial valleys in Pakistan. They are known by various names such as chiggers, harvest mites, Kedany or scrub mite. Important species of the genus *Leptotrombidium* are *L akamushi* which is distributed widely in Japan, Formosa, South East China, Korea, Malaysia and Philippines, and *L deliense* which is vastly distributed in the tropical regions of South East Asia, Indian sub-continent, Ceylon and Maldive Islands. In India, it is present in the whole of the Shivalik range from Kashmir to Assam, the Eastern half of the plains adjoining the foothill ranges, the Eastern and Western ghats and the Vindhyachal range in Central India (81-86).

### Morphology

Fig - 3 : Trombiculid Mite Adult



It has an oval body and eight legs and is densely covered with hair (Fig - 3). The mouth parts consist of a pair of chelicerae and a pair of palps, together giving the mite an appearance of having a false head. The adult resembles the nymph except that it is larger and more densely covered with hairs; 'Kedany' meaning hair in Japanese language. A cluster of 5 to 6 larvae is as big as a pin-head. When the cluster detaches, a scab is formed showing an evidence of recent infestation. The larva is ochre-yellow to orange-red in colour with a circular body bearing three pairs of legs which have six or seven segments and branched hairs on the body and on the legs. On the dorsal surface and placed well anteriorly, there is a roughly triangular dorsal scutum which bears 5 setae; the rest of the dorsal surface bears more than 30 setae arranged in definite rows. They are found in nature in the interior of ear cusps or on rumps of rats, mice, shrews, bandicoots and other small mammals, reptiles and birds in orange coloured clusters of as many as 50 to 200 larvae (75-80).

### Life History

The stages in the life history of a mite are egg, larva, nymph and adult. The eggs are laid singly on the surface of the soil. After about a week the egg-shell splits and the larva, although exposed, remains quiescent in the egg-shell for about a week or more (deutovum stage). After this the larva leaves the egg-shell and becomes very

active. Moving quickly over the surface of the soil and low lying vegetation, it seeks a suitable host such as rat, mouse, bandicoot and shrew and so on. Only the larval stages are parasitic. While feeding it buries the whole length of its chelicerae in the host's skin and injects an irritant secretion which causes tissue lysis. The larva feeds on the lymph and the tissue juice but not on blood. Therefore, the orange red colour of the larva is not due to ingested blood. The larvae feed for 2 to 3 days and then drop off to the ground concealing themselves in loose soil. They then enter the next quiescent stage known as 'nymphochrysalis' which lasts for another 7 days. The 8 legged nymphs develop within the larval integument. The nymphal stage lasts 14 days. During this period it is active on the soil and then enters another quiescent stage, known as the 'imagochrysalis'. After about a week or ten days the adult with sex differentiation emerges. Generally it takes 6 to 12 weeks for its development from egg to adult. The nymphs and adults are never parasitic. They exist free in the soil near the surface and feed on other small soil inhabiting arthropods and their eggs.

**Bionomics**

The whole life cycle is influenced by temperature, humidity and availability of food to the free living adults and nymphs and for the parasitic larvae. The environment, microclimate, vegetation and fauna of a place determine their abundance. The patches of ground known as 'Mite Islands' are characterized by thick vegetation cover, mainly the scrub jungles or other tall grasses, offering protection from direct sunrays and desiccation, 100 percent humidity at ground level and ambient temperature between 35˚C to 40˚C. Such conditions also provide sanctuaries for small vertebrate life such as rats, mice, bandicoots, and shrews which are hosts for larval mites. These animals are also the reservoirs of rickettsiae for which the trombiculid mites are vectors. Hence these mite islands may also become typhus endemic foci. Mites are most active during the whole rainy season and their prevalence in such mite islands in India is related to the intensity and length of the monsoons. In dry season, the adults migrate deeper into the soil, the egg laying ceases and the mite islands shrink; during monsoon, there is prolific activity and the mite islands expand. Patchy distribution of mite islands and their selective choice of locality explain the patchy nature of typhus endemic foci.

(a) The typical terrains favourable for the mite to thrive and propagate are as under:

(b) Man-made rural and urban wastelands like overgrown clearings produced by shifting cultivations.

(c) Domestic sub-urban waste lands produced around neglected patches in and around villages and even big towns, such as neglected gardens and plantations or overgrown clearings therein; deserted villages are heavily infested.

(d) Around the edges of moist depressions; water meadows; grassy but not swampy river banks; and moist sites such as seepages along over ground canal areas.

(e) The hedgerow types of features ranging from a simple bushy hedgerow to belts of forests following water courses and ravines which are commonly left in deforested areas in and below the foothills.

(f) The scrub at the outskirts of the forests" and low lying patches overgrown with elephant grass in sunny clearings inside thick forests.

**Vector Potential**

Larval mites belonging to several genera attack man but only the Genus *Leptotrombidium* contains species of medical importance. In India, *Leptotrombidium deliense* is the vector of *Orientia tsutsugamushi* causing Scrub typhus; in Japan the closely related variety *L akamushi* (kedani mite) transmits Scrub typhus. Rickettsiae taken up by larvae are carried through its nymph, adult and then its eggs. The larvae hatching out of these infected eggs are capable of transmitting the rickettsiae to the next host. The infection is thus transovarially transmitted for some generations and hence the mite also acts as a reservoir of infection. Larvae feed only once during the life time. Therefore, transmission of infection occurs in second or subsequent generations(1-4, 81-86).

**Control of ticks and mites (87-94)**

Insecticidal Control

**(a) Area Treatment**

This is the only reliable Acarine control method. Before the application of an insecticide to the areas infested with hard ticks and mites, clearing of bushes by cutting is advantageous. If possible a bulldozer should be employed. When the top soil is bare and dry, an area becomes considerably safe and more suitable for insecticidal action. Initial coverage of the area should be thorough. It may require repetition after 8 weeks and occasionally a third time during the hot-humid season. If men have to go to some nearby stream for bathing or washing their clothes, the selected area should be similarly treated, as the stream edges covered with vegetation are favourite sites for acarines. Malathion/ Fenthion may be used for treatment of area.

**(b) On Vegetation**

Control of ticks on vegetation can be achieved by insecticide dusting or spraying from the ground or air at the dosage varying from 0.5 to 2 kg/hectare. In woody and bushy areas, the dosage is increased proportionately. Malathion, Fenthion, Propoxur and Permethrin are suitable.

**(c) Premises**

Against soft ticks, applications of insecticide to floors and walls of infested premises on alternate days, after initial scraping and scorching, are necessary. Treatment for 2 weeks before occupation gives good control. During this period sweeping of floors should be discontinued. Such a series of applications repeated 6 weeks afterwards gives adequate protection to troops billeted in such huts. The

insecticides should also be applied to beds, mattresses, rugs and furniture. In known tick infested areas, particularly where there is a history of relapsing fever, infested caves, huts and houses should be avoided as far as possible. Organophosphorus compounds like Malathion and Fenitrothion or Carbamate compounds like Propoxur can be used either as 0.5 - 1.0 % spray or as 5 - 10 % dust.

**(d) Domestic Animals**

Dogs and other domestic animals can be freed of ticks by a wash or spray containing, 2 % Malathion, 1% Propoxur, Deltamethrin (0.025%) etc. Only half these concentration should be used if the animal is to be dipped; and the entire animal should be immersed except the head. Dusts containing 5 % of Malathion, Propoxur (1%), Cyfluthrin (0.1%), Deltamethrin (0.05%), Temephos (2%), Fenthion (2%) etc. may also be used. The premises which animal visits or is tied in, should also be treated.

Personal Protection

The repellant materials used for personal protection against ticks and mites are Dibutyl-phthlate (DBP) & Diethyltoluamide (DEET). These are more effective when applied to the clothing than to the skin. The effect may last for nearly six washings or weeks which ever is earlier. However, if it is ironed, the concentration falls below effective limits. DEET may be used for application on the exposed parts of the body to reinforce the use of protective clothing treated with DEET/ DBP, when working in an uncontrolled area, or under acute emergency when application of repellent on the clothing prior to entry in an unknown or uncontrolled area is absolutely impossible. Another indigenously produced repellent DEPA (Diethylphenyl Acetamide) has also been approved for use in the Armed Forces as a repellent against ticks & mites. It can be applied on the uniform as well as on the exposed parts of the body. The persistence of DEPA on ironing of clothes is superior to DEET, whereas for topical application both are equally effective. Trials in Indian Armed Forces have adequately demonstrated the efficacy of these repellants.

Wearing shirts with rolled down sleeves tightly buttoned at the cuffs, the lower ends of trousers tucked in socks and wearing of anklets considerably reduces the risk against ticks and mites.

Clothes for drying should be hung on ropes especially fixed for the purpose and not on the vegetation. Bush and grass on the periphery of a camp becomes infested by larval mites and ticks brought in by the rats migrating into the camp. Therefore, purposeless wandering in such areas should be discouraged.

More mites and ticks are picked up by standing or sitting than by walking over the infested ground. Therefore, while on patrols and marches it is unsafe to lie down on a grassy ground. The immediate vicinity of a tree base should be avoided for resting, so also the green edges of a stream or an irrigation channel. Open grassy grounds should be avoided in tick infested areas.

Before retiring at night or after leaving a tick infested area one should take a bath and carefully search one's body and clothing for presence of ticks. If a tick is found attached to the body it should be removed immediately, because every added moment of its attachment increases the danger of transmission of infection. Pulling of a tick has the danger of breaking off its parts, therefore, it should be removed by making the surrounding skin taut, slipping the point of a flat needle or a scalpel under the mouth parts and then removing the mouth parts by raising the point of the needle with a minimum of tissue damage. Iodine or any other antiseptic should then be applied to the site.

Use of mosquito net gives some protection against soft ticks.

Anti-Rodent Measures

Persistent anti-rat hygiene is of great value in reducing the risk of diseases conveyed to man through ticks and mites. The main object should be to reduce ingress of rodents by proper disposal of camp and kitchen refuse and removal of overgrown vegetation and rubble which afford them shelter. Rat destruction requires forethought; because, if the feeding of larval ticks and mites is interrupted by the death of rodent hosts, a number of released acarines may reattach themselves to another host, which may be man. Active rat destruction may be adopted when the first infestation is at its peak i.e. a month or so after the rain starts. It is better to trap and then destroy them so that their parasites do not escape. When dead rats are collected from any endemic foci the soil under and immediately around them should be treated with insecticide. Soft tick control is further achieved by rat-and-tick-proofing of dwellings. All cracks and crevices, fissures and other points of ingress should be closed and all doors should be made tight fitting to keep away rodents.

Camp Siting

Before any area in the known endemic tract is selected for camping or before the insecticide treatment is undertaken, the degree of risk should be assessed by determining the prevalence of adult and larval Acari.

**(a) Mite Survey**

Superficial layers of earth are scraped from moist areas around the roots of scrub and mixed with water in a bowl. Adult mites resembling a figure of 8 will float in a few minutes. Pieces of dark cardboard are placed edge wise forming tent fashion structures on the ground at intervals, larvae will crawl up the cardboard and congregate at its top edge within a few minutes. Rats caught from the area should be examined for the clusters of larvae or scabs in ear-cusps and shrews for clusters on their rumps. If the ears or rump is infested, they should be carefully cut with fine scissors and placed in 70% alcohol vials.

Rodent trapping is done in field (Op areas, Camps, fringe areas) by specialized traps called Sherman traps, whereas in peri-domestic areas Wonder traps may also be used. The trapping procedure is as follows:

(i) Number the Sherman traps with marking pens starting from 1-40.

(ii) Prepare flags bearing the same numbers i.e. 1-40 with cardboard pieces as per specimen provided.

(iii) Carry freshly prepared pakoras for the traps.

(iv) The laying of traps should be carried out in the late afternoons and should be completed before dusk.

(v) Personnel involved in laying/ collecting of rodent traps shall wear trousers tucked in boots/anklets and full sleeved shirt. Wear heavy duty gloves while laying/ collecting traps and use repellents on exposed skin.

(vi) Identify suspected mite islands (a patch of ground with vegetation, temp in the range of 27+ 50 C, Relative Humidity in the range of 80-100% and which provides an ideal place for rodents to hide).

(vii) Check the working condition of Sherman trap before placement.

(viii) Place pakora in traps, ensure it is placed at the closed end of the trap.

(ix) Place the trap in the bushes or where rodent is likely to be found. Place the trap with its opening facing the likely direction of rodent entry. Ensure the trap opening is not obstructed. The trap should be placed on flat ground so that the trap does not tumble if approached by rodent or any other movement in the area.

(x) Plant flag bearing the same number as the trap next to the trap so that it is visible from distance.

(xi) Tie a bandage to the bush to indicate the trap placement in the poor light conditions of dawn- the time for trap collection.

(xii) Make a spot map of trapping area with the trap numbers indicated on the map.

(xiii) Collect the trap before dawn next day.

(xiv) Use heavy duty gloves and a torch in the mornings for collection of the trap. (All protective measures as followed earlier should be ensured. If a trap is closed, do not try to open the trap, put it in a cardboard carton for transportation to the lab) (If a trap is open, fold it and collect it).

Once the traps are brought to the laboratory, the rats are transferred in to large polythene bags, anaesthetized and thereafter ectoparasite screening is undertaken and the remaining procedure as enlisted earlier is followed. For further details, the Dept of Community Medicine, AFMC, Pune may be approached.

**(b) Tick-survey**

Ticks are collected by sweeping flags made of white flannel across the vegetation. The larvae, nymphs and adults get attached to them and are easily detected against the white background of the flag. They should be picked up by forceps and placed in 70% alcohol vials. Parasitic stages of ticks on various animals can be collected by catching rodents, shrews and other animals.

(c) While carrying out the survey, one must protect oneself adequately with protective clothing and repellents. For confirmation of identification, the chopped ears of rats and shrews with attached larval mites and adult ticks should be forwarded to the Dept of Community Medicine, AFMC, Pune in 70% alcohol (methylated spirit) vials in separate screw capped bottles. A white paper label showing date and place of collection written with lead pencil should be placed inside the bottles.

(d) As a rough guide it can be said that the Scrub typhus risk in any area during the monsoon is considered low if only up to 10 % of the rats have been found infested on consecutive two surveys unless cases have occurred already; if 20-40 percent of rats have been found infested the contraction of infection is very probable; and if 50 percent or more rats have been found infested the risk is high and the site should be considered as dangerous. Similarly, even if a single rat is found infested with more than 100 larval mites the area should be avoided, being a very high risk area.

Dr (Mrs) Rina Tilak

## Some Annoying Pests

### Simulium Flies

Simulium flies are commonly known as Black flies. They have a world wide distribution. They belong to the family Simulidae, which contains over 1800 species; however, the important genera are only four, which bite humans and out of these four genera, Simulium is the most important.

#### Distribution

The members of this family are found from sea level to a height of 2000 m. In India, these have been reported from Kumaon Hills, Himachal Pradesh, Kashmir, Assam, Arunachal Pradesh, Manipur, Nagaland, Bengal, Bihar, Maharashtra, Tamil Nadu and Nilgiri Hills. In Arunachal Pradesh, they are known as Dimdam flies.

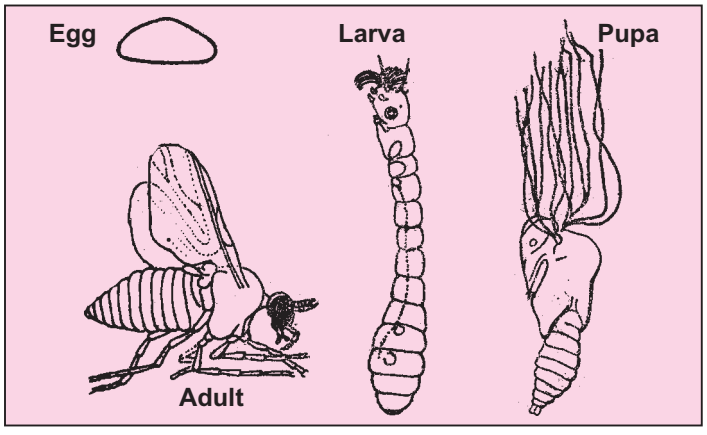
#### Morphology

The adults are small; stout bodied with a humped thorax and blood sucking flies varying in length from 1 to 5 mm. The colour varies from dark amber to bright yellow to orange. The name "black fly" is therefore a misnomer.

#### Life History

Simulium flies breed in fast flowing turbulent mountain streams and torrents because they require well aerated water. A female lives for 2 to 3 months and lays several batches of eggs under the rocks, stones, vegetation or debris submerged just below the water surface (Fig - 1). Eggs hatch in one to two days; in temperate zones the hatching period may be one week. The larvae are attached to submerged objects with their heads downstream. They feed on microscopic animals and plants and do not swim. The larva undergoes six moults in about 10 to 14 days in the tropics and 3 to 4 weeks in temperate regions. The silken pupa also is firmly anchored to the substratum. The pupal stage may extend from 4 to 5 days to 2 to 3 weeks. The imago emerges from the submerged pupal case and comes on to the water surface where it rests for a while and after sometime starts flying. In the tropics and subtropics breeding is continuous throughout the year. The life span of the adult is about three months (1-4).

Fig - 1 : Black Fly Life Cycle




#### Bionomics

Simulids are strong fliers. Their normal flight range is about 4 to 5 km. Flights up to 20 to 40 km with favourable wind are not unusual. Occasionally they fly in huge swarms. Both male and female simulids feed on plant juices, nectar and pollens of flowers; the females however, require blood meal for development of eggs and are voracious and persistent biters. They may enter through any opening in the clothing such as the sleeves or through the trousers lower opening for biting. They bite only by day in the open and are especially active on bright sunny days and retire at night to the neighbouring vegetation where the females mature their eggs.

#### Vector Potential

Several species of simulids are known vectors of Onchocerciasis, a filarial disease due to *Onchocerca volvulus* occurring in tropical Africa, Central America and Venezuela, where *S damnosum, S mettallicum and S neavei* are the vectors. In India, Simulids however, are not vectors of any known human disease. But the very annoying and persistent attacks in large numbers make working in the open virtually impossible. The immediate trauma caused by its bite produces a red haemorrhagic spot leading to papule formation. In certain cases, it may lead to secondary infections and ulcers like 'ulcus tropicum.' In sensitized persons allergic reactions like lymphangitis, lymphadenitis, rhinitis and fever may occur. Their bites are responsible for loss of livestock.

#### Control Measures

Control of the biting flies has been achieved by the use of larvicides and aerosol treatment. In the Onchocerciasis control programme in Africa, Temephos 200 g/l emulsion has been used as a larvicide with good results. BTI has also been used @ 0.54-0.72l/$m^2$ with great success. Aerosols and fogs produced by fogging machines are useful in killing adult flies. Clearing of vegetation around the perimeter also reduces the Dimdam fly nuisance. Other compounds like Permethrin and Etofenprox have also been evaluated. Use of protective clothing will prevent the flies from ascending up the sleeves and trousers or entering into the shirt front. Socks should be pulled over the bottom of trousers. Additional protection may be obtained by treating the clothing and the exposed parts of the body with any of the repellents such as DBP, Diethyl toluamide (DEET) or DEPA (95-96).

### Bugs

Bugs, belonging to the Order Hemiptera have been associated with man since antiquity. They have a world wide distribution and consist of two important families' viz. Cimicidae and Reduviidae. Family Cimicidae includes the 'bed bugs', *Cimex lectularius* of temperate regions and *C rotundatus* or *C hemipterus* of the tropics. Family Reduviidae includes the cone nose Triatomine bugs, also known as 'kissing' or Assasin bugs. In India, bedbugs have

a great nuisance value. The subsequent paragraphs will deal with Bedbugs, their bionomics and control.

### Morphology

Bed bugs are small; 5 to 6 mm long, dorso-ventrally flattened, wingless, dark brown insects with a mahogany tint. They have a very short and broad head attached to the thorax. The head bears the antennae and a pair of well developed eyes. On either side of the thorax, the stink-glands are situated which give off the nasty, pungent or offensive odour associated with this group (97, 98).

### Life History

A bed bug passes through the stages of egg and 4 nymphal stages. Metamorphosis is incomplete. The fertilized females lay flask shaped, operculated eggs singly, in hidden sites such as cracks and crevices in the walls and floorings, spaces in the wood work of furniture, behind pictures, mattresses, pillows etc. A female lays 2 to 10 eggs a day, a total up to 200 to 300 in her life time of 6 to 8 months. The eggs usually take 5 to 10 days to hatch. The nymph starts feeding within an hour or two after emergence and continues to feed intermittently in all the further stages of development. There are four nymphal stages, each lasting 6 to 7 days; at the end of each a skin is cast off. It takes 4 to 6 weeks for the development from egg to adult.

### Bionomics

Adults can subsist without food for months under favourable conditions. Bugs are disseminated through traveling bags, laundry, furniture, bedding, old charpoys, soiled clothing, infested household goods, public conveyance and public gathering places. Bed bugs, like lice have been companions of man for centuries. Hiding in cracks and crevices during the day, they become active during the night and come out of their hiding places to feed on hosts, and engorge completely in 3-6 min. They may travel long distances for sucking blood. They are gregarious, occurring in great assemblages. All stages are parasitic and thrive on human blood.

### Medical Importance

Bedbugs have all along been suspected for the transmission of various diseases but so far they have not been incriminated for any human disease. They are of public health importance primarily for their biting nuisance and demoralizing effect on the troops as their infestation may cause insomnia, pruritis, dermatitis, allergy and anaemia.

### Prevention and Control

The first and foremost principle for the prevention of bedbug infestation is to maintain a very high standard of hygiene. All furniture and belongings of new occupants should be thoroughly checked for the presence of bed bugs and immediate measures taken to prevent their multiplication by one of the appropriate insecticides. Residual insecticides applied directly into the hiding places control the bedbugs. Organophosphorus compound Malathion (2%) may be used, however, it is reported to be losing its effect at a number of places. In its place, Chlorpyrifos @0.5% may be used. Disinfestations of blankets, beddings, mattresses and mosquito nets may be carried out by subjecting them to heat at or above 70$^{0}$C. Synthetic pyrethroids like Bifenthrin (0.096%), Permethrin (0.125%), Cyfluthrin (0.04%) and Deltamethrin (0.03%) can also be used to achieve optimum results. Residual insecticidal spraying for malaria control undertaken systematically and methodically will also help in reducing the density of bed bugs as a collateral benefit. Pyrethroid impregnated bed-nets will also help in reducing the menace of bed bugs (8, 19, 99).

### Debugging

In the Armed Forces barracks, all furniture, charpoys, beddings, walls, floor and ceiling should be thoroughly inspected every week for the presence of bed bugs. The charpoy should be lifted to a height of about 1 metre by two persons holding it at opposite ends and gently dropped on the floor. This process repeated 2 to 3 times will result in the bugs falling on the floor from their hideouts. Whenever charpoys chairs and other items of furniture are found infested, these should be thoroughly sprayed with a residual insecticide. The charpoy need not be inclined against the wall nor the coir netting or niwar loosened. The cots should be thoroughly treated on all sides with insecticidal spray. All cracks and crevices should be fully flooded. The kit boxes, chairs, tables and other items of furniture may be similarly treated. The insecticide formulation may also be directly applied to the hiding places such as joints, cracks and crevices in the cots/chairs/tables and folds or creases in the mattresses and other items of beddings.

The studies carried out at the Armed Forces Medical College, Pune have shown that the slow drip technique involving the use of the common paint brush for treatment of the infested cots and other items of furniture is far superior as compared to the routine method of spraying with the compression sprayer. In this technique, the ready to use solution of insecticide in water is taken in a plastic mug of one litre capacity, a paint brush is dipped in the solution, and the solution so lifted is slowly drained into the cracks and crevices as well as the joint spaces from different directions. The process is repeated by turning the cot upside down so that all such hiding places are thoroughly flooded with the insecticide.

## Cockroaches

### Introduction

One of the most annoying pests encountered in an urban area are the Cockroaches. The common domestic species which infest buildings are *Blatella germanica,* the German roach; *Periplaneta americana,* the American roach and *Blatta orientalis,* the oriental roach. The German cockroach, although a native of Europe, is the most widely distributed species.

### Morphology

Cockroaches are dorso-ventrally flattened creatures with colour varying from dark brown to black. The head is flexed backward. The antennae are filiform. Most of the species have two pairs of wings. In some of them, the wings are vestigial. In the oriental cockroach the wings are

short in the females but much developed in the males which possess the power of flight (1-4, 100).

**Life History**

They have simple metamorphosis and lay 16 to 48 capsulated eggs. The eggs hatch out in 2-6 months in most of the species, depending on temperature and humidity. The young ones are almost white and wingless. They moult a number of times and the total developmental period may be 6 months to 1 year. They may produce three generations in a year and usually have a long life span.

**Bionomics**

They breed in warm moist places in the humid microclimate of the kitchen and pantry laying eggs in cracks, crevices and sinks. They can run swiftly by means of long well developed legs. They are highly gregarious and primarily nocturnal in habit, but may be seen during the day as well. The mouth parts are adapted for biting and chewing and they are omnivorous, feeding on any material meant for human consumption like meat, milk, grains and sugar.

**Disease potential**

They are filthy, annoying pests imparting a nauseating 'cockroach' odour to the food articles and utensils they come in contact with and the places they infest. They destroy food, damage fabrics, books and other household articles. They may enter houses and other buildings from outdoors through infested containers or from adjoining rooms and apartments or through drains. On account of their indiscriminate roaming and feeding habits, they may spread diseases like cholera, typhoid, dysentery, protozoal cysts, intestinal worms etc. by polluting food with filth carried on their legs and bodies (102, 103).

**Control Measures** (104-110)

(a) Prevention

(i) Good housekeeping is the key to cockroach control, whether in the home, restaurant, hotel or grocery stores.

(ii) All cracks and crevices should be properly filled up.

(iii) All areas should be kept thoroughly clean so that no food particles, debris, dust and rubbish remain to support and nourish cockroaches.

(b) Surveillance

(i) Use of sticky traps for surveillance.

(ii) Use of visual assessment method, whereby light is switched on late in night and the cockroaches counted for a stipulated time period, say five minutes. This method also indicates the hiding places in a room of the cockroaches besides indicating the level of infestation.

(c) Control

Cockroach infestation can be controlled with insecticidal sprays, dusts or baits. The insecticide should be applied thoroughly to runways, cracks, crevices, undersides of tables, and even under the table spreads, rear of sinks, meat safes and other harbourage areas. Use of 2-5 percent dust or 1-3 percent solution or emulsion of Organophosphorous compounds like Malathion or Carbamate insecticide such as Propoxur gives excellent results. To obtain a quick effect in heavy infestations or to drive them out from the hiding places a direct spray containing 0.3 % Pyrethrum or 0.5 to 1.0 % DDVP or Fenitrothion may be used. Small pills of flour containing boric powder left on dining table, food safes and pantry boards or under table cloth also kill cockroaches. Abermectin and Synthetic pyrethroids are currently being used for control. Newer insecticides, Fipronil and Imidacloprid have been found to be very effective in controlling cockroaches. Trials in Armed Forces have shown the efficacy of Fipronil in the control of German cockroaches. It needs to be taken note that chemical control with insecticides gives only temporary results and maximum efforts should be made to improve the environmental sanitation and housing conditions. Moreover, there are reports that the German cockroach has become resistant to several Organo-chlorine, Organo-phosphate, Carbamate and Pyrethroid insecticides.

Cockroach control

The control of cockroaches relies heavily on emphasis on maintenance of good hygiene conditions in the kitchens. The next best option is to use insecticides for the control of cockroaches. The insecticides recommended for control are:

| Insecticide | Concentration | Use |
|---|---|---|
| Boric acid | 100 % | Baits / sprinkle along corners |
| Imidacloprid Gel | 1.85-2.15% | Cracks and crevices |
| Fenitrothion | 1-2% | Spray |
| Malathion | 3% | Spray |
| Cyphenothrin | 0.1-0.5% | Spray |
| Deltamethrin | 0.03% | Spray |
| Fipronil Gel | 0.01-0.03% | Cracks and crevices. Has a cascade effect. |

## Scorpions

Scorpions are one of the commonly encountered venomous arthropods of the class Arachnida. The last segment of their bodies is modified to form a flexible tail, with a vesicle holding poison glands and a sharp spine. They vary in size from about 2 to 20 cm and are cryptozoic and nocturnal, spending the day concealed under stones or fallen tree branches or in burrows, venturing out after sunset in search of food. The common Indian species belongs to the genera *Buthus* (Mesobuthus) and *Palamnoeus*; the former are more poisonous.

Scorpion sting as a rule is not more dangerous than bee or wasp sting, as the chemical nature of the poison is similar to formic acid. It is, however, much more painful, and if sufficient poison has been injected, may cause distressing symptoms which may take twenty four hours to pass off. Cardiovascular effects like hypertension, arrhythmia, cardiac failure and pulmonary oedema may be

encountered following stings of Mesobuthus tamulus. Stings of red scorpion *(Mesobuthus tamulus)* can be serious, with release of catecholamines, producing raised BP, arrhythmias, cardiac failure and pulmonary oedema. Profuse sweating, dilated pupils and priapism can occur. There is no commercially available antivenin for treatment of *Mesobuthus tamulus* stings in India. The effects are more marked in children. It is, however, very rare that a fatal dose of the venom is injected. If the sting is on the extremities, an immediate ligature may be helpful. Application of a strong solution of ammonia relieves pain in a majority of cases; a series of injections of 1 % Novocaine or Lignocaine and Adrenaline at the spot and along the nerve may be necessary in others. Barbiturates in large doses are useful in reducing restlessness. Patients developing priapism, dilated pupils, sweating and bradycardia may require early energetic treatment with vasodilators. Preventive measures include alertness in avoiding contact with scorpions in infested areas, putting on clothes and shoes after shaking them well and proper housekeeping. Propoxur 2% or Chlorpyrifos @ 0.2-0.5% may be used. Synthetic pyrethroids are generally not used as they irritate the scorpions and risk is increased further (111).

#### Treatment of Scorpion Sting

(a) A Scorpion sting case needs immediate medical attention.
   (i) A local anaesthetic (1% Lignocaine) at the site of sting or a strong oral pain killer is advised.
   (ii) For stings with less pain, ice therapy works well.

(b) Prevention of scorpion stings by not encroaching their hiding places especially ill equipped (i.e. barefoot or wearing loose / open sandals) in areas with loose stones, fallen debris etc.

(c) Scorpions are active at nights. Always carry a torch while moving in infested areas at night.

(d) Erect barrier up to 20 cm by means of tiles at the base of walls and steps to prevent scorpion encroachment.

(e) Fill cracks and crevices to deny hiding places.

(f) People should sleep with mosquito nets properly tucked. It is advisable to use treated bed nets.

(g) Clear all junk and rubbish from around the house.

(h) Lastly use chemicals if problem still unresolved.

### Ants

Ants are common annoying insects. They have also been experimentally incriminated in the mechanical transmission of excremental infections. They should therefore, be kept away from foodstuffs by placing the legs of food safes, tables etc. in anti-formicas viz. bowls or tins containing water or waste crude oil. Insecticidal sprays like Pyrethrum or Malathion are effective. Ordinarily the ant-bite causes only a sharp stinging; the bites of some of the larger ants may be very painful involving faintness and shivering. Dilute ammonia or any other alkaline solution applied relieves the pain.

### Bee, wasp and hornet

The stings of these insects are often painful with local wheeling and redness. In sensitized individuals there may be alarming symptoms. The sting along with poison gland may be frequently left in the puncture, particularly by the honey-bee. It should be removed gently by pulling it out, care being taken not to squeeze the venom in the wound. Local application of an alkaline solution of sodium bicarbonate or ammonia or soap and applying pressure with a moistened piece of lint are useful in relieving pain. Papain diluted roughly 1: 5 with tap water is said to produce immediate relief of pain. Disturbing the honey-comb may bring the whole swarm on the person responsible, or any one who happens to be in the vicinity. Their stings may cause serious allergic symptoms requiring adrenaline and/or morphia administration.

Wasp's nests are generally destroyed at night when all wasps are inside. Insecticidal treatment includes use of 1% Dichlorvos, 0.015% Deltamethrin or 0.5% Chlorpyrifos.

### Centipede

Centipedes (Myriapoda) possess a pair of legs to each apparent segment of the body; the first pair is modified to form poison claws. The bites of small centipedes gives rise to mild local inflammation but the larger centipede *Scolopendra gigantia,* may cause a severe painful bite with marked local and general reaction. Solution of ammonia is useful for local application and in bites of the larger centipedes morphia may be necessary to allay the pain. 2-4% Malathion as spot application is very useful.

### Fish bites

There are many species of fish especially in tropical waters which possess poison glands in their mouths like a snake, or have poison spines or barbs. Their bites or stings may lead to severe consequences or even death. Certain jelly fish stings produce marked local reaction. In sensitized individuals more alarming symptoms may develop. Vinegar swabbed well over the whole area or applied by compress gives relief. Tetanus toxoid should also be given. Sedatives to relieve the pain and measures to prevent secondary infection may be indicated.

### Leech bites

Leeches (Hirudinea) are a class of Annelid worms. They are particularly troublesome near streams and rivers, in leafy forests and marshy jungles. The two important species are:

#### Haemadipsa zeylanica

It is the small land leech, about 2.5 cm long with great power of penetration into the interstices of clothing, putties or laced boots. They often drop from tree leaves onto man or animals passing by and suck blood. Leech bites are painless but the bleeding may be prolonged due to a powerful anti-coagulant, hirudin, present in its saliva.

#### Limnatis nilotica

It is the large aquatic leech which on being ingested fastens itself to the mucus lining of the mouth, pharynx, larynx, or nasal cavities of man or animal producing

prolonged bleeding unless removed.

Gum boots or jungle boots protect one from leech bite. A frequent search of the body for the presence of leeches should be made. The leech should not be dragged or pulled off the skin because of the risk of breaking and leaving behind its suction apparatus which is liable to cause inflammation and suppuration. Salt, vinegar or a tobacco infusion application, or a touch of the lighted end of a cigarette induces the leech to relinquish its hold. Subsequently, tincture of iodine should be applied to the bitten spot and a piece of adhesive plaster may be applied to the bitten spot. Repellents DEET & DEPA can be used to provide protection (112). The repellents can be applied on the clothing as well as topical application. At night a properly adjusted mosquito net; preferably treated variety affords good protection. Aquatic leeches can be removed from drinking water by filtering through a sieve or a piece of muslin.

## Lizards

The only poisonous lizard is the Gila monster *(Heloderma)* found in the desert of Mexico. Non-poisonous lizards sometimes bite man and may produce severe local sepsis of bacterial origin. All such bites should be cleaned thoroughly and dressed with an antiseptic. Treatment should consist of cleaning of the bitten area and application of tourniquet and measures to prevent secondary infection including tetanus and other supportive measures.

## Spiders

The true spiders (Arachnida) have poison glands and inject venom into their prey. The common species of spiders as a rule do note bite man. If by chance it happens to bite, the bite amounts to no more than a pin prick. Some spiders, especially those belonging to the genus *Latrodectus* produce severe effects in man. Important species are *L hasselti,* the 'red-backed' spider and *L mactans* the black widow, and the allied species. The acute symptoms generally subside after a few days but pain may persist for some time. In *Latrodectus* bites, the death rate may amount to 6 percent or higher. The 'tarantulas' of the tropics are loathsome spider like creatures, but contain no poison glands and are not dangerous, though they are severe biters. In case of a spider bite an immediate washing and ligation as for snake bite should be carried out. If pain is uncomfortable Aspirin may be given, however use of sedative is contraindicated. For local urticarial reactions, antihistamines will control the symptoms. Morphia may be necessary for relieving pain. A hot tub bath affords prompt but temporary relief. Intravenous Calcium gluconate or Magnesium sulphate also gives dramatic relief to cramps. Spot (Area) treatment with 3% Malathion, 0.03% Deltamethrin, Chlorpyrifos @ 0.2-0.5% has been found to be effective against spiders (19).

Dr (Mrs) Rina Tilak

## Key to the Identification of Adult Anopheles (female only) of India

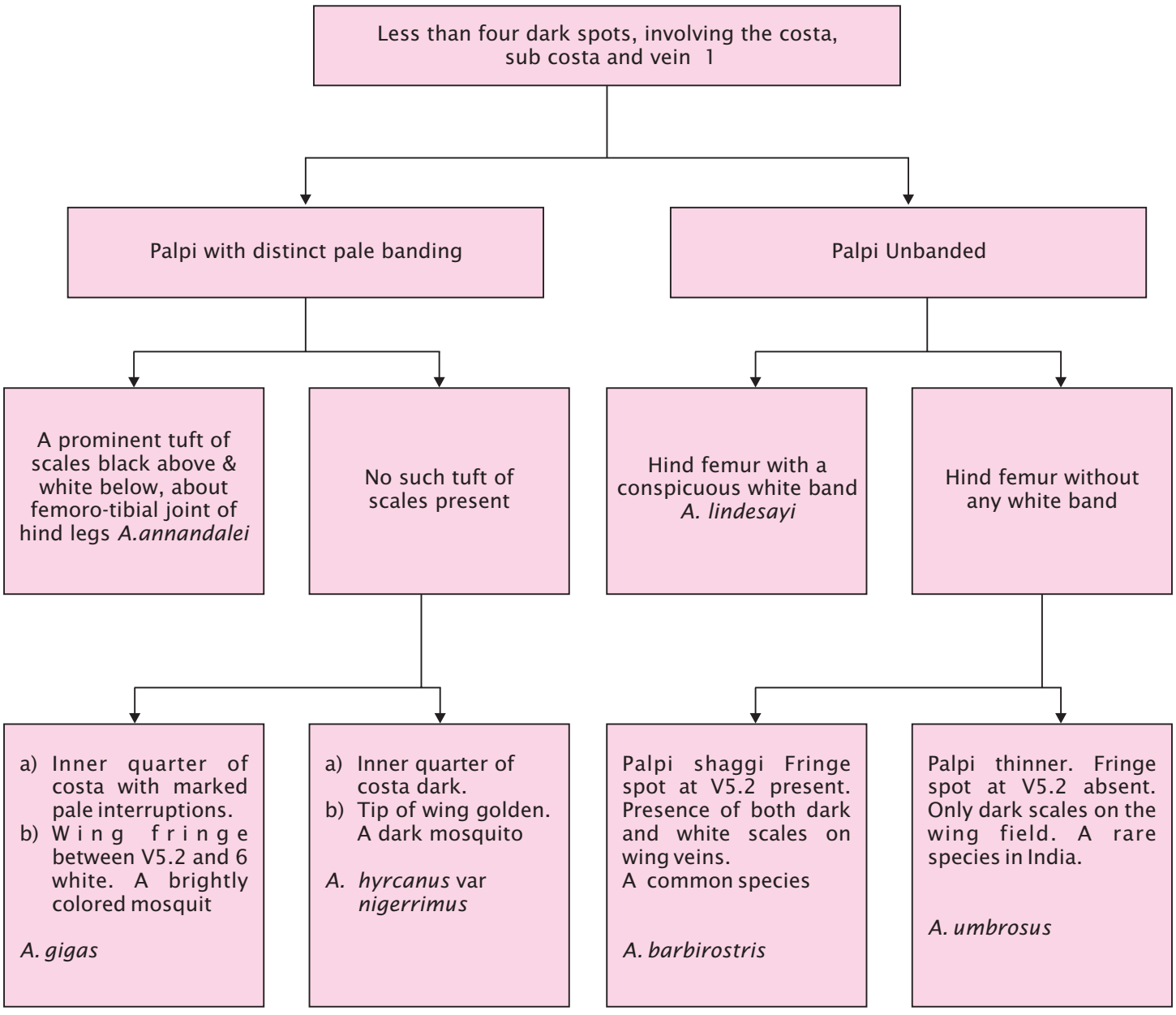
**Anopheles mosquitoes identification : Group - I**

Costa uniformly dark i.e. not interrupted by any pale spot. Also no white spot on the wing field

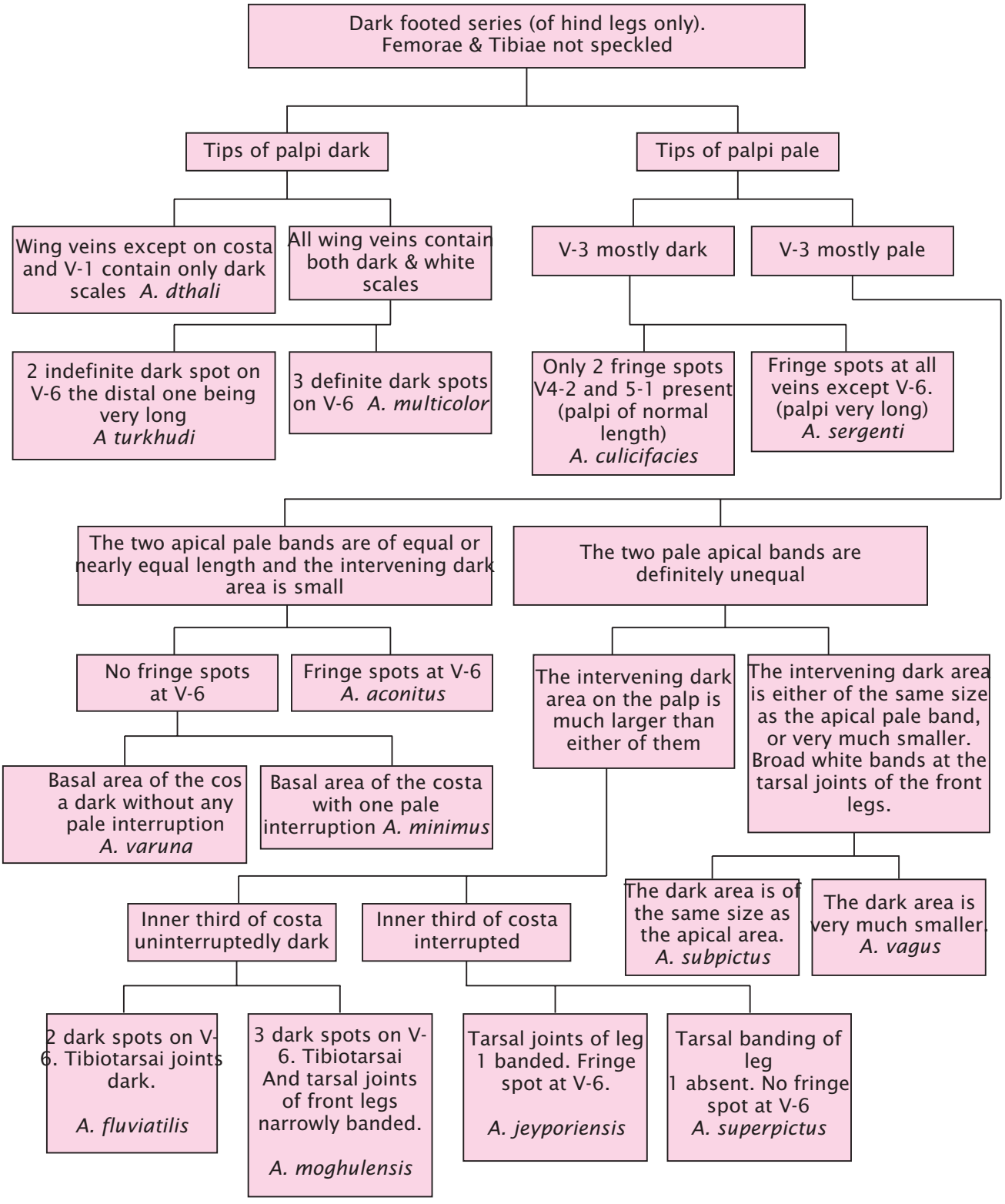
- Anterior forked cell much larger than the posterior *A. aitkeni*
- Anterior forked cell of nearly the same size as posterior
  - Distinct white banding at the distal end of hind femur; frontal white scale tuft present. *A. barianensis*
  - Banding absent. Scale tuft absent *A. culiciformis*

Group III to VI have at least 4 dark spots Involving the costa, sub Costa and vein 1.

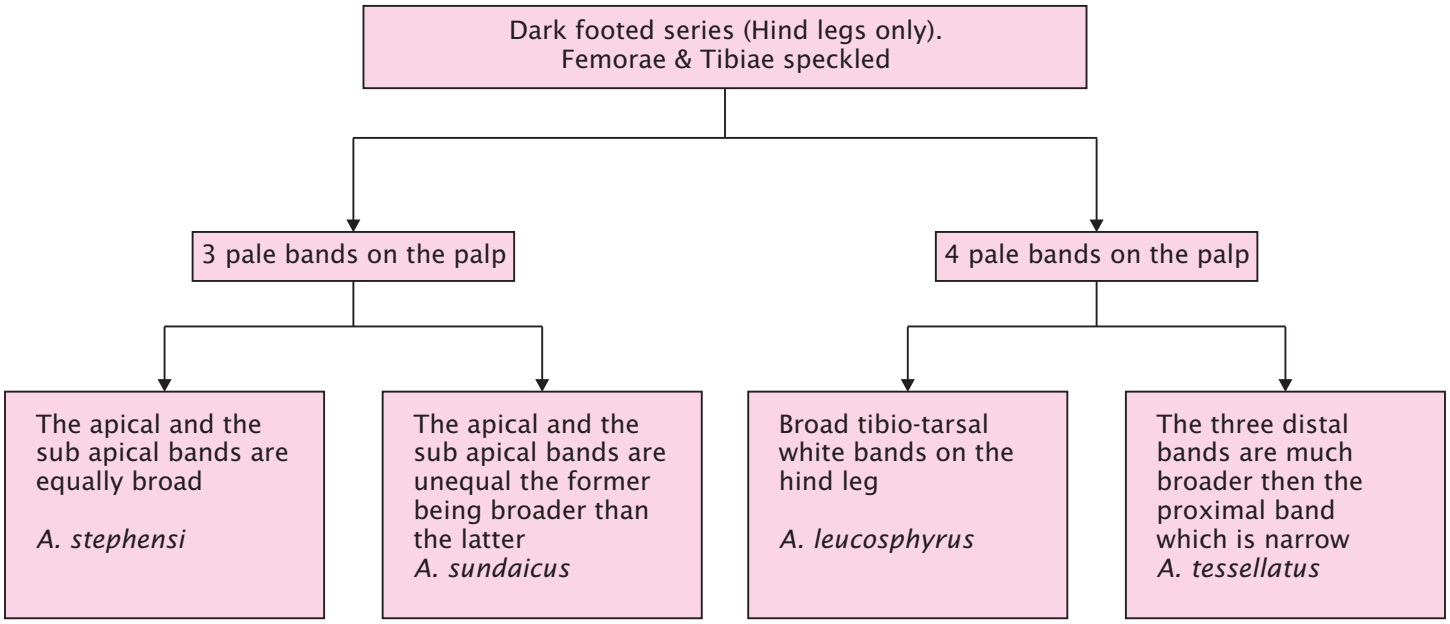
**Anopheles mosquitoes identification : Group - II**



**Anopheles mosquitoes identification : Group - III**



**Anopheles mosquitoes identification : Group - IV**



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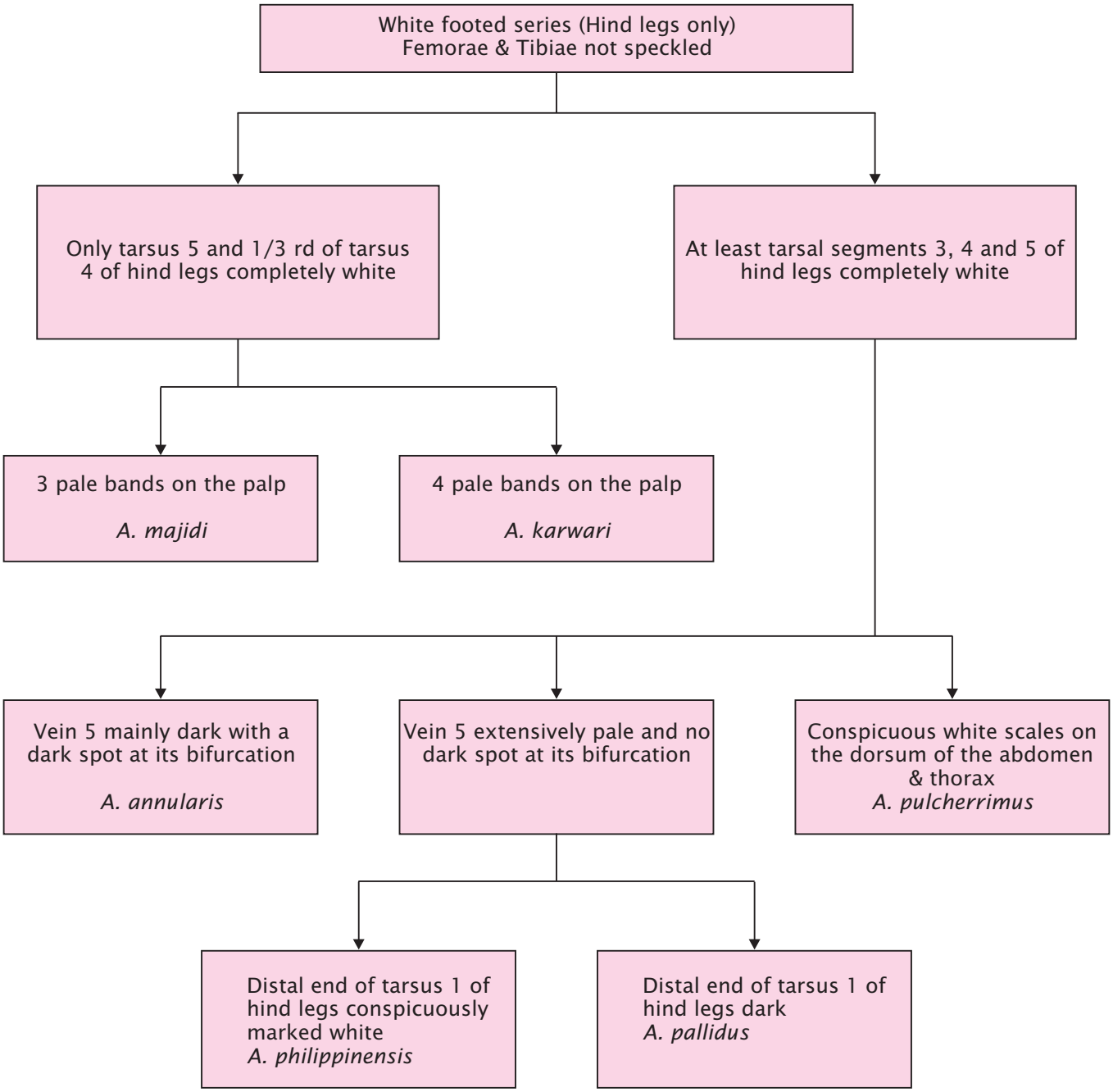
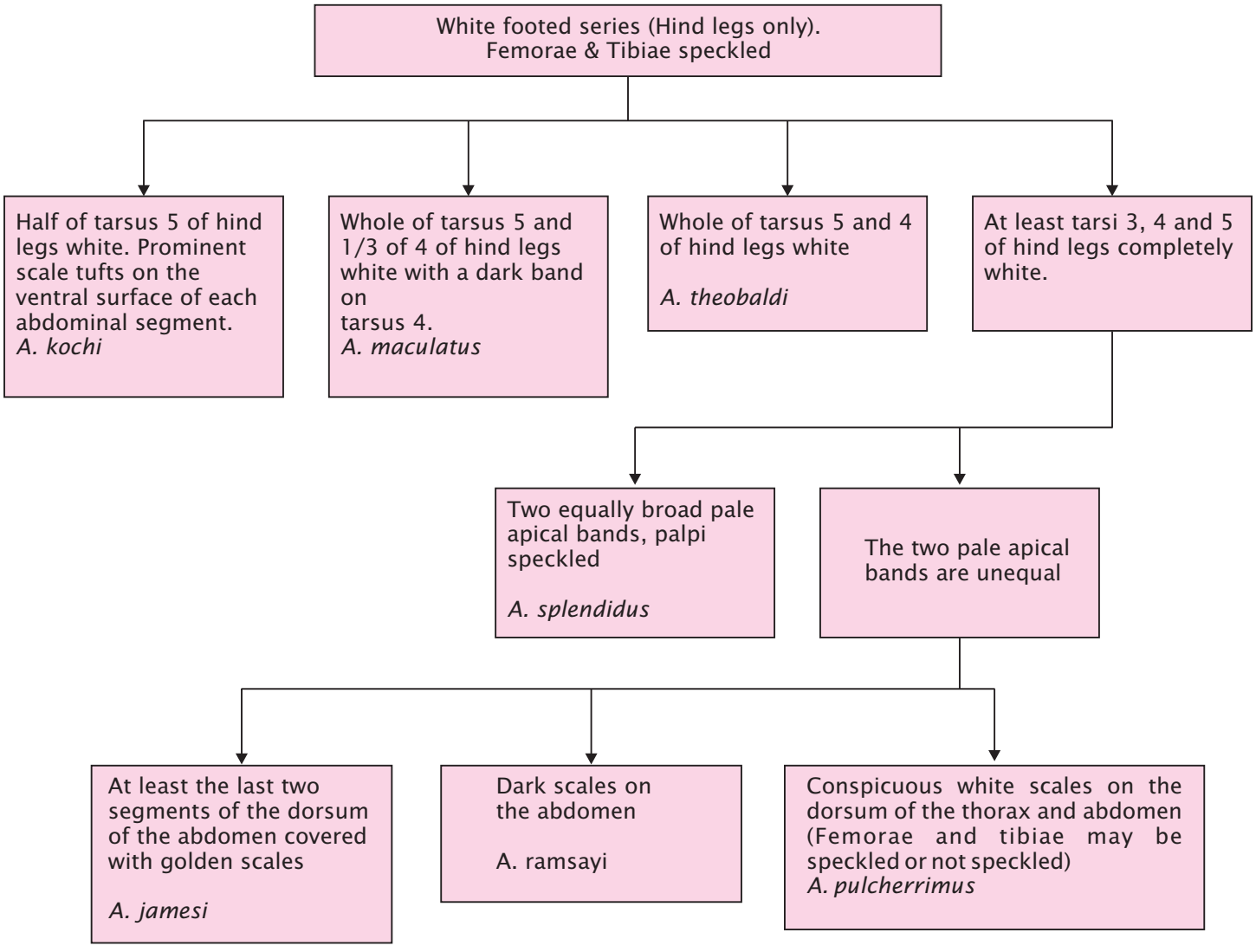


**Anopheles mosquitoes identification : Group - VI**



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# Bio-Medical Sciences

## Diseases Transmitted by Insect Vectors


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# Lymphatic Filariasis

## Introduction

Lymphatic Filariasis is widely known as Elephantiasis. More than a billion people in more than 80 countries are at risk of suffering from the disease. India accounts for one - third of the people infected with the disease (1). Filariasis is caused by three species of nematode worms belonging to the super family *Filarioidea* and family *Onchocercidae* which are transmitted to man by the bite of infective mosquitoes. The three species are *Wucheria bancrofti, Brugya malayi* and *Brugya timori. Wucheria bancrofti* is the most widespread among these three species (2). Several mosquito species are known to transmit the infection. However, *Culex quinquefasciatus* and *Mansonia annulifera* are the two most important vectors in India. In tropical and subtropical areas the prevalence of infection is continuing to increase. The major reason for this increase is the rapid and unplanned growth of cities which greatly enhances breeding of the mosquitoes that transmit the disease. This painful and profoundly disfiguring disease is usually acquired in childhood, but manifests its most disfiguring forms in adults (3, 4). The disease due to lymphatic filariasis is characterized by disfigurement of the limbs (elephantiasis) and genitalia (hydroceles and other anatomical changes in the male genitalia). Consequently, it often has adverse economic and psychosexual effects as well as medical consequences (5). Lymphatic filariasis is one of the six infectious diseases considered eradicable by WHO with the available tools (6).

## History

In 1863, Demarquay first described the microfilariae that are the larvae which live in the blood stream. Microfilariae were found in urine by Wucherer in 1868. Patrick Manson was the first to speculate in 1878 that filarial may be transmitted by mosquitoes (2).

The disease has been known in India since ancient times. It finds mention in “Susruta Samhita” which dates back to the 6th century B.C. Madhavakara, described the signs and symptoms of the disease in his treatise ‘Madhava Nidhana’ in 7th century A. D. In 1709, Clarke called elephantoid legs in Cochin as ‘Malabar legs’ (7)

## Epidemiology

Worldwide

According to the World Health Organization, about 1.25 billion people are at risk of suffering from lymphatic filariasis. As on 31 Dec 2006, 83 countries are considered endemic for filaria. The highest proportion of cases is in the WHO South - East Asia Region with 64% followed by the WHO African Region with 32%. The WHO European Region remains free of lymphatic filariasis transmission (8). Approximately one third of those at risk live in India, another one third in Africa and the remainder in other parts of Asia, the Pacific and the Americas. The most highly - endemic countries are Bangladesh, Democratic Republic of Congo, India, Indonesia, Madagascar, Nigeria and the Philippines (9). The total number of persons infected worldwide is estimated to be 120 million, one third of whom have serious disfigurement and incapacitation (1). Almost 25 million men suffer from genital disease, most commonly hydrocoele, while an estimated 15 million people, mostly women suffer from lymphoedema of the leg (elephantiasis). Among the three parasitic worms responsible for the disease, *Wucheria bancrofti* is the most prevalent particularly in hot and humid climates of Asia, Africa, the Americas and the Pacific. *Brugya malayi* is found in Southern India, South East Asia and South and Central China. *Brugya timori* has only been found in parts of Indonesia (2).

More than half of all cases of Lymphatic filarias is live in South East Asia. Of the estimated 700 million people living in endemic areas in the region, about 60 million are estimated to be infected or suffering from the disease (10).

India

One - third of the people infected with the disease live in India (1). The disease has been described as being second only to malaria as a major public health problem. The disease is endemic to most parts of the country. Indigenous cases have been reported from about 250 districts in 20 states / union territories. Local transmission is known to occur in Andhra Pradesh, Assam, Bihar, Chhattisgarh, Goa, Jharkhand, Karnataka, Gujarat, Kerala, Madhya Pradesh, Maharashtra, Orissa, Tamil Nadu, Uttar Pradesh, West Bengal, Pondicherry Andaman & Nicobar Islands, Daman & Diu, Dadra & Nagar Haveli and Lakshadweep. The North Western and North Eastern parts of India appear to be free from indigenously acquired filarial infection. These include the states of Jammu & Kashmir, Himachal Pradesh, Punjab, Haryana, Chandigarh, Rajasthan, Delhi, Uttaranchal Sikkim, Arunachal Pradesh, Nagaland, Meghalaya, Mizoram, Manipur and Tripura (7). Almost all the cases in India are caused by *Wucheria bancrofti* (99.4%) while the remaining) 6% are attributed to *Brugya malayi* (7).

Over 400 million people live in filariasis endemic areas in India. Three fourths of those at risk live in rural areas. An estimated 49 million individuals in India are infected. Of these, over twenty million people suffer from chronic forms of filariasis while another 28 million are thought to be microfilaria carriers (11-13).

## Economic and social impact

Lymphatic filariasis is primarily a disease of the poor as it occurs mostly in rural areas or urban slums. The increase in lymphatic filariasis over the past few years has been attributed to the expansion of slum areas and poverty, particularly India and Africa. As many filariasis patients are physically incapacitated, it has a significant economic impact. Lymphatic filariasis also exerts a heavy social burden. Among men, genital damage may be a severe handicap leading to physical limitations and social stigmatization. Enlargement of a leg or arm, the genitals, vulva and breasts may result in severe stigmatization of women (1).

## Agent

The three species of nematodes causing lymphatic filariasis, *W. bancrofti, B. malayi* and *B. timori* are threadlike in appearance. They have five stages in their life cycle. Unlike other vector borne diseases, the infective stage of the parasite is not injected into the human body by the mosquito vector. The Infective third - stage larvae are deposited on skin by the vector and penetrate on their own or through the opening created by mosquito bites within minutes to reach the lymphatic system. They then

proceed to shed their cuticle and develop a new surface as they moult into the fourth stage larvae (10). These fourth - stage larvae migrate to central lymphatic vessels and develop into sexually mature adult male or female worms over a period of approximately 9 months. The adult worms are significantly larger than larval stages, with male worms being 20 - 40 mm in length and female worms 40 to 100 mm in length. The adults reside mostly in the afferent lymphatics. The preferred sites for the adult worms seem to the lymphatics of the lower extremities, upper extremities and the genitalia.

The mean reproductive life span of adult worms is approximately 5 years. Following copulation female worms discharge large numbers (10,000 per day) of microfilariae measuring 150 X 7 µm into the blood stream via the lymphatics. The number of microfilariae in the peripheral blood is variable. There is usually a surge in their numbers during the night. These microfilariae are ingested by the mosquito vectors during feeding. The microfilariae exsheath in the mosquito stomach to become first stage larvae. They penetrate the stomach wall and move to the thoracic muscles of the mosquito where they moult twice to develop into the infective third stage larvae. The infective forms then move to the mouth parts of the mosquito and the cycle repeats. The extrinsic incubation period is usually two weeks (2, 3, 13).

### Vector

A wide range of mosquitoes can transmit the parasite, depending on the geographic area. The primary vectors for Filaria are the night biting Culex and Anopheles mosquitoes. *Culex quinquefasciatus* is the principal vector in urban areas in South East Asia. In rural areas of both Asia and Africa, Anopheles species are the important vectors particularly *Anopheles gambiae* and *Anopheles funestes* (2). Aedes and Mansonia are also responsible for transmitting the infection in the parts of Asia and the Pacific region (3).

In India, the most important vector for lymphatic filariasis is *Culex quinquefasciatus.* It is the vector for *Wucheria bancrofti.* It is a ubiquitous mosquito and is present all over the country. Culex breeds in polluted water. Important breeding sites are wet pit latrines, septic tanks, drains, disused wells and paddy fields. *Mansonia annulifera* and *Mansonia uniformis* are the vectors for *Brugya malayi* in India. Mansonia lay eggs on the under surface of the leaves of plants (7).

Filarial nematodes are poorly transmitted by the vectors. A very small proportion, usually less than 1% of mosquitoes are infective even in endemic areas (14). Repeated mosquito bites over several months result in lymphatic filariasis. People exposed to intense transmission for a long period are at the greatest risk for infection. Visitors to endemic areas from non endemic areas for short periods rarely develop disease (2, 15).

### Host

Varied patterns of infection and disease are seen in different endemic areas. Infection is usually acquired in childhood (16) The prevalence of infection rises with age from 5 years to 30 years beyond which it stabilizes. Prevalence may decline somewhat among the elderly. Signs of disease start becoming apparent during late adolescence and rise steadily with age (2). Both sexes are equally susceptible. Minor differences, however, are shown by various groups. It has been postulated that females in the reproductive age group may be more resistant to infection than males because of hormonal factors (17). Lymphatic filariasis is primarily a disease of the poor. The occupations which expose the person more to mosquito bites show a higher incidence. The disease is most prevalent in rural areas and urban slums. The World Health Organization states that the fight to eliminate lymphatic filariasis is also a fight against poverty (1).

### Environmental Factors

Environmental conditions that enhance vector breeding and survival increase infection rates. The optimum conditions for the breeding of the vectors and the development of parasites in them are temperature between 15°C and 35°C and relative humidity above 60%. The density of *C. quinquefasciatus* is at its minimum during the monsoon, but due to favourable atmospheric conditions, somehow the maximum infectivity rate in the mosquitoes occurs during this period. India, presents areas of widely variable endemicity because of its large size and variable climates from region to region (18).

### Clinical features

The incubation period is very variable stretching from eight to 16 months or even longer. The adult worms induce an immunological reaction. A wide variety of clinical manifestations can be seen in lymphatic filariasis. A large proportion of infected persons remain asymptomatic despite the presence of microfilariae. The manifestations result from either acute inflammation or chronic lymphatic obstruction. Clinical manifestations range from those without apparent clinical disease to those with lymphedema and severe disfigurement of the limbs and genitalia. Fever may or may not be present in both the acute and chronic forms. The various presentations can include lymphangitis and adenitis, funiculitis and hydrocoele, abscess formation, lymphadoema and elephantiasis, chyluria and monoarticular arthritis. Occult filariasis in which the classical features of the disease are absent and microfilaria can not be demonstrated in blood, can present as tropical pulmonary eosinophillia. About 40% of patients have renal involvement with proteinuria and haematuria (2, 4, 5, 14)

### Diagnosis

Diagnosis in symptomatic patients living in endemic areas is based on appropriate history and typical clinical findings. In patients above 15 years of age the appearance of lymphedema of the extremities or disease of the male genitalia is most likely due to filarial infection.

A definitive diagnosis can be made only by detection of the parasites. The standard method for diagnosing active infection is the identification of microfilariae in a blood smear by microscopic examination. The microfilariae exhibit nocturnal periodicity with surges of circulating microfilariae at night. Blood collection should be done at night to coincide with the appearance of the microfilariae. A small dose of Diethylcarbamazine (DEC) can increase microfilaraemia during the day as it causes the microfilariae to be expelled from the pulmonary vascular bed. A thick smear should be made and stained with Giemsa or Hematoxylin and Eosin. Microfilariae are sometimes detected in chylous urine, hydrocoele fluid and ascites fluid (19). An alternative to microscopic detection of microfilariae is provided by serologic techniques for the diagnosis of lymphatic filariasis. Patients with active filarial infection are found to have elevated levels of antifilarial IgG4 in the blood and these can be detected using routine assays (19).

The difficulty in detection of microfilariae led to the development of simple immunochromatographic tests. These are very sensitive, very specific and simple "card tests" to detect circulating parasite antigens without the need for laboratory facilities. They use only finger - prick blood droplets taken anytime of the day (1, 20). Adult worms are difficult to detect. Sonographic examination of the scrotum or breast using high frequency ultrasound may result in the identification of adult worms within dilated lymphatics (2, 5).

**Treatment**

Diethylcarbamazine (DEC) is the drug used most widely for treatment of lymphatic filariasis. It exerts no direct lethal action on the adult worms but changes them in a manner which makes their removal by the host's immune system possible (2). It is considered safe and effective against all filarial infections. The dose is 9 - 12 mg / kg orally in three divided doses for 14 or 21 days. The full dose must be reached slowly, starting with 50 mg daily to avoid side effects. For treatment of tropical eosinophillia, a 21 day treatment regimen must be followed. This course may be repeated twice at intervals of 4 - 6 weeks. Ivermectin has also been found effective in a single oral dose of 200 - 400 µg / kg body weight. Two drug regimens have also been found effective. The combinations that may be used include 400 mg albendazole with 6 mg / kg DEC or 400 mg albendazole with 150 µg / kg ivermectin once a year. Symptomatic treatment such as analgesics, antipyretics and antihistaminics may be required. Surgical procedures to correct elephantiasis must be preceded by drug therapy.

In filariasis endemic areas, the primary goal of community treatment is to eliminate microfilariae from the blood of infected individuals so that transmission of the infection by the mosquito can be interrupted. Recent studies have shown that single doses of diethylcarbamazine (DEC) have the same long - term effect in decreasing microfilaraemia as the 12 day regimens of DEC. The use of single doses of two drugs administered together (albendazole with DEC or ivermectin) is 99% effective in removing microfilariae from the blood (1).

Prevention and Control of Filariasis

Active disease surveillance, vector control, personal protection and mass treatment of communities in endemic areas are the corner stone of lymphatic filariasis control. The success of control measures depends on the level of co - operation by the public. The importance of health education cannot be overemphasized. Vector control and personal protective measure are dealt with in detail in the chapter on Entomology. In the Armed Forces, the Filaria survey is an important method of active surveillance.

Filaria Survey (21)

The objective of filaria survey is to find out the extent of filaria infection and filarial disease prevalent in a locality, factors responsible thereof and to recommend suitable control measures. Three main purposes of the survey are as under :

(a) To obtain baseline data on the prevalence and distribution of filariasis.

(b) To define the public health importance of filariasis in an area.

(c) To monitor and evaluate changes in endemicity including those due to control programmes.

Method of Survey

A filaria survey comprises of the following elements and procedures :

**(a) General**

This should include meteorological data, local morbidity, statistics, socio - economic aspects of local population such as occupation, income, literacy, social habits and attitudes, records of previous survey if any and any existing control measures. A close liaison must be established with local populations before starting the actual survey. A map should also be prepared.

**(b) Technique**

It should be a random representative sample of the area. All persons in a household should be examined. Following four types of surveys can be conducted :

(i) **Blood (Parasitological) survey** : The blood smears should be collected between 9. 30 p. m. to midnight. Approximately 20 $mm^3$ of blood (3 drops) from each person should be taken on a clean glass slide and made into a thick smear. After drying, a serial number is given as in the proforma. The slides are dehaemoglobinised, fixed and stained next day, preferably with JSB - I stain. The slides are then washed, dried and examined for microfilariae. The other methods employed in parasitological surveys are - counting chamber technique and membrane filter concentration method.

(ii) **Clinical Survey** : It is better if this is carried out separately during day time when all members of the family are present and detailed history of each case can also be taken. Each person's length of stay, history of fever, lymphangitis, chyluria and clinical signs of filarial disease are recorded.

(iii) **Skin Tests** : Recent studies have revealed that the intra - dermal tests are of considerable importance in detecting early cases of filariasis. Lack of standardized antigens and their specificity is the main drawback.

(iv) **Diethylcarbamazine Provocative Test** : This test is based on the principle that administration of hetrazan stimulates the appearance of microfilarae (MF) in the blood circulation.

(v) **Entomological Survey** : This should include types of vector breeding places, collection of larvae, adult collections and dissections, precipitin tests and bionomics of local vectors such as their density, resting habits and their biting / feeding behaviour.

(vi) **Zoonotic Infection** : To rule out the prevalence of any zoonotic focus of filariasis, the study may include a blood survey on the local animals and birds.

Filarial indices

The extent of filariasis problem in a given area before and after the institution of control measures can be assessed by certain indices which are defined as under :

**(a) Microfilaria Rate**

It is the number of persons showing microfilariae in a unit (20 $mm^3$) of blood expressed as a percentage of population examined.

**(b) Filarial Disease Rate**

It is the number of persons showing clinical manifestations of filariasis expressed as percentage of population examined.

**(c) Filarial Endemicity Rate**

It is the number of persons showing microfilariae in blood, or filarial disease or both per 100 persons examined during a survey.

**(d) Microfilaria Density**

It is the number of microfilariae present in a unit volume of blood (20 $mm^3$) from individual persons.

**(e) Average infestation Rate**

It is the average number of microfilariae per positive person in a sample.

**(f) Filaria Mosquito Infection Rate**

It is the number of mosquitoes found positive for all stages of developing larvae expressed as percentage of the total female mosquitoes dissected.

**(g) Mosquito Infectivity Rate**

It is the number of mosquitoes positive for infective stage of larvae expressed as percentage of the total female mosquitoes dissected.

WHO strategy to eliminate lymphatic filariasis

The WHO strategy of the Global Programme to Eliminate Lymphatic Filariasis aims to stop the spread of infection and morbidity control. To interrupt transmission, districts in which lymphatic filariasis is endemic must be identified and then mass treatment programmes implemented to treat the entire at - risk population. Mass Treatment involves once - yearly administration of single doses of two drugs given together, albendazole plus either diethylcarbamazine (DEC) or ivermectin. An alternative community - wide regimen with equal effectiveness is the use of common table / cooking salt fortified with DEC in the endemic region for a period of one year (1) This programme in operation on a national level in India (7, 22-24).

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# Malaria

## Introduction

Malaria is a tropical disease caused by protozoan parasite of the genus Plasmodium and transmitted to man by the bite of certain species of infected female anopheles mosquitoes. It remains widespread throughout the tropics, but also occurs in many temperate regions. It exacts a heavy toll of illness and death especially amongst children and pregnant women. Treatment and control have become more difficult with the spread of drug resistant strains of parasite and insecticide resistant strains of mosquito vectors. The overriding importance of malaria for the mankind in general and, for our country and Armed Forces in particular, is evident from the fact that there a number of text books available on the subject of malaria. Interested medical officers are advised to refer to these texts.

## Geographical Distribution

Malaria is usually restricted to tropical and subtropical areas and altitudes below 1500m. However, the distribution might be affected by climatic changes esp global warming and population movement. *P. falciparum* is the predominant species in world. *P. vivax* and *P. ovale* are traditionally thought to occupy complimentary niches with *P. ovale* predominantly in Sub Saharan Africa. *P. malariae* has wide global distribution being found in South America, Africa and Asia.

## Magnitude of the problem

(a)Global

Malaria is endemic in over 105 countries and is responsible for over 300-500 million clinical cases and over a million deaths annually. Out of around 3000 deaths a day, over 90% are in Sub Saharan Africa.

(b) SEAR

Out of the 11 countries of the SEAR, 10 are malaria endemic. Maldives has no endogenous transmission since 1984. SEAR accounts for 30% of global morbidity and 8% of global mortality due to malaria. An estimated 82. 8% of the total population here is at risk of malaria. Out of the total population, 41. 5% are at mod-high risk, 41. 7% are at low risk while remaining only 16. 8% are free from malaria.

(c) India

Malaria transmission occurs in almost all areas of India except areas above 1800 meters sea level. Countries 95% population lives in malaria risk prone areas. Malaria in India is unevenly distributed. In most parts of India about 90% malaria is unstable with relatively low incidence but with a risk of increase in cases in epidemic form every 7-10 yrs. This depends on the immune status of the population and the breeding potential of the mosquitoes, rainfall being the leading cause of malaria epidemic as it increases vector density. In North-East states efficient malaria transmission is maintained during most months of the year. Intermediate level of stability is maintained in the plains of India in the forests and forest fringes, predominantly tribal settlements in 8 states (AP, Gujarat, Jharkhand, MP, Chattisgarh, Maharashtra, Orissa and Rajasthan).

The reported incidence is between 2-2. 5 million cases annually with some fluctuations every year for last over two decades. out of these 44. 3% are *P falciparum* cases. Malaria situation in India in last few years is given in the Table - 1 :

Table - 1

| Year | Malaria Cases (in million) | Pf Cases (in millions) | Deaths (exact numbers) |
|---|---|---|---|
| 1995 | 2.93 | 1.14 | 1151 |
| 1996 | 3.04 | 1.18 | 1010 |
| 1997 | 2.57 | 0.99 | 874 |
| 1998 | 2.09 | 0.91 | 648 |
| 2002 | 1.84 | 0.87 | 973 |
| 2003 | 1.87 | 0.85 | 1006 |
| 2004 | 1.92 | 0.89 | 949 |
| 2005 | 1.82 | 0.80 | 963 |
| 2006 | 1.75 | 0.76 | 890 |

(d) Armed Forces

In 2006, malaria ranked 4th amongst top 20 causes of hospital admission contributing to 3.86 % of total admissions of serving personnel in Armed Forces. It featured second only to intestinal infections in communicable diseases category. Average duration of hospital stay due to malaria was 11.54 days in 2006. The decadal incidence is shown in Table - 2.

Table - 2 : Decadal Incidence of Malaria in Army Personnel 1996 To 2006 (Rate Per 1000)

| Year | Total |
|---|---|
| 1996 | 12.87 |
| 1997 | 8.62 |
| 1998 | 7.03 |
| 1999 | 6.03 |
| 2000 | 4.32 |
| 2001 | 4.08 |
| 2002 | 4.67 |
| 2003 | 5.53 |
| 2004 | 5.67 |
| 2005 | 4.63 |
| Average for 10 Yrs | 6.35 |
| 2006 | 4.07 |

**Agent Factors**

The disease is caused by the haemoparasites of genus Plasmodium. There are four species: *P. vivax, P. falciparum, P. malariae,* and *P. ovale*. The first two are the commonest; the third is of focal distribution and the fourth is rare. The cyclopropagative life cycle of the plasmodium occurs in two stages (Fig - 1 ). The sexual stage starts with the 'gametogony' in the human host and progresses through 'sporogony' in the mosquito. The asexual stage starts with injection of sporozoites by the infective mosquito into the human host and progresses through three phases of 'schizogony'. The broad outline of events occurring during the two stages is as follows.

(a) Sexual Cycle in Mosquito (Sporogony)

The vector female anopheline mosquito ingests male and female gametocytes from a malarial subject. In the mosquito's stomach the male gametocyte becomes rounded, its chromatin splits into 5 to 8 particles, which get arranged along its edge. Cytoplasm around each chromatin particle elongates into a 'flagellum' and together with chromatin separates from the main mass as a 'microgamete'. Female gametocyte extrudes polar bodies and becomes a 'macrogamete' ready to be fertilized. Syngamy of microgamete and macrogamete forms 'zygote'. This becomes an elongated, motile 'Ookinete'. Penetrating the stomach wall, this comes to lie under its external basement membrane, becomes rounded & develops into 'oocyst' measuring 6 to 12. As the oocyst matures, it increases in diameter from 6 to 60 and rapidly undergoes division and subdivision to form a large number of haploid sporozoites (varying from new hundreds to thousands). Finally, the oocysts rupture, releasing the elongated sporozoites into the body cavity, majority of which find their way into the salivary glands. Sporozoites injected in human host through the mosquito bite start schizogony.

(b) Pre-erythrocytic Phase

Sporozoites injected by infective mosquito into human body circulate for approximately 30 minutes and thereafter leave the peripheral blood. Fully matured, pigmentless schizonts, containing cryptozoites are seen in the parenchymal liver cells. The cycle lasts approximately 8 days in *P. vivax*, 6 days in *P. falciparum* and 9 days in *P. ovale.* On full maturity of the pre-erythrocytic schizonts, the liver cells rupture and cryptozoites enter the erythrocytes.

(c) Erythrocytic Phase

Th earliest intracorpuscular form of parasite is the 'trophozoite' which has a fine ring of cytoplasm with a small chromatin dot. It grows in the parasitised RBC that becomes pale and, in some species, enlarged or distorted. The haemoglobin changes into haemozoin pigment and is seen in the cytoplasm of the parasite as black or brown granules. Fully developed trophozoite fills the RBC and undergoes segmentation. The chromatin divides into a number of particles which migrate towards the periphery. The cytoplasm around each particle separates off forming merozoites; the pigment concentrates in the centre of the RBC. This is called 'rosette' or 'schizont'. The parasitised RBC eventually ruptures releasing merozoites which enter other RBCs repeating the asexual cycle. Each asexual cycle is completed in 48 hours in *P. falciparum, P. vivax* and *P. ovale* and in 72 hours in *P. malariae*.

(d) Gametogony

After a few cycles of erythrocytic schizogony, male and female gametocytes appear in the blood. The female macrogametocyte has a dense and deeply staining cytoplasm and a small compact nucleus, while the male microgametocyte has a less dense and faintly staining cytoplasm and a relatively large and diffuse nucleus. The gametocyte of *P. vivax* is large and round filling the enlarged RBC, the gametocyte of *P. falciparum* is sausage or crescent shaped. Gametocytes remain within the corpuscles until taken up by the mosquito or their final disintegration.

(e) Persistent Tissue Phase (Exoerythrocytic phase)

After the establishment of blood infection the initial tissue phase (pre-erythrocytic phase) disappears completely in P. falciparum, whereas in *P. vivax, P. ovale* and *P. malariae* it continues in the form of a persistent tissue phase in the liver. These exoerythrocytic forms never arise from the merozoites of erythrocytic schizogamy and are now considered responsible for relapses of vivax , ovale and quartan malaria.

Reservoir and Source

For human plasmodia the only reservoir is a malaria case. In some parts of Africa Chimpanzees may act as reservoir of P. malariae. The source of infection is a malaria case with adequate number of mature viable gametocytes circulating in the blood. It has been estimated that in order to infect a mosquito, the blood of a human carrier must contain at least 12 gametocytes per $mm^3$ and the number of female gametocytes must be more than the male gametocytes.

Communicability Period

The human case of malaria becomes infective to mosquito when mature, viable gametocytes develop in the blood of the patient in sufficient density. Gametocytes of *P. vivax* appear in peripheral blood 3 to 5 days after the initial appearance of the asexual forms of parasites where as in falciparum infections they do not appear until 10-14 days after the first appearance of asexual parasites.

**Host Factors**

Age

All ages are equally affected. Children are usually effective carriers of gametocytes.

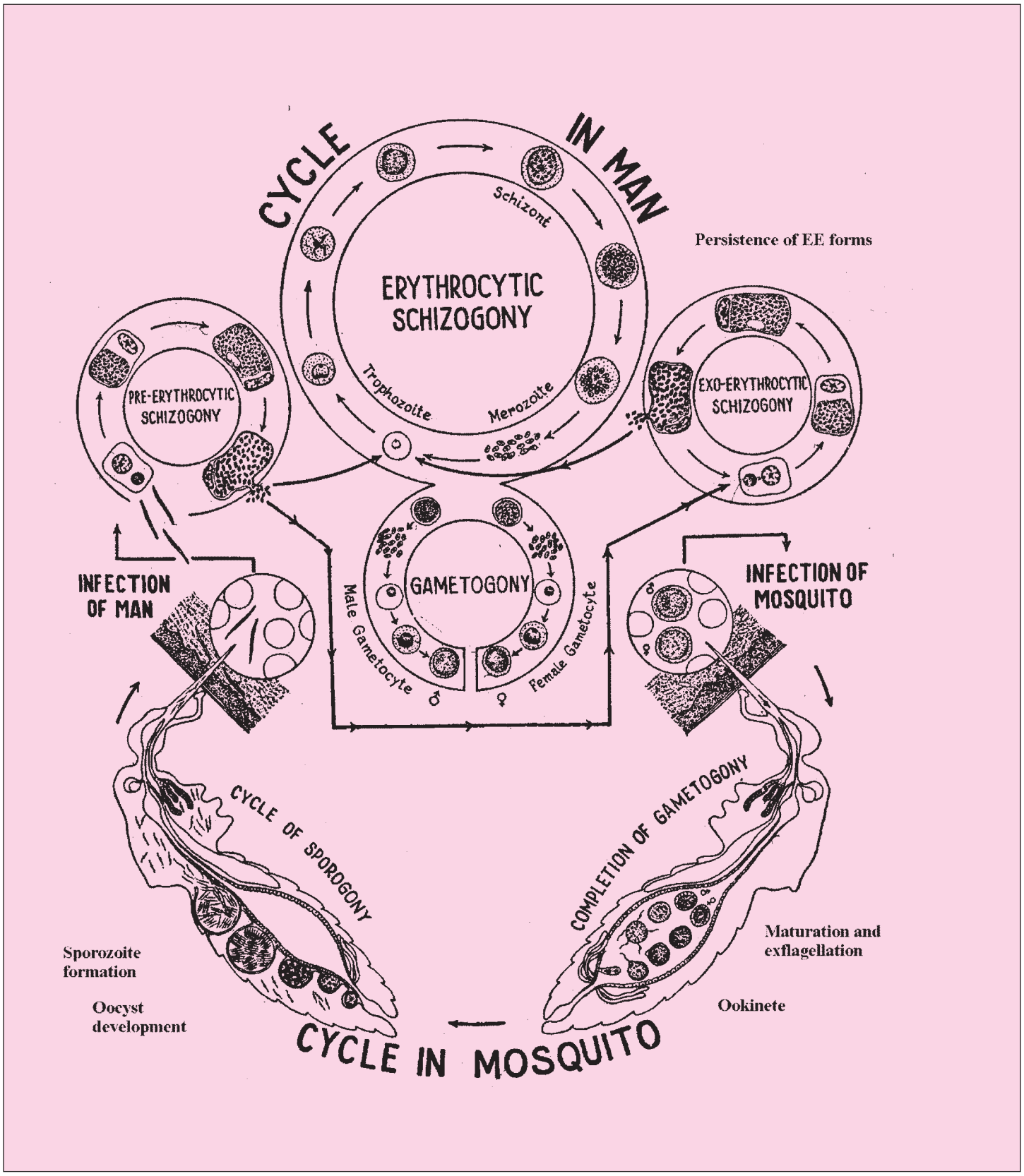
Sex

It makes no difference except by way of clothing and the occupation which have a bearing on the man-mosquito contact.

Race

Racial immunity against one or more species of malaria parasite has been observed in certain parts of the world. Negroes with sickle cell trait have been found to be relatively immune to *P. falciparum* infection. Recent

Fig - 1 : Life cycle of the malaria parasite



studies indicate that HbE, or thalassaemia traits do not confer any selective advantage or disadvantage in malaria. Persons with G6PD deficiency suffer more from *P. Vivax* infection. They are not protected from *P. falciparum* infection.

Economic Status

It is inversely related mainly because of poor housing. Ill ventilated and poorly lighted houses provide ideal resting places for mosquitoes.

Movements

Migration of populations due to natural calamities, aggregations of labourers and movements of nomads may lead to reintroduction of malaria into areas where the disease has already been eradicated or effectively controlled.

Habits

Habits of sleeping outdoors without mosquito nets, ignorance and apathy, social and religious beliefs, all these factors may either create malariogenic conditions or lead to perpetuation of malaria transmission in a locality.

Aquired Immunity

Man possesses no natural immunity. In areas with high falciparum transmission, newborns will be protected during the first few months of life presumably by maternal antibodies transferred to them through the placenta. As these antibodies decrease with time, these young children become vulnerable to disease and death by malaria. If they survive to an older age (2-5 years) they will have reached a protective semi-immune status. Thus in high transmission areas, young children are a major risk group and are targeted preferentially by malaria control interventions. In areas with low transmission, malaria is found in all age groups.

Pregnancy and Malaria

In pregnancy malaria is more common due to immunosuppression. It is more atypical and severe .The parasitemia is ten times higher and thus all the complications of falciparum malaria are more common. As some antimalarials are contraindicated in pregnancy, the treatment is also more difficult.

Genetic Factors

Biologic characteristics present from birth can protect against certain types of malaria. Two genetic factors, both associated with human red blood cells, have been shown to be epidemiologically important. Persons who have the sickle cell trait (heterozygotes for the abnormal hemoglobin gene HbS) are relatively protected against *P. falciparum* malaria and thus enjoy a biologic advantage. Persons who are negative for the Duffy blood group have red blood cells that are resistant to infection by *P. vivax.*

**Environmental Factors**

Environmental factors influence the bionomics of the vector species of anopheline mosquito and the habits of human host. In most parts of India the meteorological and physiographical conditions are favorable to the occurrence of malaria.

Climate

The topography, weather, flora and fauna modify the life cycle of the mosquito. There are seasonal variations in their density, resting, feeding and biting habits, longevity and flight capabilities. Malaria is therefore, seasonal in most parts of the country. In most of the states the maximum transmission is during the period July to November.

Temperature

An optimum temperature of 20˚ to 30˚ C is necessary for completion of the sporogonic cycle of malaria parasite. P. vivax is, however, adapted to lower temperatures and may complete its developmental cycle at 15˚ C. Although these temperatures may suggest limits for survival of the parasites, the temperature and humidity in the actual surroundings of vectors, particularly their day time resting places, are more important. This microclimate plays a vital role on longevity and biting habits of mosquito, sporogonic development of malaria parasite and consequently on the transmission of malaria.

Humidity

Humidity plays a vital influence on the life of a mosquito by determining the speed of its development, its daytime resting habits, its biting activity and also on the development of parasites in its gut. A relative humidity (RH) of 60 percent is considered optimum for transmission of malaria.

Rainfall

It has influence on the breeding of vectors and hence on the incidence of malaria. However, the correlation is not always obvious. While heavy rains in certain areas may discourage stream breeders, intermittent moderate rain with intervals of sunshine may be conducive to anopheline breeding. Similarly, droughts may either precede or eliminate vectors in other areas. The influence of rainfall should, therefore, be assessed only in relation to the local pattern of vector breeding. Rainfall also increases the atmospheric humidity, which has already been discussed above.

Wind

While it favours the dispersal of adult mosquitoes, it has an adverse effect on ovipositing. The wind being minimum as a rule at dawn and dusk, it favours man mosquito contact at these hours.

Topography

Altitude, configuration and character of water collections determine the transmission of malaria to a great extent. Transmission decreases with increasing altitude and as a rule and it stops above the heights of 2000 m.

Man-made Malaria

Construction of roads, railways, irrigation works, dams and barrages, deforestation and other engineering projects have resulted in creation of mosquito breeding place in many new areas. All these ecological changes have led to an increase in the incidence of malaria.

### Vectors of Malaria

There are 56 species of anopheline mosquitoes in India but only 6 are regarded as primary vectors and another 3 or 4 as secondary or local vectors. The following characteristics of vector mosquitoes play an important role in the epidemiology of malaria.

Breeding Habits

The breeding habits of mosquitoes show a lot of variation. Hence, vector mosquitoes tend to be confined to certain geographical areas only. A few examples are as follows :-

(a) Slow moving water, seepages, terraced rice fields - *A fluviatilis*
(b) Brackish waters - *A sundaicus*
(c) Wells, cisterns and over head tanks -*A stephensi*
(d) Tanks, pools, burrow pits and ditches - *A philippinensis*, *A annularis*
(e) Forest pools, streams and slit trenches - *A dirus*

Vectorial Capacity

Why only certain species and not others act as vectors is not exactly known. A complexity of factors determines the vectorial status of a mosquito. Certain new species are emerging as secondary vectors in different parts of the country.

Density

For effective transmission of malaria in a locality, the mosquito vector must attain and maintain a certain density. This is called critical density and it varies from one mosquito to another and also under different environmental conditions. *A culicifacies* needs a very high density for transmission of malaria.

Longevity

A mosquito, after an infective blood meal, must live for at least 10 days to complete the development of malaria parasites.

Tropism

Some mosquitoes like *A fluviatilis* prefer human blood and are called anthropophilic. Others like *A culicifacies* preferably feed on animal blood and are called zoophilic. This preferential feeding habit is called tropism. It has obvious bearing on the transmission of malaria.

Biting Behaviour

Some vector mosquitoes bite at or soon after dusk, others either during late night or early hours of the morning. However, some species may be active at two different periods during the same night.

Resting Habits

A female mosquito after a blood meal rests either indoors (endophilic) or outdoors (exophilic) for maturation of its eggs. A knowledge of these habits is necessary for organizing antiadult measures. The common resting places are either human dwellings, cattle sheds or mixed dwellings.

Flight Range

The range of flight and dispersion varies from one vector to another. Knowledge of this is important for planning control measures. Some have a short flight range e.g. *A dirus, A annularis* and *A fluviatilis* upto 1 km distance; *A. culicifacies* and *A. stephensi* upto 2 km; and *A. sundaicus* which may fly even upto 8 or 10 km.

Resistance to Insecticides

When a vector mosquito in a locality becomes resistant to a particular insecticide one has to use an alternative insecticide. A close liaison with local NAMP unit is necessary for knowing the susceptibility/ resistance status of the vectors to various insecticides.

As per the global classification, India is covered by 3 out of the 12 epidemiological zones. The present distribution of malaria vectors in these zones is given below :

Northern and Peninsular India

(a) **Main Vectors**
*A. culicifacies, A stephensi, A. fluviatilis.*
(b) **Local Vectors**
*A sundaicus, A. annularis and A. varuna.*

Eastern India

**(a) Main Vectors**
*A dirus, A sundaicus, A. philippinensis, A. minimus, A maculatus.*

Andaman and Nicobar Islands

(a) **Main Vector**
*A sundaicus*
(b) **New Vectors**
*A dirus, A. maculatus* and *A tesselatus.*

### Mode of Transmission

(a) By Vector

The most prevalent mode of transmission of malaria is through the bite of certain species of infected female anopheles mosquito. It is infective only if the sporozoites are present in its salivary glands.

(b) Direct Transmission

Malaria can be transmitted by intravenous or intramuscular injection of infected blood or plasma in an otherwise healthy person. The parasite can stay alive for nearly two weeks at -4°C in bottled blood.

(c) Congenital

Although rarely but transmission can also occur from infected mother to the newborn.

### Incubation Interval

Incubation interval denotes the duration of the full cycle of malaria parasite. It is the sum of the time taken for the development of the parasite in the mosquito and that in the human being. The incubation interval in case of *P. vivax* is approximately 22 days while for *P. falciparum* it is 35 days.It is important as the surveillance cycle of less

than one incubation interval will catch most of the secondary cases before the commencement of next cycle. Through this activity, the malaria surveillance can be measured. Technical justification for a fortnightly blood smear collection is based on this transmission dynamics of malaria

The intrinsic incubation period in human host in the case of *P. vivax, P. ovale* and *P. falciparum* is 10 to 14 days; whereas in *P. malariae* it may vary from 18 days to 6 months. The incubation period is also prolonged when prophylactic doses of antimalarial drugs are administered.

### Malaria Survey

Survey is carried out for assessing extent and intensity of malaria in an area, distribution and period of transmission, and establishing the identity and bionomics of mosquito vectors. Detailed surveys are carried out by examination of the population, especially children, for the spleen and parasite rate; collection of mortality and morbidity data; enquiries into past surveys, hospital admission records and dispensary attendance; scrutiny of meteorological conditions in relation to mosquito genesis and bionomics; collection and identification of larvae and adult mosquitoes; dissection of adult mosquitoes, studying their bionomics and determine the feeding habits and host preference of mosquitoes. Study of topography is important. Rapid diagnostic kits namely immunochromatographic test and dipstick antigen captive assay are sensitive kits for rapid diagnosis of P. falciparum malaria in field. Details of undertaking malaria surveys are also provided in Govt of India publication.

### Malariometry

Prevalence

During an emergency when it is not feasible to carry out a detailed malaria survey, it is possible to assess the prevalence of malaria in an area in a short time by the collection of following data.

**(a) Spleen Rate**

It is expressed as the percentage of children between two and ten years of age showing enlargement of spleen. A child spleen rate above 10 is considered high warranting implementation of control measures in the Armed Forces.

**(b) Parasite Rate**

It is expressed as the percentage of children between two and ten years of age showing malaria parasites in their blood films. The child parasite rate is a true index of local prevalence of malaria because the children do not possess premunition and are less likely to have contracted the infection outside the area.

**(c) Infant Parasite Rate**

It is defined as the percentage of infants below the age of one year showing malaria parasites in their blood films. It is regarded as the most sensitive index of recent transmission of malaria in a community.

**(d) Proportional Case Rate**

It is expressed as the number of cases diagnosed as clinical malaria for every 100 patients attending the outpatient departments of hospitals and dispensaries.

Incidence

The indices described above indicate the prevalence of malaria in a locality as judged from a sample of the population. A new tool of evaluation has been introduced under the National Programme, which measures not prevalence but the incidence of malaria. This method is called case detection or surveillance and is expressed as Annual Parasite Incidence (API).

**Annual parasite index** is calculated as under

**Annual Blood Examination Rate (ABER)**

Malaria surveillance presumes that every malaria case will present itself with symptoms of fever at some point of

$$API = \frac{\text{Confirmed cases of Malaria during one year}}{\text{Population under surveillance}} \times 1000$$

time during the course of infection. Therefore, if all fever cases occurring in the community are kept under surveillance over a period of time and their blood smears are examined for malaria parasite, the total malaria parasite load can be examined

The value of API is linked with adequacy of coverage of the population under surveillance in respect of blood examination. This is indicated by ABER. It is recommended that the monthly number of blood smears examined should be at least 1 percent of the population. For accurate estimates of malaria endemicity, the blood smear examination rate specially the Monthly Blood Examination Rate (MBER) rate should be equal to fever rate of the month in the community. Therefore it is necessary to ensure that all persons having fever during malaria transmission months are included in the total blood slides examined during the year. ABER is the cumulative sum of monthly rates during the year. ABER/ MBER is an index of operational efficacy of the programme. The Annual Parasite Incidence (API) depends upon the ABER

**Slide Positivity Rate (SPR)**

The Slide Positivity Rate among the blood smears

$$ABER = \frac{\text{Number of blood smears examined During an year}}{\text{Population under surveillance}} \times 100$$

$$MBER = \frac{\text{No. of blood smears collected during a month}}{\text{Population covered under surveillance}} \times 100$$

collected through both active and passive surveillance gives more accurate information on distribution of malaria infection in the community over a period of time. Monthly SPR can be calculated to find out the seasonal rise and fall in malaria prevalence in the community. SPR

among children 2-9 years of age can be utilized for comparison with pre-control Child Parasite Rates to assess the impact of control measures on local malaria endemicity and transmission. SPR in the age group of less than one year (Infant Parasite Rate) can be utilized for assessment of the impact of control operations. Trends in SPR can be utilized for predicting epidemic situations in the area. If monthly SPR exceeds by 2 ½ times of the standard deviation observed in SPR of the preceding 3 years or preceding 3 months of the same year, an epidemic build up in the area can be suspected. Monthly or yearly trends of SPR are utilized to study the impact of control operations. SPR is measured as follows:

**Clinical Features**

(a) Uncomplicated Malaria

$$SPR = \frac{\text{No. of blood smears found positive for malaria parasite}}{\text{No. of blood smears examined}} \times 100$$

The classical (but rarely observed) malaria attack lasts 6-10 hours. It consists of :

**Cold Stage**

There is a general sensation of cold followed by rigors. The temperature rises to 40º C and stays for nearly 1 hour. At this time parasites are demonstrable in the blood.

**Hot Stage**

In this stage there is fever, headaches and vomiting. Skin feels hot and dry .This lasts from 2-6 hours.

**Sweating Stage**

The patient sweats profusely and temperature returns to normal. This stage lasts from 2-4 hours.

Classically the attacks occur every second day with the "tertian" parasites (*P. falciparum, P. vivax,* and *P. ovale*) and every third day with the "quartan" parasite (*P. malariae*). More commonly, the patient presents with a combination of symptoms of fever, chills, sweats, headaches, nausea, vomiting, body aches and general malaise. Physical findings may include elevated temperature, perspiration, weakness, enlarged spleen etc. In P. falciparum malaria, additional findings may include mild jaundice, enlargement of the liver and increased respiratory rate. Diagnosis of malaria depends on the demonstration of parasites on a blood smear examined under a microscope. In *P. falciparum* malaria, additional laboratory findings may include mild anemia, mild decrease in blood platelets (thrombocytopenia), elevation of bilirubin, elevation of aminotransferases, albuminuria, and the presence of abnormal bodies in the urine (urinary casts").

(b) Severe Malaria

Severe malaria occurs when *P. falciparum* infections are complicated by serious organ failures or abnormalities in the patient's blood or metabolism. The manifestations of severe malaria include cerebral malaria, with abnormal behavior, impairment of consciousness, seizures, coma, or other neurologic abnormalities, severe anemia due to hemolysis, hemoglobinuria, pulmonary edema or acute respiratory distress syndrome (ARDS), which may occur even after the parasite counts have decreased in response to treatment, abnormalities in blood coagulation and thrombocytopenia, cardiovascular collapse and shock.

**Relapse**

In cases of *P. vivax* and *P. ovale* infections, recurrent attacks could be due to re-activation of hypnozoites in the liver. This can occur any time after 30-180 days of the primary attack. The relapses have the characteristic symptoms of malaria. Splenomegaly may be a prominent feature in these patients. Such long-term relapses commonly occur in patients who have either not taken primaquine or taken incomplete treatment.

**Recrudescence**

In *P. falciparum* and *P. malariae* infections, the parasites can remain in the blood for months or even years and cause recurrent symptoms from time to time. In falciparum malaria, such recrudescence can occur within 28 days of the primary attack and may indicate partial resistance to chloroquine. However, treating every case of recurrent *P. falciparum* as resistant malaria is unjustified. One should consider the possibility of re-infection in most of these cases.

**Diagnosis**

Peripheral smear examination for malarial parasite is the gold-standard in confirming the diagnosis of malaria. Thick and thin smears prepared from the peripheral blood are used for the purpose. The thick smear of correct thickness is the one through which newsprint is barely visible. Thick smears are used to detect infection, and to estimate parasite concentration. Thin film examination is the gold standard in diagnosis of malarial infection.

The QBC Test, developed by Becton and Dickenson Inc., is a new method for identifying the malarial parasite in the peripheral blood. It involves staining of the centrifuged and compressed red cell layer with acridine orange and its examination under UV light source. It is faster and easier.

The other tests include Para Sight F test, OptiMal Assay, the immuno chromatographic test (ICT Malaria P.f. test), Polymerase Chain Reaction, detection of antibodies by Radio immuno assay, immunofluorescence or enzyme immuno assay.

Rapid Diagnosis of Malaria (Dipstick Test)

The immunochromatographic tests for the detection of malaria antigens, developed in the past decade, have opened a new and exciting avenue in malaria diagnosis. However, their role in the management and control of malaria appears to be limited at present. Immunochromatographic tests are based on the capture of the parasite antigens from the peripheral blood using either monoclonal or polyclonal antibodies against the parasite antigen targets. Currently, immunochromatographic tests can target the histidine-rich protein 2 of *P. falciparum,* a pan-malarial Plasmodium aldolase, and the parasite specific lactate dehydrogenase. These RDTs are kit based, much faster and need only little training. A potential problem with the dipstick test is that

the circulating antigen will be detectable for many days even after the elimination of viable *P. falciparum* from the blood stream. A positive test therefore may not always indicate an active infection. Species differentiation and quantification are also not possible.

### Prevention and Control Measures

The malaria prevention and control measures aimed at breaking the 'man-mosquito-man' cycle of transmission include a number of methods which are complimentary to each other. None of the measures will be successful if applied alone in any given environment. At the same time use of all of them together may not be feasible for technical or administrative reasons. Local environmental conditions, resources and feasibility will have to be studied before optimum measures may be implemented. A survey enables us to plan and organize antimalaria measures. In practice the majority of schemes will include all these measures in various grades. For the details of all malaria control measures interested readers are advised to refer to AO 27/2004/DGMS on prevention of malaria and other mosquito borne diseases.

### Personal Protective Measures

Individual personal protection against mosquito bites is achieved by use of mosquito nets, repellents and protective clothing. The feeding and resting habits of the vectors and the cultural practices and sleeping habits of people are important determinants of the efficacy of personal protective measures. These will be most effective when the vector is endophilic/endophagic and the people are protected during the active period of vector.

#### Mosquito Nets

The use of mosquito net is the most effective personal protective measure. Net should be put up before dusk and tucked all round under the bedding. They should always be maintained in a good state of repairs by patching holes and tears and not by stitching or knotting. Mosquito net inspection should be held regularly as a drill. Definite arrangements should be made to fix the nets in barracks, huts and tents. Mosquito nets should be used in all cases of clinical/slide positive malaria cases admitted in the hospital to prevent transmission.

For making the mosquito nets more effective, the nets are now being treated/medicated with synthetic pyrethroids like deltamethrin, cyfluthrin etc. These insecticide treated bednets (ITBN) provide an irritant and excitorepellent effect besides the contact action. An additional collateral benefit is also provided against pests like bed bugs, houseflies etc. These ITBN's can be used even if torn slightly. They prevent mosquitoes from entering from any hole or biting through the net, and kill any mosquito that comes in contact with the net. These nets can be used by pregnant women & small children. These nets are also effective against sand flies. Now pretreated mosquito nets (Long Lasting Insecticidal Nets-LLINs) are also available, with a shelf life of 5 years.

#### Repellents

Diethyl toluamide (DEET) is a repellent, which is reputed to be even better than DMP Di-methyl-phthalate. A new repellent DEPA (Diethyl phenyl acetamide), indigenously manufactured by DRDE, Gwalior, has been found to be at par with DEET in efficacy and spectrum, in the trials conducted at AFMC and in the field. DEET & DEPA have been found to be very effective when applied on uniform against all haematophagous arthropods as well as leeches Repellents are used to prevent biting in the early evening before people retire to bed or into houses .

#### Protective Clothing

The wearing of long trousers and shirts with rolled down sleeves after dusk should be enforced in all epidemic areas and when personnel move by rail or road. Added protection is given by wearing web anklets.

#### Screening of Houses and Barracks

This measure is effective only when all doors, windows and ventilators in the building are screened by wire mesh of proper gauge and size (1.2 to 1.5mm).

### Anti-larval Measures

Larval control is the only effective method of radical mosquito control. In urban areas, like cantonments, garrison stations and base areas, this method complements the adult mosquito control. Anti-larval work is carried out by preventing breeding and destruction of larvae and pupae. For long term and permanent mosquito control, greater emphasis should be placed on the prevention of breeding during non-transmission season than on larvicidal measures during breeding season.

#### Vector Engineering

Avoidance of man-made mosquitogenic conditions is of primary importance. A positive aspect of mosquito breeding prevention should be kept in view and deliberately incorporated in the planning and execution of all engineering constructions and town planning schemes like River valley projects, dams and barrage constructions, road and railways constructions and irrigation systems. Drainage in water supply projects may lead to mosquitogenic conditions. Besides these, indiscriminate digging, disposal of discarded tins, containers and water collections, overhead storage tanks and septic tanks without covers are potential mosquito breeding places in urban areas. Clean edging and water deweeding, channelling, filling or draining, exposing to sunlight, shading or covering are the usual methods adopted. Underground drainage constitutes the best method of bio-engineering method for control of mosquito breeding.

#### Dry Day

Intermittent drying once a week is an effective method of prevention of breeding. This principle is applied for the control of breeding in irrigated areas and also in domestic breeding places by observance of a weekly 'dry day'. It should fall on the day when the anti-mosquito staff is due to visit that area for anti-larval work. All fire fighting tanks, ornamental ponds or water storage tanks, water coolers, fire buckets, and all domestic water containers should be emptied and allowed to remain dry for a few hours on the weekly 'dry day'.

### Larviciding and Biological control

Larval control with chemical or biological agents is relevant as the sole method of vector control only if a high proportion of breeding sites within mosquito flight range of the community to be protected can be located and are accessible, and the breeding sites are of manageable size.

### Insecticides

Use of organochlorine insecticides as contact and oral poisons to mosquito larvae has been stopped due to emergence of a genotype of resistance. Organophosphorus compounds like Temephos (Abate), Fenthion (available as Baytex liquid and Baytex granules), Pirimiphos methyl and Dursban are being used as larvicides in some countries. The Insect Growth Regulators (IGR's); the Chitin Synthesis Inhibitors and the Juvenile Hormone Mimics are the safer alternatives available for larval control.

### Biological Control

Various predators, parasites and pathogens have been trial evaluated for mosquito control. Larvivorous fishes like Gambusia affinis, Poecelia reticulata and Aplocheilus lineatus have been found effective and are being used for larval control in India. There use could complement other methods in an integrated control approach to increase an impact on vector population.

The other promising & effective agents are the biocides, Bacillus thuringiensis var israelensis and Bacillus sphaericus. These biocides are spore producing bacteria and when ingested they kill the mosquito larvae by causing internal lysis of gut due to the action of delta endotoxin. Floating layer of polystyrene beads prevent mosquito breeding for long periods when used in confined sites such as cesspits and water tanks.They may be used effectively against *An. stephensi , Ae. Aegypti* and *Culex quinquefasciatus.*

## Anti-adult Measures

### Indoor residual spraying

The principle of malaria control by intercepting its transmission, by shortening the life span of the vector species to a period shorter than the extrinsic incubation period of the parasite, has come to be established. This principle has been successfully employed by the application of residual insecticides to the resting places of mosquitoes, viz. the inside of all the walls of habitations. For the limited objective of disease control it is not necessary to carry out the work throughout the year or in the entire territory but only in houses and shelters in endemic zones during the transmission season. However, there are certain conditions under which the absolute efficacy of this procedure may be doubted, for instance, where vector is exophilic or though biting indoors it does not rest indoors, or where the surfaces sprayed are subject to frequent mud plastering or white washing. Even when local conditions do not appear to be absolutely favorable, the application of residual insecticide gives relative success in disease control. DDT, Malathion and the members of synthetic pyrethroids like cyfluthrin, deltamethrin etc are the residual insecticides of choice depending upon the susceptibility of the vectors. At least 85% of the dwelling units should be covered for effective control. Residual spray is of limited value where the vector species are exophilic. To select an insecticide one must consider its residual effectiveness, safety/toxicity, vector susceptibility, its impact on disease incidence, cost effectiveness, resistance status and consumer acceptability.

### Space Sprays

Space spraying of insecticides can be used against adult mosquitoes. Pyrethrum in the strength of 0.1 percent is an excellent space spray. It is used mainly when an uncontrolled, unknown or infected area has to be occupied at a short notice or when an unforeseen epidemic breaks out. Space spraying carried out more often results in better mosquito control. Aerosols are also used as space insecticides under emergency conditions in small enclosed places. In some areas spraying of organophosphorus compounds such as Malathion by ground generated fogs and aerial ultra low volume (ULV) application has been tried with varying results. The spraying operation should be timed to coincide with the peak activities of the vectors. The operational costs are high and the residual effect is low. Thus, it may be more relevant in urban areas where large numbers of people congregate outdoors at night or during epidemics to contain transmission.

### Genetic Control

The control of adult mosquitoes by means of 'Sterile Male Release' (SMR) technique and other genetic methods such as cytoplasmic incompatibility, chromosomal translocations, sex distortion and gene replacement have been attempted in the past. However, all these methods have still to prove their worth and utility in the field. The scope of recombinant DNA technology is immense and research is being carried out to use this tool for vector control.

### Insecticide Resistance in Malaria Vector

Insecticide resistance has been commonly recorded by laboratory tests in many malaria vector populations throughout the world. Resistance can be due either to detoxification of insecticide by enzymes or by mutation on its target site: sodium channels for DDT and pyrethroids (kdr), and acetyl-cholinesterase for organophosphates and carbamates. It is considered that the most practical approach to resistance management in residual spraying programmes is the rotation of unrelated insecticides according to a pre-arranged plan or the switching of insecticides in response to the results of resistance tests. The use of mixtures of unrelated insecticides or treatment of different parts of a net with different insecticides is thought to be promising. The combination of two safe and effective insecticides on the same net offers great potential.

## Environmental Management

Environmental management approaches to vector control aim at modifying the environment to deprive the target vector population of its requirements for breeding,

resting and feeding purposes. This reduces human-vector contact and renders conditions less conducive for disease transmission. These include periodic flushing in streams by means of small dams with siphons and sluice gates, changing the salinity of breeding habitats of *A. Sundaicus* , the location of housing to avoid proximity to major breeding sites, intermittent irrigation, proper lining and shaping of irrigation canals etc.

#### Chemoprophylaxis

Chemoprophylaxis is a valuable supplementary measure under high risk situations, but not a substitute for other control measures. It reduces clinical attacks by suppressing the schizogony. Extent of suppression depends upon the virulence of the local strain, the state of herd premunition, the density of infected mosquitoes and the sporozoites introduced per infected mosquito bite. These are high at the height of the malaria transmission season. Chemoprophylaxis is begun one week before entering a malarious area and is continued until four weeks after leaving it.

#### Early Case Detection and Chemotherapy

In all cases of fever reporting to MIRoom /hospital malaria has to be kept as a provisional diagnosis. A peripheral blood smear will be taken in all fever cases and presumptive treatment given as per the drug policy.In case of a positive slide report, radical treatment will be instituted.

Armed Forces Policy on chemoprophylaxis and chemotherapy is given in the DGAFMS Medical Memorandum No. 81.

#### Malaria Vaccine

Significant progress has been made in the development of the malaria vaccine during the last 20 years. An ideal malaria vaccine is one that would prevent the infection at the first instance and if this is not possible, should decrease the intensity of infection and should be successful in preventing malaria transmission. The most well identified difficulty in vaccine research is the rapid alteration in its antigenic determinants. Vaccines based on a single antigen have a limited role to play in malaria because not all people respond to the same antigen. Further plasmodia can create antigen variants to elude immune system surveillance. So efforts have been directed to develop multi-stage, multi-component vaccine, incorporating multi-antigenic sequences from different asexual and sexual stages of plasmodia. About nine different malaria antigens have been identified so far, which may not be the end of the road (Table - 3).

### Malaria Control in the Armed Forces - Basic Principles

Malaria control measures in civilian or military life, in peace or war, in garrison stations or operational areas are based on the same scientific principles. Circumstances, however, may require emphasis on a particular control measure to be employed and its implementation, which should be suitable to the specific requirement of the particular area occupied. Medical Officers are advised to refer to the detailed Army Order on Prevention and Control of Malaria and other mosquito Borne Diseases.

In garrison peace stations and cantonments, long term mosquito control should be carried out by prevention of breeding through permanent engineering anti-mosquito methods and by application of other anti-larval measures; use of residual insecticides should be the second line of defence. Personal protection by the use of a mosquito net or repellents may be needed for greater safety. In the endemic areas, in base camps, at command zones and in static formations, greater emphasis and reliance should

Table - 3 : Classification of Malaria Vaccines

| Stage of Plasmodium | Antigens | Salient features |
|---|---|---|
| Pre-erythnocytic infection of abort an | Irradiated sporozoites, Circum Sporozoite Protein (CSP) or peptides, Liver stage | Stage/species specific; antibody blocks liver; large immunising dose required; can infection |
| Merozoite and Erythrocytes thus | Antigens -1 (LSA-1) Erythrocyte Binding Antigen (EBA-175), Merozoite Surface Antigen 1&2 (MSA-1&2); Ring Infected Erythrocyte Surface Antigen (RESA); Serine Repeat Antigen (SERA); Rhoptry Associated Protein (RAP); Histidine | Specific for species and stage; Cannot abort an infection; Prevents invasion of erythrocytes, reducing severity of infection |
| Gametocytes & gametes this maturation in | Rich Protein (HRP); Apical Membrane Antigen-1 (APM-1) Pfs 25, 48/45k, Pfs 230 | Prevents infection of mosquitoes; antibody to antigen prevents either fertilization or of gametocytes, zygotes or ookinetes; is of use endemic areas but not suited for travelers; antibody blocks transmission cycle |

be placed on anti-adult measures by residual insecticide spraying, anti larval measures and personal protection against mosquito bites. In order to achieve perfect safety the surroundings villages should also be included in the insecticidal spraying programme. Close collaboration and in certain cases, integration of anti-malaria scheme with the local civil anti malaria organization is essential. Their representative should be co-opted on the 'Station Health and Anti-malaria Committee.

In operational areas, personal protection by the use of mosquito nets gives maximum protection, provided its use is not hampered by intolerable heat, rain, night air attacks and other unfavourable conditions. Repellents are useful under high risk situations. Residual insecticidal spraying carried out with good organization and efforts keeps malaria incidence very low even in the operational areas.

**Chemoprophylaxis (Suppressive Treatment)**

Chemoprophylaxis is indicated only when there is a high degree of malaria risk in an area. The regime consists of a 4 aminoquinoline drug like chloroquin sulphate 300 mg or amodiaquin 400 mg given on a fixed day of the week at a formal parade under the supervision of an officer, JCO or an NCO. The treatment will be instituted under the orders of the GOC-in-C Command on the advice of his DDMS. Some of the situations under which chemoprophylaxis may be recommended are as follows:

(a) When troops are about to enter an operational area in which malaria risk at the time of entry is high.

(b) When troops in occupation of an area liable to high seasonal malaria incidence have to remain in that area during the whole or part of the malaria season

(c) When personnel in malarious areas, already on suppressive treatment, are proceeding on temporary duty/annual leave to stations in non-malarious areas.

(d) When personnel from non-malarious area are proceeding on temporary duty to stations in malarious areas where suppressive treatment is already in force.

(e) Personnel or body of troops, not on suppressive treatment, when moving out on exercise/training in uncontrolled area where there is risk of contracting malaria.

(f) At the termination of malaria season or on withdrawal of troops from a malarious area to a non-endemic area, suppressive treatment will be stopped and one time radical treatment consisting of 600 mg of chloroquin and 45 mg of primaquin will be given under strict medical supervision. Break through cases, if any will be given radical treatment for 5 days (Army Order 25/S/71, 6/79 and 27/2004/DGMS on Prevention and Control of Malaria and other mosquito borne diseases).

A camp site which affords little chance to mosquitoes for breeding and biting should be selected for occupation in operational and training areas. If tactical reasons demand siting of camps in malarious areas, the least dangerous site should be selected. The camp or its sectors should be at least one and a half km away from habitation and from any collections of water likely to breed vector species. The camp should preferably be on high ground and the direction of the prevailing wind should not be from the village or breeding places. Troop movements towards villages from dusk to dawn should be forbidden. For deciding on a suitable camp site, antimalaria measures, and for subsequently assessing the success of such measures, an investigation into the local malaria risk is necessary.

**Immediate Measures in Case of a Focal Outbreak**

Malaria often presents as a focal outbreak in one or more of the units, whether in peace or field areas. All medical officers must keep themselves well prepared to promptly undertake control measures in such situations. Equally important is to have, in place, an efficient surveillance system to keep a track of cases of malaria / fever so as to have an early warning of increase in incidence. Prompt investigations and control measures should be applied at the earliest indication of an increase in incidence rather than waiting for the full fledged epidemic to evolve. The surveillance should be at all levels by RMOs, OC ADS, SMOs / SEMOs, CO Hospital, and at Fmn HQs by Specialists in Preventive & Soc Medicine. The following steps should be quickly undertaken in the event of an impending outbreak or if a focal outbreak has occurred :

(a) Define the population (subunit / unit/ Garrison / Station) which forms a part of the epidemic so that concerted efforts can be focused to this population / area.

(b) Quick survey, preferably a total population survey

**Measures for Prevention and Control of Malaria**

**(a) Personal protective measures**
- (i) Use of mosquito nets ITBNs and LLINs
- (ii) Use of repellents DEET, DEPA, etc.
- (iii) Protective clothing
- (iv) Screening of houses and barracks

**(b) Anti - larval measures**
- (i) Vector Engineering
- (ii) Dry Day
- (iii) Use of Insecticides
- (iv) Biological Control

**(c) Anti - Adult measures**
- (i) Indoor Residual Spray
- (ii) Space Spray
- (iii) Genetic Control

**(d) Environmental management including source reduction**

**(e) Chemoprophylaxis**

**(f) Early Case Detection and Chemotherapy**

**(g) Outbreak control measures**

or at least a fever survey, taking blood slides of the total population / of fever cases, along with a rapid clinical examination. This survey should be completed within 7 to 10 days and definitely within 15 days.

(c) For all cases of fever, a blood slide must be taken and presumptive treatment with oral chloroquin to be given. Cases positive on PBS to be admitted for radical treatment.

(d) Cases of fever not responding to routine treatment within 48 hours (irrespective of whether blood slide is positive or negative) to be admitted to the military hospital / ADS for management.

(e) Mass Radical Treatment can be considered if large number of troops are being affected or the epidemic is evolving very rapidly, by the fmn cdr, depending on the assessment of situation / advise of Sr Advisor in Preventive & Social Medicine at Fmn HQ.

(f) Outdoor thermal fogging with malathion 95% technical or deltamethrin 1.25% ULV will be undertaken to decrease the adult population at dusk and dawn as an immediate measure. The residents will be advised to open all doors and windows while the operation is in progress. Fogging machine may be mounted on a motorcycle or small vehicle running at a speed of not more than 6Km/hr. Fogging machines may be procured/ kept servicable from local resources in advance before beginning of malaria season.

(g) Space spray with 0.1% pyrethrum solution at dusk, in all living areas (units, barracks) as well as in offices where night duty personnel are staying, for the next 15 days or till epidemic starts declining, which ever is later.

(h) Residual insecticide spray (usually Malathion 50%) on the inner surfaces of all tents / living-in barracks, as a special round, irrespective of the earlier rounds already conducted.

(j) Strict enforcement of antimalaria discipline: Proper clothing, keeping exposed body area to the minimum.

(k) Enforcing 100% use of mosquito nets by troops while sleeping, unless operationally impossible.

(l) Ensuring that all troops, while outdoors, from dusk to dawn, apply repellants (Odomos / DEET/DEPA/ Mosfree) on exposed body parts.

(m) Quick and detailed search for mosquito breeding spots in and within one Kilometre around the affected area and coverage of all areas with Fenthion / Temephos (for potable water) within the next 15 days. Simultaneously, mosquito surveillance activities to be started.

(n) Impregnation of mosquito nets with Deltamethrin / Cyfluthrin.

(o) For troops deployed outdoors, the following measures can be tried :-

(i) Cloth patches impregnated with deltamethrin, stuck to uniforms with a Velcro, around the collar, around the jungle hat, sleeves and lower ends of trousers.

(ii) Impregnation of camouflage nets (often used at sentry posts) with Deltamethrin / cyfluthrin.

(p) Ongoing monitoring of the incidence, while the control measures are being enforced, and thereafter.

Several of the measures enumerated above will be instituted together for immediate control of an outbreak. Finally, the success of all measures depends upon the discipline and cooperation of all ranks and a well-organized execution of all measures. Discipline depends mainly on training. Well trained and disciplined troops have a lower incidence of malaria than ill trained and indisciplined personnel. Training in the prevention and control of malaria should be an essential part of all 'training for war'. All ranks must receive frequent practical demonstrations in the correct method of using a mosquito net, protective use of clothing and application of insect repellent. Unit spraying squads must be drilled in the proper method of spraying in barracks, tents, bashas, bunkers and bivouaces. Spraying equipment must be used properly and always maintained in working condition; the squad must be adequately trained to do this. Commanders should be constantly advised in the principles of camp selection and siting, anti-malaria measures and discipline. Full cooperation of all ranks will not be obtained unless officers and men realize the seriousness of the malaria menace to war efforts, if it breaks out among troops; and the importance and the

**Outbreak Control Measures**

(a) Define the population at risk.

(b) Disease Management - A rapid fever survey and presumptive treatment of all fever cases in the affected area.

(c) Reduction of transmission through vector control

(i) Outdoor Thermal Fogging

(ii) Indoor Knockdown Space Spray

(iii) An additional round of Indoor Residual Spray

(iv) Larviciding and abolition of all breeding spots in 1 Km area around affected place.

(d) Strict enforcement of anti malaria discipline

(e) Impregnation of mosquito nets, cloth patches, Camouflage nets etc.

(f) Consider mass radical treatment

(g) Consider chaemoprophylaxis for high risk groups like pregnant women and non-immune people

(h) Educate the environment at all levels.

(j) Ongoing monitoring of incidence and control measures

necessity of prevention of its occurrence under the present unbalanced state of malaria eradication in our country.

**Anti-malaria Organization in The Armed Forces**

(a) In cantonments and garrisons the Station Commander, under the advice of the SEMO, is responsible for the initiation and execution of all control measures, broadly based upon the current formation orders and instructions in collaboration with the Station Health Committee.

(b) This committee scrutinizes the proposed anti-malaria measures, notes the progress of the campaign and remedies any observed defects, in the months prior to the beginning of the malaria season and in the month preceding the one in which malaria incidence is usually at its maximum. It reviews the results of the anti-malaria measures and formulates a tentative scheme for the following year in the month after the termination of the malaria season.

(c) Officers commanding the units are responsible for all anti-malaria measures within their units and in the adjoining area placed under their charge.

(d) Every unit has an anti-malaria squad under the supervision of the trained regimental anti-malaria officer.

(e) In operational areas the formation Commander may call similar meetings of unit commanders and representatives of the medical and engineering services to discuss similar subjects whenever necessary.

(f) Technical medical staff officers (DADH/ADH) and the officers Commanding Station and Field Health Organization assist the Commanders in planning control measures, advise unit commanders, maintain scrutiny regarding anti-malaria measures within their respective zones, and co-ordinate control in different sectors of the station or area into a closely integrated scheme.

(g) The station, camp, base or comn zone and its periphery for 1 km in depth is divided into a number of circles depending upon the size of the station or area and the degree of prevailing malaria. Each is further sub-divided into five zones, each of which is capable of being treated on one working day by the available labour gang or unit squad.

(h) In endemic areas the following records should be maintained by units/formations:

(i) A chronological diary showing the principal events in the malaria season, the programme and progress of anti-malaria work, meetings held, state of equipment, initiation and termination of anti-larval measures and of spraying campaign, initial determination and periodical check of spleen and parasite rates in villages.

(ii) Weekly meteorological records correlating the number of adult anophelines (by species) caught per collection in any catching stations ear marked, incidence of malaria cases by units and sub units.

(iii) The records regarding the dates, dosage and number of rooms, houses, huts and tents treated with insecticide.

(iv) A large scale map of the area showing temporary or permanent (potential and actual) breeding places and a unit spot map showing each case by barracks and quarters for indicating the effectiveness of control measures.

(v) Malaria case register showing the personal, clinical and epidemiological particulars of each case with columns showing number rank, unit/sub unit, date of onset of fever, date of admission to hospital, date of positive microscopic diagnosis; the species of Plasmodium, relapse or fresh; if relapse the previous dates of fever or hospital admission for malaria, movements during the previous three months to determine the probable place of infection and whether the transmission is local or the case is imported from another locality, indication of the personal

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# Leishmaniasis

## Introduction

Leishmaniasis encompasses a varied collection of diseases ranging in severity from a spontaneously healing skin ulcer to overwhelming visceral disease (1). The disease is named after Leishman, who first identified the organisms in smears taken from an man who had died of "Dum Dum" fever in 1901 (2) An estimated two million cases of all forms of Leishmaniasis taken together occur worldwide very year (3, 4). The disease is caused by 21 species of the genus Leishmania which are pathogenic to humans and transmitted by the bite of 30 species of the phlebotomine sandfly (3, 4, ). There are four main types of the disease: Cutaneous, Diffuse cutaneous, Mucocutaneous and Visceral Leishmaniasis which is commonly called Kala azar (3). Leishmania species are members of the family Trypanosomatidae, order Kinetoplastida. They reside as intracellular amastigotes within macrophages in mammals and as extracellular promastigotes in the gut of their insect vectors, phlebotomine sand flies (5). Leishmaniasis has also emerged as an AIDS - associated opportunistic infection (6).

## Epidemiology

World

Leishmaniasis is endemic in 88 countries on five continents. More than 90% of Cutaneous Leishmaniasis cases occur in Iran, Afghanistan, Syria, Saudi Arabia, Brazil and Peru. More than 90% of Visceral Leishmaniasis cases occur in Bangladesh, Brazil, India and Sudan. The World Health Organization estimates that 350 million people are at risk of Leishmaniasis world wide. The true incidence and prevalence are uncertain because of the large number of undiagnosed cases, the lack of screening, and underreporting (7-9). Every year, an estimated one and a half to two million children and adults develop symptomatic disease and the incidence of infection is substantial when sub - clinical infections are included. The number of new cases of Cutaneous Leishmaniasis each year in the world is estimated to be about 1.5 million while the number of new cases of Visceral Leishmaniasis is estimated to be about 5,00,000. An estimated 12 million people are presently infected worldwide. Leishmaniasis is associated with about 2.4 million disability - adjusted life years and around 7,00,000 deaths per year (7-9). Since 1993, the geographical distribution of Leishmaniasis has expanded significantly.

The disease is endemic in three countries of the WHO South East Asia Region, Bangladesh, India and Nepal. Approximately 200 million people in the Region are "at risk" from the disease. The disease is reported in 45 districts in Bangladesh, 52 in India and 12 in Nepal. Of the estimated 5,00,000 people in the world infected each year, nearly 1,00,000 are estimated to occur in the Region (10).

India

India is one of the world's largest foci of Visceral Leishmaniasis, accounting for 50% of the total burden of this disease. Leishmaniasis is endemic in eastern States of India. A total of 52 districts in the country are considered endemic for the disease. An estimated 165. 4 million population is at risk of Kala Azar in four states. In India, about 1,00,000 cases of Visceral Leishmaniasis are estimated to occur annually. Of these, the State of Bihar accounts for more than 90 per cent of the cases. Cutaneous Leishmaniasis usually occurs in the dry, north eastern states of India, bordering Pakistan extending from Amritsar to Kutch and Gujrat plains. Cases of Anthroponotic Cutaneous Leishmaniasis has been reported from Bikaner city (10, 11).

## Agent

The disease is caused by 21 protozoan species of the genus Leishmania (order Kinetoplastida). The amstigote forms are obligate intracellular parasites while the promastigotes are extracellular in the arthropod vectors.

These human pathogens include the *Leishmania donovani* complex with three species (*Leishmania donovani, Leishmania infantum* and *Leishmania chagasi*). The *Leishmania mexicana* complex has three main species which are *Leishmania mexicana, Leishmania amazonensis* and *Leishmania venezuelensis.* The other major pathogenic species are *Leishmania tropica, Leishmania major* and *Leishmania aethiopica.* The different species are morphologically indistinguishable, but they can be differentiated by isoenzyme analysis, molecular methods, or monoclonal antibodies. In India, *Leishmania donovani* is the only parasite causing this disease.

The life cycle is relatively simple. Amastigotes are oval or round in shape and approximately 2 to 3 µm in diameter. They have a large, eccentrically located nucleus, a specialized mitochondrial structure, the kinetoplast, which contains a substantial amount of extranuclear DNA and a flagellar pocket and flagellum, which lie within the confines of the cell. They multiply by simple binary division. In the gut of the sand fly, leishmania live and multiply as extracellular, flagellated promastigotes that vary morphologically from short, stumpy forms to elongated ones ranging from 10 to 15 µm in length and 2 to 3 µm in diameter. A single flagellum extends from the anterior pole. After development in the sand fly gut, which takes approximately 1 or 2 weeks depending on the Leishmania species, infectious metacyclic promastigotes migrate to the proboscis (5, 12, 13).

Vector

Leishmania species are transmitted by female sand flies of the genus Lutzomyia in the Americas and Phlebotomus in other parts of the world. Depending on the species, sand flies live in forested areas, rodent burrows, or debris in peri - domestic habitats. Sandflies breed in cracks and crevices in the soil and buildings, tree holes, caves. They are weak fliers, but they can be carried considerable distances by the wind. Sand flies probe

with their proboscis to form a venous pool, from which they obtain blood by capillary action (5, 14, 15). A total of about 30 species in Phlebotomus genus (old world) and Lutzomyia genus (new world) have been identified as vectors. Sandflies are active in the evening and night - time hours. In India, *P. argentipes* is a proven vector of Kalazar. Cutaneous Leishmaniasis is transmitted by *P. papatasi* and *P. sergenti.*

Host Factors

Most leishmaniases are zoonotic and humans become infected only when accidentally exposed to the natural transmission cycle. The animal host may be wild animals, such as rodents, and domestic animals, such as dogs. However, in the anthroponotic forms humans are the sole reservoir host. Indian Kala - azar is anthroponotic with humans beings as the only known reservoir of infection.

Infection can occur in all age groups and both genders. In India peak age of infection is 5 to 9 years. Males are affected more often than females probably due to greater exposure. Population movement is important in spreading infection between endemic and non endemic regions. The disease usually strikes the poorest of the poor (10, 16, 17). It is common in various farming practices, forestry, mining and fishing who have greater risk of being bitten by sand - flies. Recovery from kala - azar gives a lasting immunity.

Environmental Factors

The disease is mostly confined to the plains. It does not occur in altitudes over 2000 feet. Prevalence usually shows a rise during and after rains. The diseases are largely confined to rural areas and those urban areas where opportunities for breeding of sand flies exist. Overcrowding, poor ventilation and accumulation of organic matter in the environment facilitates transmission. Developmental projects like forest cleaning, and cultivation projects, large water resources schemes, and colonization and resettlement programmes are bringing human beings into areas of high vector and reservoir concentration (5, 18).

Mode of Transmission

The disease is transmitted by the bite of infected female sandflies. Rarely other modes of transmission might result in infection. Visceral Leishmaniasis can be directly initiated by amastigotes via blood (shared needles, transfusion, transplacental spread) or organ transplantation. Cutaneous infection can develop after inadvertent needlestick injury if the needle or syringe contains infected material (6, 12-14).

Clinical features

The outcome of leishmanial infection is dependent on a series of complex and only partially understood interactions between Leishmania species - specific virulence factors and the genetically determined cell - mediated immune responses of their mammalian hosts. The incubation in man is extremely variable. It usually ranges from 3 to 8 months but can be as short as 10 days to as long as2 years

Leishmaniasis has several diverse clinical manifestations: ulcerative skin lesions, destructive mucosal inflammation, and disseminated visceral infection (kala azar). Epidemiology, immunopathology, and outcome are similarly diverse, since infection occurs in multiple endemic regions, in both children and adults, and is caused by nearly two - dozen distinct Leishmania species. Nevertheless, all forms of this protozoal infection share three pathogenetic features: resident tissue macrophages are targeted and support intracellular parasite replication; the host immunoinflammatory response regulates expression and outcome of disease; and persistent tissue infection is characteristic (6, 12, 13). Each of the three major clinical syndromes can present with a wide spectrum of findings. Each of these syndromes is associated with more than one Leishmania species, and any given species is capable of producing more than one syndrome. Variations are common, particularly among people who are concurrently infected with HIV or other immunosuppressive illness (5, 12, 13).

Cutaneous Leishmaniasis (5, 12)

The typical lesion of Cutaneous Leishmaniasis develops at the site where promastigotes are injected by the vector. Promastigotes are taken up by mononuclear phagocytes. They transform to amastigotes and multiply within the macrophages. A papule is formed at the site of inoculation. The papule enlarges and then ulcerates. Multiple lesions may be present in the same patient. Depending on the location, Old World Cutaneous Leishmaniasis is known locally as Oriental sore, Bouton d'Orient, Bouton de Crete, Bouton d'Alep, Bouton de Briska, Aleppo evil, Baghdad boil, and Delhi boil.

There can be marked variation in the appearance of the lesions. The classic wet lesion of *L. major* and *L. braziliensis* is "pizza - like" with a raised outer border, granulating base, and overlying white, purulent exudate. Infection by *L. tropica* produces dry lesions in the Middle East and India. The ulcer tends to be smaller and covered with a crust. Contiguous mucosal involvement may be seen in some patients. Some leishmanial lesions are papular or nodular, without ulceration. Cutaneous lesions persist for months, and in some cases years, before they heal, leaving flat, atrophic scars as evidence of disease. Once a lesion has resolved, the person is usually left with immunity against the infecting Leishmania species. Cutaneous Leishmaniasis should be considered in the differential diagnosis of subacute or chronic skin lesions in people who have lived, worked, or traveled in endemic areas.

Mucosal Leishmaniasis (Espundia)

A small proportion of people infected with *L. braziliensis* develop mucosal lesions in the nose, mouth, pharynx, or larynx months to years after resolution of the primary skin lesion. The condition is known as espundia in Latin America. Mucosal Leishmaniasis often begins with nasal stuffiness and inflammation. Ulceration of the nasal mucosa and septum follows. The lips, cheeks, soft palate, pharynx and larynx may eventually be involved, resulting in substantial disfigurement. Mucosal involvement is also observed with other Leishmania species, although the pathophysiology may be somewhat different. Destructive involvement of the nose and mouth has been reported with *L. tropica* in Saudi Arabia. Mucosal involvement has been reported rarely in immunocompetent people and more frequently in those who are immunosuppressed with neoplasms or AIDS (5, 12).

Visceral Leishmaniasis

The majority of infections of Visceral Leishmaniasis are sub clinical. Only a minority of those infected develop full - blown Visceral Leishmaniasis, or kala - azar. The disease is characterized by fever, weight loss, and hepatosplenomegaly.

Malnutrition, which is known to suppress cell - mediated immune responses and may contribute to progression to

symptomatic Visceral Leishmaniasis. The incubation is typically weeks to several months, but it may be as short as 10 days or as long as several years. The onset of Visceral Leishmaniasis is usually insidious, but it can be abrupt, with high fever. Full - blown, progressive Visceral Leishmaniasis, or kala - azar, is associated with fever, abdominal enlargement, weakness, loss of appetite, and weight loss. The clinical findings are similar with *L. donovani* and *L. infantum / chagasi.* Symptoms may be present for weeks to months before patients come to medical attention in rural, endemic areas. The fever pattern may be intermittent, remittent or rarely continuous. The spleen is firm, non - tender, and over time becomes massively enlarged. There is hepatomegaly with the enlarged liver having a sharp edge and smooth consistency. Some patients in India develop hyperpigmentation leading to the name kala - azar, which means "black fever" in Sanskrit. The late stages of disease are characterized by malnutrition, severe wasting, and progressive debilitation. Stunting may be seen in children. Death often occurs due to a secondary bacterial infection, such as pneumonia, septicemia, dysentery, or tuberculosis, or with measles or other viral infection.

Laboratory findings include anemia, neutropenia, thrombocytopenia & pronounced hypergammaglobulinemia. The anemia is usually normocytic, normochromic, unless there is concomitant iron deficiency. Leukopenia can be profound with white blood cell counts below 1000/mL. The globulin level can reach 9 or 10 g/dl.

Post - Kala - Azar Dermal Leishmaniasis.

Some patients of Visceral Leishmaniasis in India and Africa develop skin lesions following treatment, ranging from hyperpigmented macules to frank nodules. Skin lesions typically appear in India 1 or 2 years after treatment and may persist for as long as 20 years. Persistence of lesions beyond one year is associated with high anti - leishmanial antibody titers and negative leishmanial skin test responses. Anti - leishmanial treatment is indicated in Indian post - kala azar dermal Leishmaniasis. In a few instances in India, Visceral Leishmaniasis has recurred in patients with post - kala - azar dermal Leishmaniasis. The differential diagnosis includes leprosy (5, 12, 13).

HIV - Visceral Leishmaniasis co - infection

Leishmania with HIV co - infection is has emerged as a serious new disease and is increasingly frequently being reported. Immunocompromised individuals progess to full blown Visceral Leishmaniasis far more often than immunocompetent people who get infected. AIDS and Visceral Leishmaniasis are mutually reinforcing. Visceral Leishmaniasis quickly accelerates the onset of AIDS and shortens the life expectancy of HIV - infected people. Similarly AIDS increases the risk of Visceral Leishmaniasis by 100 - 1000 times in endemic areas. This combination of HIV and Leishmaniasis produces cumulative deficiency of the immune response since Leishmania parasites and HIV destroy the same cells, exponentially increasing disease severity and consequences. Visceral Leishmaniasis is considered a major contributor to a fatal outcome HIV in co - infected patients. Another implication of this combination is that Leishmaniasis can be transmitted directly person to person through the sharing of needles, as is often the case among intravenous drug users (13, 19).

Diagnosis

Cases of Leishmaniasis should be confirmed by demonstration of the parasite, which is straightforward if parasites are plentiful as in Visceral Leishmaniasis but can be difficult otherwise.

Parasite Identification

The diagnosis of Leishmaniasis is most often confirmed by identifying leishmania amastigotes in Wright–Giemsa - stained touch preparations or tissue sections or by isolating the parasite in culture. Amastigotes are seen in macrophages in tissue sections, but they may appear to be extracellular in touch preparations. Leishmania can be grown as promastigotes in NNN medium, Schneider's insect medium, and other tissue culture media. The cultures are incubated at 24 to 26°C to approximate sand fly temperatures.

Serology

Antileishmanial antibody titers are typically present in high titer in people with Visceral Leishmaniasis and at low titer or undetectable in those with Cutaneous Leishmaniasis. They can be measured by a number of assays. Enzyme - linked immunosorbent assay (ELISA), indirect immunofluorescent tests, and agglutination assays have all been used (20)

Skin Test

The intradermal leishmanin (Montenegro) skin test is positive in the majority of people who have asymptomatic, self resolving *L. donovani* and *L. infantum / chagasi* infections and in people with Cutaneous or Mucosal Leishmaniasis. The skin test is negative in people with progressive Visceral Leishmaniasis or Diffuse Cutaneous Leishmaniasis, but it becomes positive in the majority of people who are successfully treated for Visceral Leishmaniasis.

Treatment

The drug of choice for the treatment of Visceral Leishmaniasis is Sodium stibogluconate, a pentavalent antimonial compound except in regions that are considered Sodium stibogluconate unresponsive. The dose is 20 mg Sb/kg/day IV or IM daily for 20 - 30 days. However, resistance is on the rise and resistance levels as high as 43% have been reported from Bihar where Visceral Leishmaniasis is endemic. Patients resistant to stibogluconate should be treated with alternative agents, such as liposomal amphotericin (0.5 - 3 mg/kg) on alternate days or pentamidine (2 - 4 mg/kg) on alternate days for 15 doses. Amphotericin B deoxycholate is the drug of choice in India, whereas the lipid formulation liposomal amphotericin is used in Europe (2). The dose of Amphotericin B used in India is 1mg/kg IV infusion daily or alternate day for 15 - 20 infusions. The dose can be increased in patients with incomplete response with 30 injections. Miltefosine, the first effective oral treatment for Visceral Leishmaniasis, including for antimony - resistant infection has been approved for self - administered outpatient therapy (13, 21, 22). The drug is to be used in a dose of 100 mg daily for four weeks. Supportive treatment includes rest, high - calorie diet, blood transfusions, and treatment of secondary infections.

Prevention and Control

Leishmaniasis can be prevented by interrupting sand fly transmission or by removing or treating reservoirs of infection

(18, 23). The short - term visitor to an endemic area should use personal protective measures to avoid sand fly bites. Sand flies tend to bite from dusk to dawn. The application of DEET (diethyltoluamide) - containing insect repellents to exposed skin and under pant and shirt cuffs, the use of fine - mesh screens or insect nets, and the application of insecticide (usually permethrin or other pyrethroids) to clothing and bed nets–decrease the risk of transmission of Leishmaniasis. Further details on vector control are given in the chapter on Entomology.

Vaccine

There is experimental evidence to indicate that Leishmaniasis should be vaccine preventable. However, there is currently no vaccine against any form of Leishmaniasis for general human use. One major factor may be the lack of a conceived market for human Leishmaniasis vaccines. Leishmaniasis is a considered a local/regional problem and not a global one (24). A number of candidate vaccines are undergoing clinical trails. Killed parasites as vaccines produced encouraging results in Brazil in the 1970s. Trials have tested autoclaved *L. major* plus BCG versus adjuvant (BCG) alone. In Ecuador, two doses of a killed multi-leishmania species cocktail plus BCG reduced Cutaneous Leishmaniasis incidence by 73% the first year (13,25).

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# Rickettsial Diseases

## Introduction

Rickettsial diseases are widely distributed throughout including large parts of the Indian subcontinent. As re-emerging diseases they represent some of the oldest and most recently recognized infectious diseases (1,2) Of the 14 currently recognized rickettsioses, six have been described within the last 12 years (1). Rickettsia are morphologically and biochemically similar to other Gramnegative bacteria. These obligate intracellular parasites are arthropod-associated bacteria, but they are also capable of infecting vertebrates, including humans, usually as accidental hosts (3). The geographic distribution of rickettsial diseases is largely determined by their vectors (4).

## General Considerations

### Bacteriology

Rickettsiae are a diverse collection of organisms with several differences. The common threads that hold the rickettsiae into a group are their epidemiology and their obligate intracellular lifestyle. Phylogenetically they occupy a position between bacteria and viruses. The genus Rickettsia is included in the bacterial tribe Rickettsiae, family Rickettsiaceae, and order Rickettsiales. They include the genera Rickettsiae, Ehrlichia, Orientia, and Coxiella. Rickettsia are small (0.3 X 2 µm) aerobic, obligate intracellular parasites. They are Pleomorphic, usually cocobacillary. They appear blue with Geimsa's stain and their growth is enhanced in the presence of sulphonamides.

### Host Factors

Groups at risk for exposure to agents of rickettsial diseases are travellers, wood cutters, farmers and army personnels as their occupational or recreational activities bring them in contact with habitats that support the vectors or animal reservoir species associated with these pathogens (5).

### Pathogenesis

Rickettsiae are transmitted to humans by the bite of infected ticks and mites and by the faeces of infected lice and fleas. The rickettsiae present in the dried excreta of insects may also enter through the conjunctivae or even through inhalation. After entering the body rickettsia spread through the bloodstream to infect vascular endothelium in the skin, brain, lungs, heart, kidneys, liver, gastrointestinal tract and other organs.

### Distribution

The geographic distribution, epidemiological and clinical aspects of rickettsial agents are described below in the Table - 1 and Table - 2.

## Epidemiologic Features of Rickettsial Diseases

Table - 1 : Epidemiologic Features of Rickettsial Diseases

| Antigenic group | Disease | Agent | Vector | Animal reservoir | Geographical distribution |
|---|---|---|---|---|---|
| Typhus fevers | Epidemic typhus | *Rickettsia prowazekii* | Human body louse *(Pediculus humanus corporis)* , | Humans, | Mountainous regions of Asia, and Central and South America, Africa India:J&K, Himachal, Uttarakhand,W Bengal, Arunachal Pradesh. |
| | Murine typhus | *R. typhi* | Rat flea *(Xenopsylla cheopis)* | Rats mice | Worldwide |
| Spotted fevers | Indian Tick Typhus | *R. conorii* | Tick *(Ixodes sp Boophilus sp Hemophysalis sp)* | Dogs, rodents | Africa, India, Europe, East, Mediterranean. India:Uttaranchal |
| | Rickettsial pox | *R. akari* | Mite | House mice | Russia, South Africa, Korea, Turkey, Balkan countries |
| | Rocky Mountain spotted fever | *R. rickettsii* | Tick | Rodents | Mexico, Central, and South America |
| Orientia | Scrub typhus | *Orientia tsutsugamush* | Mite *(L deliense)* | Rodents | Asia and Australia India: J&K, Himachal, Uttarakhand,W Bengal, Arunachal Pradesh |
| Coxiella | Q fever | *Coxiella burnetii* | Inhalation of infectious aerosols; tick | Goats, sheep, cattle, domestic cats. | Worldwide |
| Bartonella | Cat-scratch disease | *Bartonella henselae* | Cat flea | Domestic cats | Worldwide |
| | Trench fever | *B. quintana* | Human body louse | Humans | Worldwide |

Table - 2 : Clinical Features and Treatment of Rickettsial Diseases

| Disease | Predominant symptoms | Treatment | Incubation period | Vaccine | Weil Felix Reaction |
|---|---|---|---|---|---|
| Epidemic typhus | Headache, chills, fever, prostration, confusion, photophobia, vomiting, rash (generally starting on trunk) | Doxycycline 100mg BD for 7-10 days or till person is afebrile. Chloramphenicol 60-75mg/kg/day in 4 divided doses for pregnant women | 6 – 15 days | + | OX-19 |
| Murine typhus | As above, generally less severe | -do- | 8 – 16 days | - | OX-19 |
| Indian Tick Typhus | Fever, eschar, regional adenopathy, maculopapular rash on extremities | -do- Alternative-Ciprofloxacin | 5 – 10 days | - | OX-19 or OX-2 |
| Rocky Mountain spotted fever | Headache, fever, abdominal pain, macular rash progressing into Papular or petechial (starting on extremities) | -do- | 2 – 14-days | - | OX-19 or OX-2 |
| Scrub typhus | Fever, headache, sweating, conjunctival injection, adenopathy, eschar, rash, respiratory distress | Doxycycline 100mg BD. Rifampicin 600-900mg/day, Azithromycin and Ciprofloxacin are other alternatives | 6 – 21 days | - | OX-K |
| Q fever | Fever, headache, chills, sweating, pneumonia, hepatitis, endocarditis | Doxycycline. Rifampicin, Ciprofloxacin are other alternatives | Acute Q fever-3 -30 days | + | None |
| Trench fever | Fever, headache, pain in shins, splenomegaly, disseminated rash | Tetracyclines | - | - | None |

Epidemic Typhus

Epidemic typhus is the classical form of rickettsial disease. It is characterized by sub-acute onset, with fever interposed by rigors, accompanied by headache, nausea, giddiness, vomiting and flushed dry skin. On the third day, the temperature rapidly rises up to 40° C, face and eyes become suffused, headache and bodyache become severe, and the peculiar stuporose, drunken, confused and delirious state, similar to that found in enteric fever is seen. The patient has a foul smell and heavily coated tongue. The spleen is enlarged and haematuria and albuminuria occur. Blood pressure falls. Temperature remains high for 12-14 days. Rash occurs on 5th or 6th day. The case fatality varies widely and is influenced by the nutritional state and age of patient. In healthy, well fed young adults the case fatality is less than 5 percent. Diagnosis is confirmed by microscopic agglutination (MA), complement fixation (CF) and fluorescent antibody (FA) tests. About 30 million cases including 3 million deaths occurred in the Soviet Union & Eastern Europe during 1918-1922. During World War II, typhus struck heavily in concentration camps in Eastern Europe and North America. No case has been reported in the Indian Armed Forces since 1970.

Mode of Transmission

Human body louse, *P. humanus corporis* transmits *R. prowazekii.* Rickettsiae multiply enormously intra cellularly in the midgut of the louse. Within 10 days, they rupture, releasing a large number of rickettsiae in the body fluid and in the insects faeces. The infection is transmitted by the entry of the infectious faeces, the gut contents, or the body fluid of the crushed louse through abrasion on the skin caused by simultaneous scratching. The rickettsiae present in the dried excreta of insects may also enter through the conjunctivae or even through inhalation. The infected lice remain infective throughout their remaining life. Usually they die in a week to 12 days.

Host

Man has no natural immunity; one clinical attack confers high immunity but not life long and a second attack may occur. All ages and sexes are susceptible. The immunity is type specific; therefore, an attack does not confer immunity against other rickettsial diseases.

Communicability Period

The case is infectious to the louse during the last two or three days of the incubation period, and throughout the febrile period, for a total of about 12 to 13 days.

Prevention and Control

A high standard of personal hygiene to prevent louse infestation, avoidance of contact with those likely to be infected with the

disease and infested with louse and preventive immunization are the important preventive measures.

**(a) Personal Hygiene**

In order to reduce the likelihood of troops getting infested a very high standard of personal hygiene should always be ensured. Louse infested areas should be put out of bounds to troops.

**(b) Delousing**

Treatment of louse infested individuals can be carried out by application of dust of 10% DDT, 1% malathion or 1% lindane powder, propoxur (1%) to the person as well as his clothing. Treatment can also be done with phenothrin dust 0. 3-0. 4%. Other lotion or shampoo formulations can also be applied for better results e. g. permethrin lotion (1. 0%), deltamethrin lotion (0. 03%) etc.

**(c) Immunization**

A formalin inactivated epidemic typhus vaccine prepared from rickettsia grown in embryonated eggs was used to protect troops during World War II. It is given in 2 subcutaneous injections of 1 ml each at an interval of 10 to 14 days. Booster doses are recommended every 6 months. A recent advancement is the development of a vaccine consisting of live attenuated strain 'E' rickettsial organisms. It has been tried extensively and appears to be effective when tested under field conditions. It is not yet available for general use.

Murine Typhus (Endemic Typhus)

It is an acute febrile illness caused by Rickettsia typhi and transmitted to humans by the rat flea *Xenopsylla cheopis*. The mode of transmission is by contamination of the broken skin by rickettsia-laden faeces, and dried flea faeces gaining entry through conjunctivae or the upper respiratory tract by aerosol. Complement fixing antibodies against murine typhus have recently been detected in paired sera from local cases of PUO by workers of NIV, Pune. Similar studies elsewhere indicate that murine typhus is endemic in practically every town of India especially where rats abound. Control measures should be directed against rodents and rat fleas. There is no specific vaccine. Epidemic typhus vaccine does not protect against murine typhus. However following attack by one disease, there is some cross-protection against the other disease.

Srub Typhus

It is a rickettsial infection with a broad clinical spectrum. There may be many inapparent or mild infections. A severe attack of the disease is characterized by fever, headache, conjunctivitis, lymphadenopathy and a local vesicular lesion at the site of mite attachment which turns into an ulcer or eschar. A macular rash may appear on the body on 5th to 7th day and last for a few hours to a few days. Complications such as pneumonitis, myocarditis, encephalitis and peripheral circulatory failure may occur. With modern therapeutic agents, the case fatality and period of convalescence have been markedly reduced. The diagnosis can be confirmed by Weil-Felix (WF), fluorescent antibody (FA), complement fixation (CF) or microscopic agglutination (MA) test. Of late, PCR has become one of the important diagnostic techniques for scrub typhus. Ready to use ELISA kits are also available for the same. Geographical Distribution

The disease is limited to Southeastern and Eastern Asia, Northern Australia, India, Pakistan, Ceylon and other islands in the region. In India it is present in whole of the Shivalak range from Kashmir to Assam, Eastern and Western Ghats and the Vindhyachal and Satpura ranges in the central part of India. The distribution of the disease corresponds with the distribution of *Leptotrombidium deliense* and *L. akamushi*. The vector mite is now known to be present in diverse ecological niches such as equatorial rain forests, semi-deserts and Alpine subarctic terrains in the Himalayan regions. Endemic foci are usually associated with specific habitats such as abandoned plantations, gardens or rice fields, overgrown forest clearings, shrubby fringes of fields and forests, river banks and grassy fields. These ecological patches which attract the natural host of mite vectors are called "mite islands". Within the mite islands there may be a limited area of intensive transmission of rickettsiae called "Typhus Island".

Incidence

The outbreaks of scrub typhus have been reported in India both among civilians and personnel of the Armed Forces. During 1965 Indo-Pak conflict, large number of Indian troops suffered from this disease in Jammu-Sialkot sector. An unusual incidence of seropositive cases of scrub typhus was also reported during 1971 Indo-Pak conflict in the Eastern and Western borders. During peace time the incidence has been low, being always less than 0. 1 per 1000 strength. In the recent past incidences of scrub typhus from J&K and north eastern sector have been reported indicating a scrub typhus active zone but in 2006 there were no admissions due to scrub typhus in the Armed forces. Scrub typhus has been of particular interest to various workers in Indian Armed Forces as evidenced by a number of published papers on the epidemiology, management and prevention (6 -11).

Agent

*Orientia tsutsugamushi* is the agent of scrub typhus in India. It differs from other rickettsiae in its antigenic structure. At least eight serotypes are recognized. Infection with one strain does not produce immunity against infection by others.

Reservoir and Source

Permanent reservoirs of infection are many species of wild rodents, other mammals and birds. The infection is transmitted through the larval mites or "chiggers" belonging to the family *Trombiculidae*, genus and subgenus *Leptotrombidium*. More than 150 species have been described but only a few are known to be of importance to man. About 204 trombiculid mite species have been described from India so far. The important mite species are *L. deliense, L. akamushi, L scutellare*, *L pallidum* and so on. The rodents and acarine hosts do not succumb to the disease. Transovarian transmission of rickettsiae occurs in mites for at least 12 generations. Thus the field rodents and the vector mites act as a reservoir and between the two the infection perpetuates in nature. The migration of infested or infected rodents leads to establishment of new foci of disease. The immediate source of infection for man is the infected larval mites.

Mode of transmission

The infection is transmitted to man through the bite of infective mite larvae, which feeds on lymph and tissue fluid rather than blood. Human infection takes place when man accidentally picks up an infective larval mite while walking, sitting, or lying on the infested ground.

Immunity

Man has no natural immunity. All ages and both sexes are equally susceptible. Infection with one strain does not produce immunity against that by other strains.

Communicability Period

No person to person spread occurs.

Prevention and Control

**(a) Camp site selection**

Before occupation, the camp site should be first examined for typhus risk by assessing mite infestation of rats and soil and scrutinizing records of previous units for typhus incidence. As far as possible the infested areas should be avoided. If it must be occupied, it should be cleared and treated with insecticide (HCH insecticides Malathion / Fenthion) before occupation. This may be repeated if necessary at intervals specified by local medical authorities, depending on the density of infestation and extent of typhus risk. All mite infested areas may not be typhus areas.

**(b) Treatment of clothing**

Repellents like DEET & DEPA should be used for personal protection. Manual application of repellents to all the clothes normally used when working outdoors has always caused a reduction in the infection rate. The process is tedious and very seldom carried out thoroughly. Barrier treatment is less laborious and easily implemented in an emergency. Impregnation of clothing by mixing DBP in soap water while washing or by mechanical means has been thought of from time to time. But this has presented several difficulties including that of a heavy financial burden. Until such time as a more convenient method is not available, a systematic manual application on a parade is the only sure way to reduce the incidence of scrub typhus, especially when area treatment is not possible when engaged in active operations.

**(c) Antirodent measures**

These measures help to maintain low level of mite infestation in an area. Anti-typhus precautions should be observed by personnel during the periods and in localities as per instructions issued from time to time.

Action on occurrence of cases

On occurrence of the disease, the patient should be admitted to hospital. Isolation and disinfection are unnecessary as the patient is not infectious. Attendants and contacts do not require any special precautions. Notification of the clinical diagnosis as Gp B disease should be immediately communicated to the unit, ADMS, DDMS and DGMS and equivalent appointments in Navy and Air Force without waiting for serological confirmation. Units require early notification for taking necessary remedial and control measures. Technical staff officers should keep a spot map of case incidence as they require a general picture of endemicity of the areas successively occupied by troops keeping in view the patchy distribution of the disease. The general measures of importance under the operational conditions are (12, 13).

**(a) Camp Siting**

Mite avoidance by proper site selection, and personal precautions.

**(b) Housekeeping**

Persistent anti-rodent hygiene by denying shelter and food to rodents by proper storage of food, hygienic disposal of refuse and keeping the area and lines cleared of all junk, rubble, vegetation and by good house keeping.

**(c) Rodent Control**

Active anti-rat measures to reduce the rodent population wherever feasible. This should be carried out during the dry season.

**(d) Vector Control**

Use of HCH WDP insecticides e. g. Malathion/ Fenthion on the ground after thorough clearing, before occupying the area in an endemic zone. This has to be carried out every year before the monsoon starts and repeated as required until risk exists.

**(e) Repellents**

Application of repellants to all clothing is the most important single preventive measure while preparing for combat in or occupation of uncontrolled area.

Q fever

It is an acute infectious disease caused by *Coxiella burneti* and characterized by fever, malaise, myalgia, headache, weakness, anorexia, loss of weight and interstitial pneumonitis. Case fatality is low but convalescence is prolonged. Complications such as hepatitis, endocarditis, thrombosis, heamorrhages and meningitis may follow. The diagnosis is confirmed by CF tests. Phase II antibodies develop by the 4th week. Phase I antibodies indicate past infection, presence of chronic infection or immunity due to immunization. Radiological findings resemble those of primary atypical pneumonia.

Geographical Distribution

The disease has world-wide distribution. During World War II it was a cause of major epidemics in Europe (Balkan grippe). In Australia, the disease is enzootic in animals, especially bandicoots, and is transmitted in nature by ticks. Sheep, goats and cows are found naturally infected in North America and Europe.

Incidence

Apart from two case reports, studies on human Q fever in India have been mainly limited to sero epidemiological surveys in several parts of the country. Isolation of *C. burneti* and demonstration of its antibodies from human milk have also been reported

Agent

The causative organism of Q fever was described by Derrick in Brisbane, Australia in 1930s and named as *Rickettsia burneti.* It was later renamed *Coxiella burneti.* It is resistant to heat, drying, chemical agent and UV light. The antigen of *C. burneti* isolated from ticks, animals or man and maintained in laboratory animals is called phase I. It does not react with convalescent sera from Q fever cases. After adaptation to egg embryos, the antigen is changed into phase II, which is used for serological tests.

Reservoir and Source

Small mammals and possibly some birds are the permanent

reservoirs of infection with some Ixodid and argasid ticks acting as vectors. From the wild animals the infection spreads to cattle, sheep and goats. The immediate source of infection to man is the dust contaminated by products of domestic animals particularly placental tissues and fluids and raw milk. Other sources are animal carcasses, contaminated straw, wool and so on.

Mode of Transmission

The mode of transmission for humans is by inhalation of infected dust, by handling infected materials and possibly by drinking contaminated raw milk.

Human Host

Focal outbreaks or sporadic cases may occur amongst people who have close contact with infected cattle, sheep and goats. Thus it is an occupational hazard for dairy workers, farmers, veterinarians and laboratory workers.

Incubation Period

It ranges from 15 to 26 days; average incubation period is approximately 19 days.

Communicability period

The disease is not transmitted from man to man.

Prevention

The disease can be prevented by avoiding exposure to infected aerosols. Milk from infected cattle must be boiled or pasteurized. Persons at risk such as dairy workers, butchers, wool sorters, farmers, cowherds and laboratory workers can be protected by immunization with specific vaccines such as those prepared from phase I rickettsiae. Human cases of Q fever should be treated with tetracyclines or chloramphenicol.

Brill-Zinsser Disease

It is a recrudescent episode of epidemic typhus which occurs years after the initial attack, in persons who have recovered from the epidemic disease acquired while residing in the endemic country (14, 15). The recurrence is presumed to be precipitated by stress or a waning immune system. The illness is similar to louse borne typhus but is usually milder. Weil-Felix reaction may be negative in very low titre.

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# Dengue and Dengue Hemorrhagic Fever

## Introduction

Dengue is a vector borne viral disease which occurs in tropical and sub - tropical regions around the world, predominantly in urban and semi - urban areas. Dengue fever is the most rapidly spreading vector borne viral disease and is a major international public health concern (1, 2). The disease is caused by the four serotypes of the Dengue virus which are arboviruses of the genus *Flaviviruses*. The principal vector for the disease is the *Aedes aegypti* mosquito. The disease can present in several forms, from asymptomatic illness to life threatening diseases like Dengue Heamorrhagic Fever (DHF) and Dengue Shock Syndrome (DSS).

The virus is widely distributed in the tropical and subtropical regions of the world. The global prevalence of Dengue has grown dramatically in recent decades. The World Health Organization reports that the disease is now endemic in more than 100 countries in Africa, the Americas, the Eastern Mediterranean, South - East Asia and the Western Pacific. South - East Asia and the Western Pacific are most seriously affected. WHO currently estimates there may be 50 million cases of Dengue infection worldwide every year. 2.5 billion people live in Dengue endemic countries and are at risk of acquiring the infection (4, 5).

## Epidemiology

### World

The geographical extent of the disease has risen significantly in the recent past. It has spread to new areas and reemerged in areas where it appeared to have been controlled. Tropical areas in South - East Asia, Africa, Western Pacific and the Mediterranean are most seriously affected. Prior to 1970 only nine countries had experienced DHF epidemic, a number that had increased by more than four times by 1995.During 1998 over 1.2 million cases with 3,442 deaths were reported to WHO which is the largest for any single year. WHO currently estimates there may be 50 million cases of Dengue infection worldwide every year with around 24,000 deaths (5). The rapid rise in the geographical extent of the disease has been attributed to the enhanced geographic distribution of the four Dengue viruses and of their mosquito vectors, particularly the predominantly urban *Aedes aegypti*. A rapid rise in urban population particularly urban slums has contributed to the rise in the number of cases (3, 5). The WHO expects the spread of the disease to continue because of increasing urbanisation, increasing population movement, and proliferation of man - made larval habitats of the mosquito vector.

1.3 billion people living in South - East Asia are at risk of Dengue fever. In 2003 only eight countries in South - East Asia Region reported Dengue cases. By 2006, ten out of the 11 countries which form part of the WHO South - East Asia region were reporting the disease. Bhutan reported the first Dengue outbreak in 2004. An outbreak, with a high case fatality rate (3.55%) was first reported in Timor-Leste in 2005. Nepal reported Dengue cases for the first time in November 2006 (6-8).

### India

Large parts of India are endemic for Dengue Fever. The disease is reported from most parts of the country except those at high altitudes. The first major outbreak in India was reported during 1963 in Kolkata. The next major outbreak of Dengue / Dengue Haemorrhagic Fever was reported in Delhi and neighboring states in 1996. Following this outbreak, the reporting of Dengue fever was made mandatory to ensure early preventive measures in case of outbreak. Out of 18 endemic states, the most affected states are Delhi, West Bengal, Kerala, Tamil Nadu, Karnataka, Maharashtra, Rajasthan, Gujarat and Haryana (9). Data for the last 10 years reveals that the largest number of cases and deaths due to Dengue/DHF were reported in 1996 while the next increase was in 2003. 12,317 cases with 184 deaths were reported to the National Vector Borne Diseases Control Programme in India in 2006 (9). Delhi recorded several outbreaks of Dengue fever between 1967and 2006. The outbreak in 2006 was estimated to have resulted in 10, 344 cases and 162 deaths (10, 11).

## Agent

DF / DHF is caused by Dengue virus which belongs to genus *Flavivirus* family *Flaviviridae* and includes serotypes 1, 2, 3 and 4 (Den - 1, Den - 2, Den - 3 and Den - 4). The Dengue virus is composed of single - stranded RNA. Each serotype provides specific lifetime immunity and short - term cross - immunity. All serotypes can cause severe and fatal disease. There are genetic variation within the serotypes. Some genetic variants within each serotype appear to be more virulent or have greater epidemic potential. When a person has had classic Dengue, a second infection later by another serotype increases the likelihood of suffering from DHF as explained by the immune enhancement mechanism (1, 2, 4).

## Vector

*Aedes aegypti* is the main vector of Dengue transmission in India. Another important vector is the *Aedes albopictus*. The mosquito is a peri - domestic and domestic breeder. Mosquito breeding can occur in any water - storage containers, such as desert coolers, flower vases, coconut shells, construction sites, overhead uncovered or partially covered water tanks, discarded buckets, tyres, utensils and large containers used for collecting rain water which are not emptied and cleaned periodically. The mosquitoes rest indoors on various objects, in closets and other dark places. Outside, they rest where it is cool and shady. Aedes mosquito can fly upto a limited distance of 400 metres but can spread over vast distances mechanically in various types of vehicles used by man. *Aedes aegypti* is

primarily a day time biter (4, 6, 12, 13).

### Environmental Factors

The outbreaks of DF/DHF are most likely to occur in post - monsoon period when the breeding of the mosquitoes is highest. High temperature and high humidity during these seasons prolongs the life span of the vector. The spread of Dengue has resulted from several factors including human behavior, climate and movement of humans. Usually urban areas, having high population density, poor sanitation and large number of desert coolers, flower vases, construction sites, overhead tanks etc which promote mosquito breeding, are at high risk. Dengue fever/DHF can also occur in rural areas where the environment is friendly for mosquito breeding like storage water for cattle feeding and drinking, cement cisterns and underground cemented water sumps (4, 6, 8).

### Transmission

The infection is transmitted by the bite of an infected female mosquito *Aedes aegypti*. Mosquitoes acquire the virus while feeding on the blood of an infected person. After an extrinsic incubation period of 8 to 10 days, an infected mosquito can transmit the virus for the rest of its life. Trans - ovarian transmission of the Dengue virus in mosquitoes maintains the virus in nature. Humans are the main host of the virus, although studies have shown that in some parts of the world monkeys may become infected. The virus circulates in the blood of infected humans for two to seven days (4, 6, 12, 13).

### Clinical manifestations

The incubation period of Dengue fever is usually 5 - 6 days, but may vary from 3 to 10 days. Infection with Dengue virus can result in four different clinical syndromes. They are undifferentiated fever, the Classic Dengue fever, Dengue Hemorrhagic fever (DHF) and Dengue Shock syndrome (DSS) (14-16).

#### Undifferentiated Fever

This is the most common manifestation of Dengue infection. Almost 90% of those infected remain either asymptomatic or only mildly symptomatic. The patient has fever, headache, body ache and may develop a mild rash.

#### Classic Dengue Fever

This is characterized by abrupt onset of high fever, severe headache, severe muscle and joint pain (Break Bone Fever), rash and other haemorrhagic manifestations.

#### Dengue Hemorrhagic Fever

DHF is a potentially deadly complication that is characterized by high fever, accompanied by headache, anorexia, vomiting and abdominal pain. Petechiae on the extremities, face, and trunk are the manifestations of haemorrahage. Bleeding from nose, gums and gastrointestinal tract may be found. In moderate cases, spontaneous mucocutaneous bleeding, nasal bleeding and GI bleeding usually occurs. In severe cases, the patient's condition may suddenly deteriorate after a few days of fever. Any case with fever, or recent history of acute fever, hemorrhagic manifestations, low platelet count (100,000/$mm^3$ or less), and objective evidence of "leaky capillaries" in the form of elevated hematocrit (20% or more over baseline), low albumin, or pleural or other effusions meets the case definition for DHF.

#### Dengue Shock Syndrome

Patients may rapidly develop varying degree of circulatory disturbances and go into a critical state of shock. Patients with DHF who develop evidence of circulatory failure manifested indirectly by rapid and weak pulse, narrow pulse pressure (< 20 mm Hg) or hypotension for age, cold, clammy skin and altered mental status meet the criteria for DSS. Frank shock is direct evidence of circulatory failure. Prolonged shock is often complicated by metabolic acidosis and severe bleeding. Case fatality rates can exceed 20% in such patients. A major cause of deaths due to DHF is leakage of plasma in the pleural and abdominal cavities leading to hypovolaemic shock. Encephalitic signs associated with intracranial haemorrhage, metabolic and electrolyte disturbances, and hepatic failure may occur.

### Differential diagnosis

Differential diagnosis must include all other arboviral fevers, measles, rubella and other systemic febrile illnesses, especially those accompanied by rash (6). The presence of marked thrombocytopenia with concurrent haemoconcentration differentiates DHF / DSS from other syndromes such as endotoxic shock from bacterial or meningococcaemia.

### Alarming signs in Dengue

(a) Minute spots on the skin suggesting bleeding within the skin.

(b) Nose bleeds and gum bleeds, haemetemesis.

(c) Abdominal pain and/or passage of black tarry stool.

(d) Refusal to food or drink.

(e) Abnormal behaviour or drowsiness.

(f) Difficulty in breathing or cold hands and feet, reduced amount of urine being passed.

### Diagnosis

Patients suspected to be suffering from Dengue fever must undergo repeated clinical laboratory tests : Complete Blood Counts including WBC, platelets, hematocrit, Liver function tests, and urine analysis for microscopic hematuria. These blood tests may indicate a diagnosis of Dengue fever and DHF / DSS. Thrombocytopenia (100,000 cells or less per $mm^3$) and haemoconcentration as evidenced by a greater than 20% rise in average haematrocrit for age and sex are the hematological criteria for diagnosis.

Laboratory tests essential for confirmatory diagnosis of Dengue infection include isolation of the virus, demonstration of a rising titre of specific serum Dengue antibodies, and demonstration of a specific viral antigen or RNA in the tissue or serum. Virus isolation can be done by inoculation of clinical material in tissue culture,

mosquitoes or suckling mice and further detection is performed using fluorescent antibody test or haemagglutination inhibition test. Viral antigen can be demonstrated by doing direct fluorescent antibody test using specific monoclonal antibodies for Dengue virus. Viral RNA or genomic sequence can also be detected in autopsy specimen, serum, CSF or culture supernatant by doing Polymerase Chain Reaction (PCR) and gene sequencing.

Serological diagnosis is based on detection of IgM antibodies. IgM antibodies against Dengue virus appear around 5 days after onset of symptoms and are detectable for one to three months after the illness. The tests employed are IgM capture ELISA test and Rapid IgM strip test. IgM capture ELISA test kit is available from NIV Pune and commercial sources and Rapid IgM Strip Test kit is available commercially.

### Treatment

The basics of management of cases of Dengue fever are fluids, rest, antipyretics (avoid aspirin and non - steroidal anti - inflammatory drugs) and close monitoring of blood pressure, hematocrit, platelet count and level of consciousness. Liberal fluids intake including home available fluids like rice water, kanji, fruit juices, plain water or ORS solution are recommended for patient with excessive sweating, nausea, vomiting or diarrhoea to prevent dehydration (1, 3). Monitoring must be continued after defervescence. If the level of hydration falls intravenous fluids, guided by serial hematocrits, blood pressure, and urine output must be given. The volume of fluid needed is similar to the treatment of diarrhea with mild to moderate isotonic dehydration.

### Management of DHF

Patients of DHF need regular assessment by serial haematocrit levels. Urine output should be monitored closely in areas where serial haematocrit estimation is not possible. A rise in haematrocrit of 20% or more or single haematocrit value of more than 40%, platelets count of 50,000/cmm or less and spontaneous haemorrhage are all danger signs.

### Management of Dengue Shock Syndrome (DSS)

DSS patients present with shock. Volume replacement is the most important treatment measure and immediate administration of intravenous fluids to expand plasma volume is essential. Close observation with good nursing care is imperative. Blood transfusion should be given in case with significant haemorrhage. Fresh frozen plasma or concentrated platelet transfusion may be given when disseminated intravascular coagulation causes massive bleeding. Readers may refer to standard texts for details on management of patients (3, 4, 14 - 17)

### Immunity

Infection with one serotype provides life - long homologous immunity but does not provide protection against other serotypes, and instead may exacerbate subsequent infection (4, 6, 7).

### Prevention and control

Vector Control

Vector control and personal protective measures are the mainstay of prevention of Dengue infections. Both aspects are dealt with in detail in the chapter on Entomology.

Surveillance

Epidemiological surveillance of the disease as well as the vector form an important part of control measures. The disease surveillance should include fever surveillance, diagnosis based on standard case definitions, and reporting of DF/DHF cases to state health authorities. Vector surveillance includes both larval and adult vector surveillance (18).

A number of indices have been described and are currently used to monitor the vector population :

#### House index

Percentage of houses positive for larvae of *Aedes aegypti*. House index of more than 10% indicates high risk of transmission

#### Breteau index

Number of positive containers for *Aedes aegypti* per 100 houses. An index of more than 50 indicates high risk of transmission while index below five indicates low risk of transmission.

Notification

Dengue is a cross border disease. With massive air travel, outbreaks can rapidly cross international borders. Outbreaks must, therefore, be notified at the earliest to both the national as well as international health authorities.

Vaccine

No effective vaccine is available for Dengue. Research into Dengue vaccines has focused on the use of live attenuated or inactivated vaccines, infectious clone derived vaccines, and nucleic acid vaccine (19).

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# Japanese Encephalitis

## Introduction

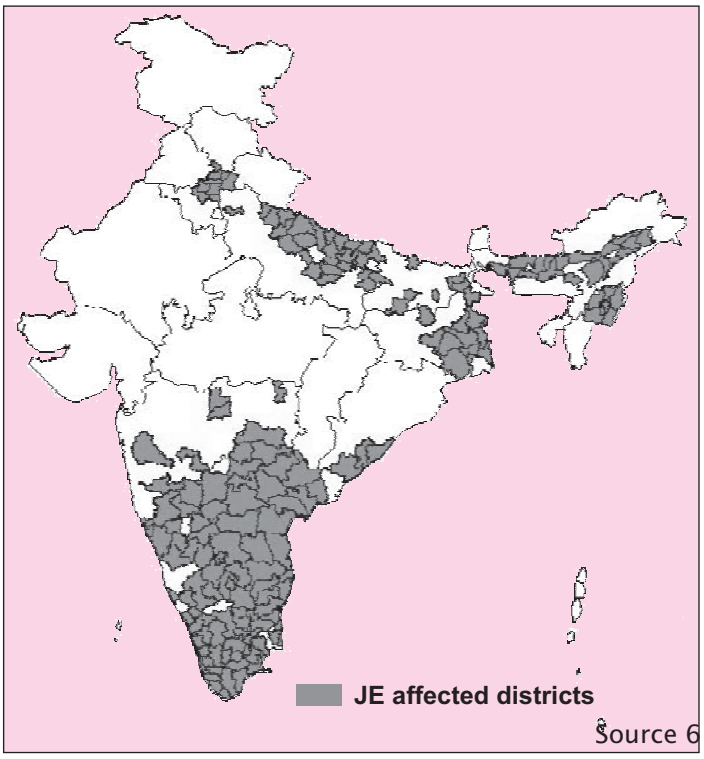
Japanese encephalitis is an arboviral disease spread by culicine mosquitoes. The disease presents periodically in epidemic form in areas such as northern India, parts of central and southern India. An overwhelming majority of the infections are asymptomatic. However, among symptomatic individuals case fatality rates may be higher than 20%. The public health importance of this vaccine preventable disease lies in the fact that most infections occur among children and that a sizeable proportion of the survivors are left with permanent neurological and/or psychiatric sequelae (1). The incidence of Japanese encephalitis has shown an increasing trend in recent times and the disease is fast becoming a major public health problem in India (2).

## Epidemiology

Japanese encephalitis infections occur throughout the temperate and tropical zones of Asia. The annual incidence of Japanese encephalitis disease varies considerably from one country to the other as well as within affected countries, ranging from less than 10 to more than100 per 100 000 population. Nearly 3 billion people or close to half the global population live in Japanese encephalitis endemic regions. Over 50, 000 cases are reported worldwide every year with 10, 000 deaths (3). The disease periodically becomes hyperendemic in areas such as northern India, parts of central and southern India, southern Nepal, and northern Viet Nam (3). Other countries reporting large number of cases of Japanese encephalitis include Philippines, Thailand, Cambodia, Mynamar, and Sri Lanka. Though named Japanese encephalitis, the disease is now rare in Japan, due to extensive vaccination and adequate vector control.

In India Japanese encephalitis was first reported in 1955 from Vellore in Tamil Nadu (4). Currently this disease is reported from 26 states in India. Of these, only 15 states are reporting JE regularly. The total population at risk is estimated 160 million (5). A disturbing feature of Japanese encephalitis reporting in India has been the occurrence of several large outbreaks from different parts of the country. The first major outbreak of was reported from West Bengal in 1973 in two districts followed by another outbreak in 1976. Subsequently outbreaks have been reported from the states of Bihar, Uttar Pradesh, Assam, Manipur, Andhra Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Tamil Nadu, Haryana, Kerala, West Bengal, Orissa and union territories of Goa and Pondicherry (2). In the recent past the reported annual incidence in India has ranged between 1765 and 3428 and deaths between 466 and 707 (6). The current Japanese encephalitis situation in India is shown in Fig - 1.

Fig - 1 : Japanese Encephalitis in India




## Agent

Japanese encephalitis virus belongs to the family Flaviviridae, which are single - stranded RNA viruses. Like other flaviviruses, the Japanese encephalitis virus is an enveloped, plus sense virus. It is antigenically related to several other flaviviruses including dengue virus, St. Louis encephalitis virus, Murray Valley virus and West Nile virus (2). The envelope glycoprotein of the JE virus contains specific as well as cross - reactive, neutralizing epitopes. The virus contains several structural and non - structural polypeptides, which are encoded by a single long open reading frame (7). The virus has two sub types, Nakayam amd Jagar - 01 (2). The major genotypes of this virus have different geographical distribution, but all belong to the same serotype and are similar in terms of virulence and host preference (3).

## Vector

Anthropophilic culicine mosquitoes transfer the virus to humans from animal amplifying hosts, principally domestic pigs and wading birds. The virus is transmitted chiefly by the bites of mosquitoes of the *Culex vishnui* complex; with individual vector species differing in specific geographic areas. In India and many endemic areas in Asia, *Culex tritaeniorhyncus* is the principal vector. This species feeds outdoors beginning at dusk and

during evening hours until dawn. It breeds in water pools, marshes, flooded rice fields, and small stable collections of water around cultivated fields. This vector has a wide host range, including domestic animals, birds, and humans. In temperate zones, the vectors are present in greatest numbers from June through September and are inactive during winter months (8).

### Host

Pigs and aquatic birds (mainly herons and egrets of the Ardeidae family) are the natural hosts for the virus. Pigs are considered amplifying hosts since they allow manifold virus multiplication without suffering from disease and maintain prolonged viraemia (6). Viraemic adult pigs remain asymptomatic, but pregnant sows may abort or deliver still births. Humans are dead end accidental hosts.

Among humans, the virus has no specific age or sex predilection. In areas where the virus has been recently introduced, all age groups are affected equally. In endemic areas, however, most people are infected below the age of 15 years. In hyper-endemic areas, half of all Japanese encephalitis cases occur before the age of four years, and almost all before 10 years of age. Only 1 in 250 to 500 JE viral infections result in symptomatic disease. Those endemic regions where childhood JE vaccination has been widely implemented have experienced a shift in the age distribution of cases towards older children and adults (3). In India, Japanese encephalitis is considered to be a largely pediatric problem. Young children below 10 years of age are more likely to die, and if they survive, are more likely to have residual neurological sequelae (2).

### Environment

Environmental factors related to transmission of JE are related principally to temperature and humidity conditions conducive to breeding and survival of the vector. In tropical and subtropical areas, transmission intensifies in the rainy season. In temperate locations, transmission usually starts in April and may last until October. In irrigated areas, transmission may occur even in the dry season (3). Habitats supporting the transmission cycle of JE virus are principally in rural, agricultural locations. In many areas of Asia, appropriate ecologic conditions for virus transmission occur near and even within urban centers (8). In many Asian countries, major outbreaks of JE occur at intervals of 2–15 years (3).

### Clinical Features

The incubation period of Japanese encephalitis ranges from four to 14 days (3). The virus initially multiplies at the site of the bite and in the draining lymph nodes. Subsequently, viremia develops, leading to inflammatory changes in the heart, lungs, liver, and reticuloendothelial system. Most infections are cleared before the virus can invade the central nervous system (CNS). However, neurologic invasion can develop leading to involvement of large areas of the brain, including the thalamus, basal ganglia, brain stem, cerebellum, hippocampus, and cerebral cortex (9). Most infected persons develop mild symptoms or no symptoms at all. Symptoms soon after exposure appear 6 - 8 days after the bite of an infected mosquito. The disease is characterized by sudden onset of fever, chills, body ache and mental confusion. Severe cases may progress to coma. In children, gastrointestinal pain and vomiting may be the dominant initial symptoms. Irritability, vomiting and diarrhea or an acute convulsion may be the earliest objective signs of illness in an infant or child. JE may present as a mild disease, leading to an uneventful recovery, or may rapidly progress to severe encephalitis with mental disturbances, general or focal neurological abnormalities and coma.

Out of the approximately 50 000 cases of JE that are estimated to occur each year, about 10 000 end fatally, and about 15 000 of the survivors are left with neurological and/or psychiatric sequelae, requiring rehabilitation and continued care (2, 3). Approximately 33 - 50% of patients who survive have major neurologic sequelae at one year, including seizure disorders, motor or cranial nerve paresis, or movement disorders. Nearly 75% of symptomatic patients with JE who are evaluated five years after the disease score lower than uninfected subjects on standardized tests (9).

### Diagnosis

JE is clinically indistinguishable from other forms of viral encephalitis. History of exposure to mosquitoes in an endemic area or during an epidemic may be elicited. A CBC count often shows nonspecific modest leukocytosis in the first week of illness. A mild anemia also may be present. Some studies have reported thrombocytopenia in children with Japanese encephalitis (9). Neutrophils predominate in early CSF samples but a lymphocytic pleocytosis is typical. CSF protein is moderately elevated in about 50% of cases (2).

Confirmation of a suspected case of Japanese encephalitis is mainly based on serology using IgM - capture ELISA which detects specific IgM in the cerebrospinal fluid or in the blood of almost all patients within 7 days of onset of disease. Other methods include conventional antibody assays on paired sera for the demonstration of a significant rise in total JE - specific antibody, as well as a dot - blot IgM assay, suitable for use in the field (3).

### Case definitions for JE Diagnosis and Reporting (6)

Clinical Suspect

Febrile illness of variable severity associated with neurological symptoms ranging from headache to meningitis or encephalitis. Symptoms can include headache, fever, meningeal signs, stupor, disorientation, coma, tremors, paralysis (generalized), hypertonia, loss of coordination (Patient with fever, altered sensorium lasting more than 6 hours, no skin rash and other known causes of encephalitis excluded).

Probable

A suspected case with presumptive laboratory results : Detection of an acute phase anti - viral antibody response through IgM in serum/ elevated and stable JE antibody titres in serum through ELISA/HI/Neutralizing assay.

Confirmed

A suspect case with confirmed laboratory result : JE IgM in CSF or 4 fold or greater rise in paired sera (acute &

convalescent) through IgM/IgG ELISA, HI, Neutralization test or detection of virus, antigen or genome in tissue, blood or other body fluid by immuno - chemistry, immunoflourescence or PCR.

### Treatment

There is no specific anti - viral medicine available against JE virus. The cases are managed symptomatically. Clinical management of JE is supportive and in the acute phase is directed at maintaining fluid and electrolyte balance and control of convulsions, if present. However, treating raised intracranial pressure and convulsions have been reported to decrease the mortality and morbidity significantly (10).

### Prevention and Control

Vector control and vaccination are the two primary strategies for control of Japanese Encephalitis. In countries such as Japan and Korea the incidence of JE has decreased during several decades, primarily as a result of extensive use of JE vaccines. Improved socioeconomic conditions, changed life styles and control measures such as centralized pig production and the use of insecticides may also have contributed to this development (3). Details on vector control are available in the Chapter on Entomology.

### Vaccines

Three types of vaccines are currently in use against Japanese encephalitis. The mouse brain - derived, purified and inactivated vaccine, which is based on either the Nakayama or Beijing strains of the JE virus and is produced in several Asian countries including India. Another inactivated vaccine is the cell culture - derived, vaccine based on the viral Beijing P - 3 strain. A live attenuated vaccine widely used in China is the cell culture - derived vaccine based on the SA 14 - 14 - 2 strain of the JE virus (3).

The mouse brain - derived JE vaccine is used in India. It is produced by the Central Research Institute, Kasauli. Three doses are required to produce primary immunization. Two doses of 1 ml (0.5 ml for children below three years) are administered sub - cutaneously within a gap of 7 - 14 days followed by third dose any time after one month and before one year of the second dose. A booster is required after 3 years (6). Several othe Asian countries have adopted a similar schedule of two primary doses four weeks apart, followed by a booster after one year. In some countries, subsequent boosters are recommended, usually at about 3 - year intervals up to the age of 10 to15 years (3). For travellers aged more than one year visiting rural areas of endemic countries the established practice is to administer 3 primary doses at days 0, 7 and 28 or two primary doses preferably four weeks apart.

The mouse brain - derived JE vaccine is been considered safe. Local reactions such as tenderness and swelling occur in about 20% of vaccinees. Mild systemic symptoms, including headache, myalgia, gastrointestinal symptoms and fever may also occur. Being a killed vaccine, only contraindication to the use of this vaccine is a history of hypersensitivity reactions to a previous dose. Pregnant women should be vaccinated only when at high risk of exposure to the infection. The vaccine can be given to HIV infected individuals (3). The biggest limitation of the mouse derived killed vaccine is that rapid large scale production of the vaccine is not feasible.

The live attenuated vaccine was licensed in China in 1989. Extensive use of this and other vaccines has significantly contributed to reducing the burden of JE in China. The vaccine has recently been licensed for use in India. It is administered in two doses at an interval of one year.

### WHO position on JE vaccines

The World Health Organization recommends that JE immunization should be integrated into the EPI programmes in all areas where JE constitutes a public health problem. The most effective immunization strategy in JE - endemic settings is one time catch - up campaignsincluding child health weeks or multi - antigen campaigns in the locally - defined primary target population, followed by incorporation of the JE vaccine into the routine immunization programme (3).

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# Chikungunya

## Introduction

Chikungunya fever is an arboviral illness characterized by severe, persistent joint pains, fever and rash. The disease resembles dengue fever and is spread by the bite of infected mosquitoes. It is rarely life - threatening. However, widespread occurrence of the disease causes substantial morbidity and economic loss. Chikungunya virus disease has occurred sporadically in India and Southeast Asia for at least 200 years. Epidemics with symptoms resembling Chikungunya fever have been recorded as early as 1824 in India (1). Over the last 40 years, several widespread epidemics have occurred in many cities of India and Southeast Asia affecting thousands of people (2, 3) Occasionally, epidemics of Dengue and Chikungunya have occurred simultaneously in the same community, making clinical differentiation of the two diseases difficult. Unlike Dengue which has become endemic in many parts of Asia, Chikungunya virus disappears and reappears at irregular intervals.

The name Chikungunya originates from Swahili, and means "that which bends up, " which refers to the characteristic posture assumed by patients suffering severe joint pains. Chikungunya virus was first isolated during a 1952 epidemic in Tanzania (2, 3).

## Epidemilogy

### World

The Chikungunya virus is probably maintained in nature by transmission between jungle primates (4). The disease displays a striking epidemiological profile with major epidemics appearing and disappearing cyclically, usually with an inter - epidemic period of 7 - 8 years and sometimes as long as 20 years (1). Currently, Chikungunya is a major arboviral disease in urban parts of Africa and Asia. The known geographic distribution of the virus includes large parts of Sub - Saharan Africa, Southeast Asia including Indonesia, Philippines, and India, as well as islands in the South - west Indian Ocean (2, 3). Other affected regions include Mauritius and Seychelles in the Indian Ocean. Imported cases have been reported by European countries like France, Germany, Italy, Norway and Switzerland (5-7) .

### India

The virus was first isolated in India from Kolkata in 1963 (8). In the mid sixties outbreaks resembling Chikungunya were reported from various parts of India including Vellore, Kolkata and parts of Maharashtra (1). The last outbreak of Chikungunya virus infection was reported in 1971. There has been no active or passive surveillance of Chikungunya and therefore, it appeared that the virus had disappeared from the country (9). Since 2005, however, there have been several reports of outbreaks from widespread parts of the country and the re - emergence of the virus has been confirmed (10-12). In the present outbreak, 151 districts of eight states of India have reported Chikungunya fever as of Oct 2006. The affected states are Andhra Pradesh, Andaman & Nicobar Islands, Tamil Nadu, Karnataka, Maharashtra, Gujarat, Madhya Pradesh, Kerala and Delhi. More than 1.25 million cases have been reported from the country with 7,52,245 cases from Karnataka and 2,58,998 from Maharashtra. In some areas attack rates have reached up to 45% (1).

## Agent

The Chikungunya virus is an arbovirus belonging to the group alphaviruses of the family *Togaviridae.* It is believed that there are two distinct lineages of the Chikungunya virus, one containing Western African and the second comprising all Southern and East African strains. The virus originated in Africa and was subsequently introduced into Asia (12).

## Vector

Chikungunya is transmitted by mosquitoes, including many Aedes species which bite during daylight hours. In some parts of the world Culex species are important vectors. In India, the two important vectors are *Aedes aegypti* and *Aedes albopictus*, both of which also transmit dengue virus (13).

## Transmission

There appear to be two distinct transmission cycles for Chikungunya virus. A sylvatic cycle between wild primates and arboreal Aedes mosquitoes, similar to that of sylvatic Yellow fever virus in the same region has been seen in Africa. Urban Chikungunya outbreaks are associated with *Aedes aegypti* transmission in a human - mosquito - human cycle. Urban outbreaks are sporadic in occurrence but explosive in nature. Till recently it was believed that there is no direct person - to - person transmission. However, vertical maternal foetal transmission of the virus has been documented in an outbreak at La Reunion Island (14). The virus has been isolated from monkeys in Africa (15). There is a risk for travelers in areas where Chikungunya is endemic and in areas affected by epidemics (16, 17) .

## Clinical Features

The Incubation period is usually 2 - 3 days with a range of 1 - 12 days (3). The onset is with fever, chills, headache, photophobia, backache, nausea, vomiting, arthralgia, and rash. The acute illness usually lasts about 3 to 5 days but can be very severe. Most patients recover completely within 5 to 7 days. More than three fourths of the patients complain of severe arthralgia. One or more joints may be involved, with swelling and redness. Another characteristic feature is the rash which is maculopapular and mainly involves the trunk. In some cases the joint pains may persist for week, months or even longer. Chikungunya may also be asymptomatic (2, 5, 18-21). Children may suffer from febrile convulsions. Infrequently, hemorrhagic manifestations (petechiae, purpura, epistaxis) also have been reported.

### Diagnosis

Any illness with the classical triad of fever, rash, and joint pains in endemic areas must give rise to suspicion of Chikungunya. The definitive diagnosis can only be reached by serology or isolation of the virus. Alphaviruses can usually be recovered from blood taken during the first few days of illness. Seroconversion can be shown in acute and convalescent serum samples drawn two weeks apart. Virus - specific IgM antibodies can be detected by capture ELISA in patients recovering from Chikungunya infection and they decline within 3 - 6 months. Haemagglutination inhibition antibodies appear as the viraemia declines. Patients usually become positive by the 5th to 7th day of illness. RT - PCR can be used for molecular diagnosis at specialized centre (12, 20).

### Differential Diagnosis

Chikungunya infection is often mistaken for dengue, which has a similar distribution in Asia and Africa. It may also can be confused with West Nile virus infection.

### Treatment

Treatment is symptomatic and includes antipyretic and anti - inflammatory drugs. Aspirin should be avoided because of reports of mild hemorrhagic manifestations. Movement and mild exercise tend to improve stiffness and morning arthralgia, but heavy exercise should be avoided as it may exacerbate rheumatic symptoms. Although the joint symptoms may persist for months, Chikungunya is generally an acute, self - limited infection with no deaths reported. Patients should be nursed under mosquito nets during the viraemic stage to avoid transmission of the disease (2, 5, 21).

### Prevention and Control

There is no vaccine against this arboviral disease. No specific treatment is available. Prevention is entirely dependent upon taking steps to avoid mosquito bites and elimination of mosquito breeding sites. Control measures consist of vector control activities. Details about vector control and personal protective measures are given in the Chapter on Entomology.

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# Yellow Fever

## Introduction

Yellow fever was the first viral hemorrhagic fever to be described. It is a mosquito - borne infection endemic to Africa and South America. Its presentation is widely variable ranging from a minimal flulike illness to a fulminant disease characterized by hemorrhage, hepatic failure, renal failure and death. The Yellow Fever virus is an arbovirus, of the family *Flaviviridae* (1). Despite being currently restricted to parts of Africa and South America, Yellow fever has the potential to cause large outbreaks in other areas dur to the presence of suitable vectors and climatic conditions (2). Yellow fever has been cited in historic texts dating back to 400 years ago. The "yellow" in the name originates from the jaundice that occurs in seriously ill patients. Although an effective vaccine has been available for 60 years, the number of people infected over the last two decades has increased and the World Health Organization considers Yellow fever to be a serious public health issue again (3). The virus is transmitted by several species of mosquitoes. The Aedes is the most important vector while Haemogogus species are responsible for the transmission in South America.

## History

Major epidemics of Yellow fever occurred in the 18th and 19th century in Africa, South America, the Caribbean, Europe and North America. In 1793, a major epidemic wiped out almost 10% of the population of Philadelphia. Mosquito - borne transmission of Yellow fever was first suggested by Carlos Finlay in 1881. In 1900, Walter Reed observed that the infectious agent was transmitted by means of a mosquito bite. Extensive mosquito control measures and widespread vaccination led to the elimination of Yellow fever in the early 20th century from most areas of the world except parts of Africa, South America and the Caribbean. The slackening of vector control measures has lead to the reinfestation of *Aedes aegypti* mosquitoes in South America (1).

## Geographical Distribution

Yellow fever is currently confined almost entirely to South and Central America and Africa. The virus is constantly present with low levels of infection in these areas. Periodically this viral presence amplifies into regular epidemics. Over 500 million people live in 33 endemic countries in Africa and are considered to be at risk of suffering from Yellow fever. All these countries lie within a band from 15°N to 10°S of the equator. In South America, Yellow fever is endemic in nine countries and in several Caribbean islands. The countries considered to be at high risk are Bolivia, Brazil, Colombia, Ecuador and Peru. A small numbers of imported cases also occur in countries free of Yellow fever. Yellow fever has never been reported from Asia. However, WHO considers this region to be at risk because the appropriate primates and vectors are present (3). The global incidence of Yellow fever fluctuates with the occurrence of large epidemics in Africa. The World Health Organization estimates that there are 2,00,000 cases of Yellow fever every year with 30,000 estimated deaths. However, due to underreporting, only a small percentage of these cases are identified (3)

## Agent

The viral pathogen is a *flavivirus* belonging to the family *Togaviridae*. It is a small (40 to 60 nm), single stranded positive sense, enveloped RNA virus. The envelope consists of a lipid bilayer containing an envelope glycoprotein and a matrix protein (4, 5).

## Mosquito Vectors

The virus is transmitted by several different species of the Aedes and Haemogogus (only in South America). These mosquitoes may be domestic (breeding close to and around houses), wild (breeding in the jungle) or semi - domestic types. In South America *Haemogoggus spegazzinii* is the principal vector for forest transmission. In Africa, the principal vectors for forest transmission are the *Aedes africanus* and *Aedes simpsoni.* In both the continents, the principal urban vector is the *Aedes aegypti.* Any region populated with these mosquitoes can potentially harbour the disease. Extensive vector control measures had successfully eradicated mosquito habitats in the past, especially in South America. However, slackening of these programmes over the last 30 years has lead to increase in the mosquito population (1). Female mosquitoes become infected by feeding on an infected host usually during the first to third day of fever. The extrinsic incubation period the mosquitoes can vary from four days to 18 days depending on the ambient temperature (6). During subsequent blood meals, the virus is transmitted to a new vertebrate host. In addition, Yellow fever virus can be transmitted transovarially, allowing viral survival in the absence of adult mosquitoes. Some populations of mosquitoes transmit Yellow fever virus more efficiently than others. The principal urban vector, *Aedes aegypti* is an inefficient vector of the Yellow fever virus. However, the anthropophilic nature of the vector and the high densities of the mosquito in urban areas make it an excellent vector for human - to - human transmission (5, 7)

## Hosts

Primates are the only vertebrate hosts for Yellow fever. Humans and monkeys are the principal hosts. The reservoir of urban Yellow fever is sub - clinical human cases. For rural Yellow fever the most important animal reservoir is the monkey. In endemic areas almost 30% monkeys may be infected. Monkey is the only reservoir for jungle Yellow fever (2, 5).

## Transmission

Three transmission cycles can be distinguished in Africa. The sylvatic, intermediate and urban. In South America,

only the sylvatic and urban Yellow fever cycles of transmission are seen. In all three cycles, Yellow fever virus is transmitted between primates by diurnally active tree hole - breeding mosquitoes. In all of these cycles, endemic and epidemic disease patterns can occur (4).

**(a) Sylvatic Yellow fever**

In forested areas, Yellow fever occurs in monkeys infected by wild mosquitoes. The infected monkeys can then pass the virus onto other mosquitoes that feed on them. These infected wild mosquitoes bite humans entering the forest resulting in sporadic cases of Yellow fever.

**(b) Intermediate Yellow fever**

In the Savannah region of Africa, semi - domestic mosquitoes infect both monkey and human hosts. This area is often called the "zone of emergence", where increased contact between man and infected mosquito leads to disease. It can shift to a more severe urban - type epidemic.

**(c) Urban Yellow fever**

Large epidemics occur when migrants introduce the virus into areas with high human population density. Domestic mosquitoes carry the virus from person to person. No monkeys are involved in transmission. There is evidence to suggest that Yellow fever virus can be maintained in one place until the amplifying primates become immune and then reemerge in areas where susceptible primates live. Yellow fever virus is maintained through the dry season by means of transovarial transmission. The normal low risk to travellers increases with travel to jungle areas in endemic countries and in or near cities during urban outbreaks. Areas where Yellow fever virus is present far exceed those officially reported. The risk of exposure to infection can be reduced by taking measures to prevent mosquito bites (4, 5, 7). The mosquito vectors of Yellow fever are mostly day biters. Although reported cases of human disease are the principal indicator of disease risk, some countries may have no reported cases, either because of a high level of vaccine coverage against Yellow fever in the population or because poor surveillance resulted in no cases being reported. However, the risk of Yellow fever may still persist as the virus, the vector or the animal reservoirs are still present (8-10).

**Incubation Period**

The intrinsic incubation period in human beings is between 2 and 6 days. The extrinsic incubation period in a mosquito varies from 4 to 18 days (average 12 days), with the temperature and humidity. Once the mosquito becomes infective, it remains so for the rest of its life (2).

**Communicability Period**

The case is infective to the vector mosquito during the later part of the incubation period and first three clinical days. An infected individual, therefore, can spread infection for about 4 to 6 days, starting 2 to 3 days after exposure to the infection. It is to prevent the entry of such individuals in India that rigorous rules and regulations are enforced (2).

**Clinical Features**

The disease presents in two phases. Some infections may be completely asymptomatic. Usually the first "acute" phase is characterized by fever, muscle pain, headache, loss of appetite, nausea and vomiting. The high fever may be paradoxically associated with a slow pulse. After three to four days most patients improve and their symptoms disappear. About 15% of patients enter a "toxic phase" within 24 hours. The patient rapidly develops jaundice and has abdominal pain with vomiting. Bleeding can occur from the mouth, nose, eyes and/or stomach. Blood may appear in the vomit and faeces. Kidney function deteriorates. About half of the patients in the "toxic phase" die within 10 - 14 days. The remaining recover without significant organ damage. Yellow fever is difficult to recognize, especially during the early stages. It can easily be confused with malaria, typhoid, rickettsial diseases, haemorrhagic viral fevers, dengue fever, leptospirosis and viral hepatitis (3).

Complications

Kidney, liver and myocardial damage may occur. Ischemic changes affect other organs as well as a result of widespread hemorrhages and the resulting shock. Coagulopathy may occur as a result of two processes - decreased hepatic synthesis of coagulation factors and the presence of DIC (1, 2).

**Diagnosis**

Baseline investigations must be carried out in suspected case. Leukopenia with relative neutropenia can occur. Thrombocytopenia can occur as part of a consumptive coagulopathy. Patients are also likely to have an elevated prothrombin time and prolonged clotting times. Renal damage, if present, results in grossly elevated serum creatinine levels and markedly elevated levels of urinary protein. In severe cases liver function tests are grossly deranged. Specific laboratory diagnosis relies on serology or on detection of the virus and viral antigens. Rapid detection methods include the detection of Yellow fever antigen by monoclonal enzyme immunoassay in serum specimens & detection of viral genome sequences in tissue or blood using polymerase chain reaction (PCR). Serologic studies include the Immunoglobulin-M (IgM) antibody - capture enzyme - linked immunosorbent assay (MAC - ELISA) used to detect the specific presence of IgM for Yellow fever. IgM appears 7 - 10 days following infection. A 4 - fold rise in hemagglutination inhibition, complement fixation, or neutralization of antibodies in acute and convalescent phases is also diagnostic of Yellow fever. The Yellow fever virus can be isolated from viral culture with the intracerebral inoculation of suckling mice or inoculation of mosquito cell cultures (1).

**Treatment**

As there is no specific treatment for Yellow fever, supportive care is critical. Dehydration and fever must be corrected with oral rehydration salts and anti - pyretics. Any superimposed bacterial infection should be treated with appropriate antibiotics. Intensive supportive care

may improve the outcome for seriously ill patients, but is rarely available in poorer, developing countries.

### Prevention and Control

Vector control and vaccination are the cornerstones of Yellow fever control. Vector control is considered in detail in the Chapter on Entomology.

### Yellow Fever Vaccine

During the 1930s, both wild - type Yellow fever virus strains, Asibi and French, were attenuated to derive live vaccines known as 17D and the French neurotropic vaccine, respectively (2) Currently, 17D is the only strain of Yellow fever virus used for vaccination. 17D vaccines are heterogenous mixtures of multiple virus subpopulations (10)

#### Immune Response

More than 95% of vaccinated people develop neutralizing antibodies within 10 to 14 days of immunization. The International Health Regulations stipulate that the vaccination certificate for Yellow fever is valid for 10 days after administration of 17D vaccine, corresponding to the time at which the majority of vaccinees are demonstrably immune. Immunity following 17D vaccination is remarkably durable and may be lifelong.

#### Vaccine Dose, Route of Administration & Preparations

A 17D vaccine dose contains approximately 105 PFU in 0. 5 mL and is given subcutaneously, usually in the upper arm. Because there is no preservative in the vaccine and because the vaccine rapidly loses potency after reconstitution, it must be refrigerated at the point of use and held on ice and used soon after reconstitution. Reconstituted vaccines must be discarded within 4 hours. The Vaccine is supplied in single and multiple - dose containers.

#### Vaccine Failure

Rarely, healthy people fail to develop neutralizing antibodies following 17D vaccination. This is not an absolute refractoriness; people who fail to develop antibody after their first vaccination may develop antibody upon revaccination (2, 4, 7).

#### Precautions and contraindications

Tolerance of the vaccine is generally good. Less than 5% of vaccine recipients have mild reactions, including myalgia and headache. Contraindications include true allergy to the constituents, cellular immunodeficiency and symptomatic HIV infection. Many industrialized countries administer Yellow fever vaccine to persons with symptomatic HIV infection provided that the CD4 count is at least 200 cells/$mm^3$ (11, 12) Asymptomatic HIV - positive individuals may have a reduced response to the vaccine. There is a theoretical risk of harm to the fetus if the vaccine is given during pregnancy, but this must be weighed against the risk to the mother of remaining unvaccinated and travelling to a high - risk zone. There have been recent reports of a small number of cases of serious disease, including deaths, following Yellow fever vaccination; most of these reactions occurred in elderly persons (12, 13-15). The risk to unvaccinated individuals who visit countries where there may be Yellow fever transmission is far greater than the risk of a vaccine - related adverse event and it remains important for all travellers at risk to be vaccinated. Nonetheless, Yellow fever vaccination should not be prescribed for individuals who are not at risk of exposure to infection (16-18). Yellow fever vaccination should be encouraged as a key prevention strategy, but it is important to screen travel itineraries, particularly of older travellers and carefully evaluate the potential risk of systemic illness after Yellow fever vaccination (2, 7, 10, 11).

### Mandatory vaccination

Mandatory vaccination against Yellow fever is carried out to prevent the importation of Yellow fever virus into vulnerable countries. These are countries where Yellow fever does not occur but where the mosquito vector and non - human primate hosts are present. Importation of the virus by an infected traveller could potentially lead to the establishment of infection in mosquitoes and primates, with a consequent risk of infection for the local population. In such cases, vaccination is an entry requirement for all travellers arriving from countries, including airport transit, where there is a risk of Yellow fever transmission. If Yellow fever vaccination is contraindicated for medical reasons, a medical certificate is required for exemption (19). The international Yellow fever vaccination certificate becomes valid 10 days after vaccination and remains valid for a period of 10 years. Travellers should be aware that the absence of a requirement for vaccination does not imply that there is no risk of exposure to Yellow fever in the country.

Yellow Fever Vaccination centres in India are as follows :

(a) National Institute of Communicable Diseases, New Delhi.

(b) All India Institute of Hygiene and Public Health, Kolkata.

(c) All major Airport Health Organizations.

(d) All Port Health Organizations.

(e) Armed Forces Clinic, New Delhi (this is the designated centre for Armed Forces)

### Prevention of Entry of Disease in India

In India, *Aedes aegypti* is wide spread and the people possess no immunity against Yellow fever. Yellow fever has not so far entered India due to the stringent regulations and their rigid enforcement. It is, however, interesting to note that Yellow fever never entered India even before these regulations were introduced. May be, this was due to the slow mode of voyage from the African coast to India. Due to faster means of travel the danger of its entry has increased. The details on International Health Regulations are given in the Chapter on Aviation Health.

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# Bio-Medical Sciences

## Zoonoses


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# Anthrax

## Introduction

Anthrax (Greek : black) is a disease primarily of domestic herbivores caused by the bacterium *Bacillus anthracis*. The bacilli live in the topsoil and are ingested by animals while grazing. Infections to humans, though generally rare, have myriad presentations. Anthrax gained its popularity by the fact that it is probably the most suitable of all agents for germ warfare (1). Medical systems worldwide are facing the new threat of morbidity associated with the deliberate dispersal of microbiological agents by terrorists (2). Anthrax is also called as 'malignant pustule', 'woolsorter's disease' and 'rag pickers disease'(3).

During the great war, german scientists and officials applied anthrax in a widespread campaign of biological sabotage, their target being livestock. Large populations of livestock were ravaged when the spores were added to their feed (4). In 1936, japanese scientists were believed to have killed over 10, 000 human subjects in occupied manchuria, by testing lethality of various diseases like anthrax, plague and typhoid (5). Before the advent of anthrax use for bioterrorism, accidental contamination had already caused fatalities in pockets around the world. For e. g. a cloud of spores released from a faulty plant in Sverdlovsk in former USSR in 1979 caused many deaths in villages downwind from the plant (6). For more than two decades before 2001, bioterrorism experts all over the world were warning the environment, regarding use of anthrax in bioterrorism. A week after the infamous September 11 attack, the world was struck with incidences of letters containing anthrax spores being mailed. Eighteen people were affected and 5 died, besides hundreds of millions across the world who were struck by anxiety of the unknown (7).

## Geographical distribution

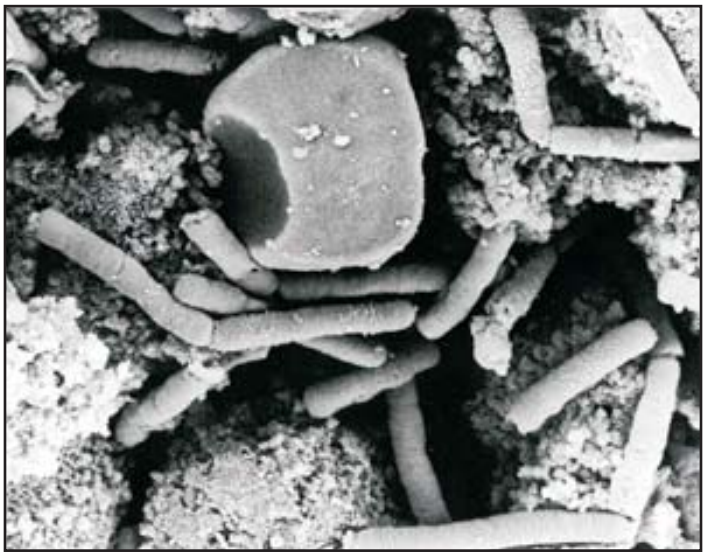
Anthrax is a documented occupational hazard, primarily of workers who are directly involved with herbivore animals e. g. Hide processors, hair and bone product workers, wool sorters, veterinarians, agricultural and wildlife workers. Personnel of armed forces handling animals especially at military farms and animal transport companies. Anthrax is endemic in Asia, Africa, South and Central America and Southern Europe (3). The disease killed over 1 million sheep in Iran in 1949 (8). Cutaneous anthrax is the most common form with around 2000 cases occurring worldwide per year (9). The largest human epidemic took place in Zimbabwe, Africa where over 10, 000 cases occurred between 1979-1985 (10).

## Epidemiology

### Agent and Transmission

*Bacillus anthracis* is a large, non-motile, brick shaped, aerobic, gram positive rod which has a capacity to make heat and dry-resistant spores under adverse conditions (Fig - 1). The spores are known to survive for decades in the topsoil and can resist temperature up to 140°C for 3 hours and even resist boiling water for 10 minutes (8).

Fig - 1 : Brick shaped bacilli on electron microscopy



Virulence is conferred by the capsule and a complex exotoxin.

Infection of the herbivorous animals is from minor trauma in the oral mucosa, which occurs due to chewing rough vegetation and soil harbouring the spores, which invariably get inoculated in the mouth. An infected animal that dies due to anthrax is loaded with vast number of bacteria and is potentially very infectious to any handler or scavenging animal (11).

Humans acquire infection by the following routes.

(a) Direct Inoculation : of spores through breaks in the skin.

(b) Inhalation of spores

(c) Ingestion of contaminated meat.

(d) Direct person to person transmission is rare but documented.

Incubation period : commonly 1 – 7 days, although incubation period extending up to 60 days has also been documented.

## Clinical presentation

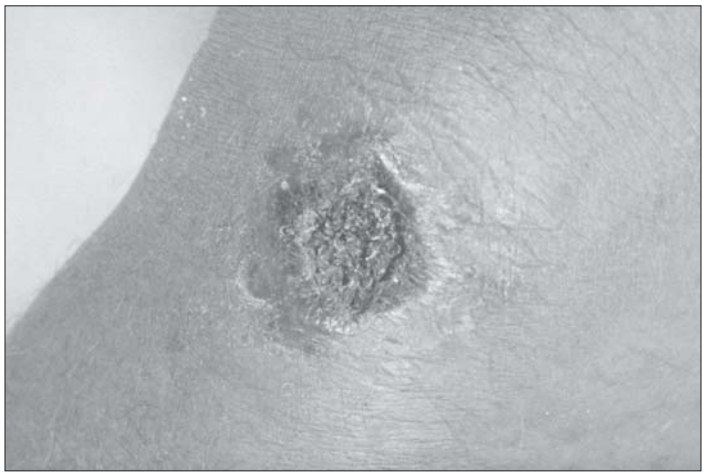
Anthrax is known to manifest in three forms; cutaneous, pulmonary and intestinal. A brief description of the various forms is as follows :

### (a) Cutaneous anthrax

The disease leads to the formation of a small papule, with a central vesicle at the site of inoculation. The following days lead to the formation of vesicles around the central lesions which ulcerate and dry out, leaving a black eschar (Fig - 2). There is generally no pain or discomfort and the lesions do not discharge pus. There is an inflammatory

response in the dependent lymph nodes. Anthrax cutaneous lesions are common on the head, neck and exposed arms, but rarely on the hands (3).

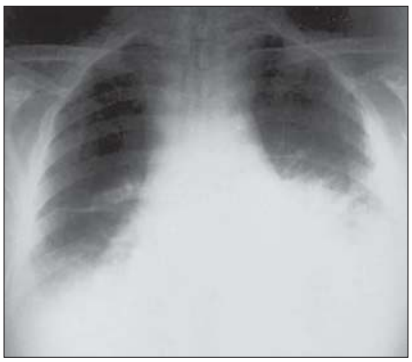
Fig - 2 : Eschar of cutaneous anthrax



(b) Pulmonary anthrax

This usually is due to inhalation of spores. The macrophages ingest the spores, many of which are destroyed. Remaining spores are transported by lymphatics to the mediastinal lymph nodes. The bacilli release exotoxins, which lead to haemmorhage, oedema and ultimately necrosis. Dose sufficient ot kill 50 % of persons exposed is 200 - 55, 000 inhaled spores (11). It commences with fever and chills. Often progresses to shortness of breath, cyanosis and respiratory distress. Lungs often get filled with interstitial fluid (Fig - 3). Death may occur within hours of onset of symptoms. Case fatality rate tends to be as high as 90 % in pulmonary anthrax (10).

Fig - 3 : Mediastinal widening seen in inhalational anthrax



**(c) Intestinal anthrax**

This form of anthrax is very common in Africa, mainly occurring due to consumption of contaminated meat. Presentation is generally non-specific, manifesting as vomiting, diarrhoea, dysentery, hematemesis and fever. Case fatality is high if not managed aggressively. Autopsy reveals an eschar in the gut.

**Management and prevention**

Diagnosis

It is mainly clinical and history based. However the confirmation of the organism is based on direct scraping from the lesion or aspiration, which can be subsequently cultured (13).

Notification

Anthrax is a notifiable disease as far as the armed forces are concerned and falls in the 'group B' of communicable diseases. On occurrence of a case of anthrax the authorities in the three services will be informed as per format on AFMSF - 73 (14).

Isolation

This is a standard precaution for the whole duration of illness, especially for cutaneous and inhalational anthrax. Standard barrier isolation practices are recommended for all hospitalized patients. The use of high efficiency particulate filter masks is not recommended (15). Though antibiotics sterilize lesions within the first 24 hours, the lesions progress through full natural course before subsiding. As human to human transmission is rare, there is no requirement of quarantine of contacts.

Specific treatment

On confirmation of diagnosis, aggressive treatment must be initiated, with a guard on vital parameters. Intravenous penicillins still remain the drug of choice. Oral amoxycillin and cotrimoxazole are good alternatives. However ciprofloxacin and doxycycline are recommended first line agents for chemoprophylaxis in individuals exposed to anthrax, but not symptomatic (14). CDC recommends that post-exposure prophylaxis should continue for 60 days (16).

Concurrent disinfection

It should be ensured that all discharges of lesions, soiled articles and linen of patients are disinfected. Sodium hypochlorite is the sporicidal of choice, however hydrogen peroxide and glutareldehyde are good alternatives. All soiled goods should also be steam sterilized (3).

Investigation and education of contacts

On occurrence of a case, rapid search should be undertaken to find all susceptible and exposed individuals. All contacts should be line-listed and followed up. Individuals involved in handling animals and animal products should be aware of anthrax. Special emphasis should be given on care of skin and personal cleanliness. Dust-control and proper ventilation should be mandatory in work areas of animal – products based industry.

Prevention in general population

The population should be encouraged not to eat the meat of animals that become ill or die (17, 18). On occurrence of anthrax deaths in livestock, the proper method of disposal of carcass must be as described later.

Anthrax vaccine

The first successful vaccines for animals against anthrax

were produced by Louis Pasteur in 1881. At present the single vaccine licensed for human use is produced from the cell free culture supernatant of an attenuated, non-encapsulated strain of *Bacillus anthracis* (Stern strain), referred to as the 'Anthrax Vaccine Adsorbed' (AVA). Clinical trials are at present underway to evaluate role of 'recombinant protective antigen' as an alternative to AVA (19). Anthrax vaccine are presently advocated for individuals having special risk of exposure i. e. Laboratory workers who handle *B. Anthracis* and workers in contact with animals (20).

**Disposal of anthrax carcass**

As anthrax is an aerobic bacillus, the spores require oxygen to multiply, which is not available in a closed carcass. Thus leading us to a conclusion that post-mortem of a suspected anthrax infected animal death is forbidden. The preferred method of disposal therefore is incineration, as it destroys all the spores. Incineration may sometimes be not possible due to either shortage of fuel or too large a number of carcasses to be disposed. In that case deep burial of the carcass must be resorted to. This is required as shallow burial will permit scavenging animals to exhume and feed on the infected carcass, thus spreading infection. The carcass should be disinfected with slaked lime before burial (13).

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Lt Col VS Grewal

# Tetanus

## Introduction

Tetanus derives its name from the Greek word 'tetanos' which means 'to contract'. An acute disease induced by the exotoxin of the tetanus bacilli, which grows anaerobically at the site of injury. The disease is characterized by painful muscular contractions, primarily of the masseter and neck muscles, secondarily of the trunk muscles (1). Despite the WHO effort to eradicate the disease by 1995, tetanus remains one of the world's major preventable causes of death, estimated to cause up to 1 million deaths every year (2).

In 1880 Nicolaier demonstrated that soil contamination of wounds resulted in tetanus, but it was Kitasato who isolated the first pure culture of Clostridium tetani in 1889. In 1890 Faber discovered the tetanus toxin and Von Behring and Kiatsato then gave the world the first tetanus antitoxin. However it was 38 years later in 1928 that Ramon performed the first successful vaccination of humans (3).

The availability of the tetanus vaccine has enabled the developed countries to virtually eliminate the disease. However as C tetani can and will never be eliminated from the soil, whenever and wherever ineffectiveness or inadequacy of the vaccination effort prevails, tetanus will occur and cause mortality (4).

## Problem statement

The disease is primarily confined to developing countries, where immunization is either not available or vaccine supply is of poor quality. 80% of cases occur in Africa and South East Asia, with Neonatal tetanus being one of the world's most underreported notifiable diseases(5). Neonatal Tetanus (NT) is a killer disease, second only to measles among the six target diseases covered in the Expanded Programme of Immunization (EPI). Case fatality rate tends to be 80 - 90 %. The SEARO five countries namely Bhutan, DPR Korea, Maldives, Sri Lanka and Thailand have eliminated NT. The remaining four, namely Indonesia, Myanmar, Bangladesh and India bear the full brunt of the cases in the region (6).

## Factors specific to India

There are certain factors existing in our country, which greatly influence and enhance the presence of NT, some of them being

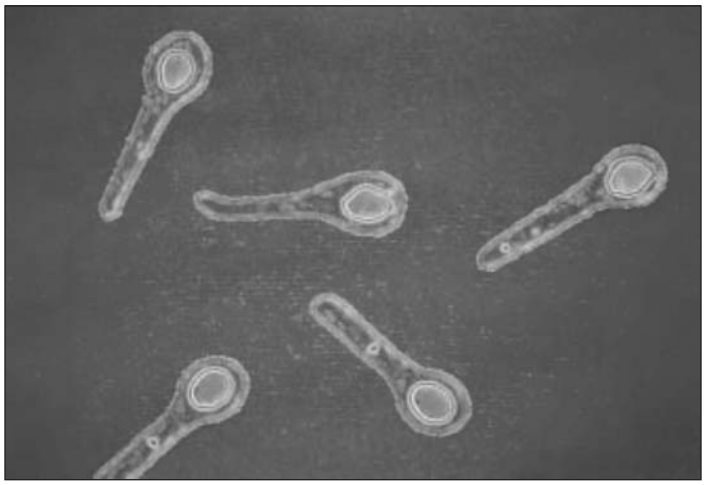
(a) Delivery practices in rural areas.
(b) Traditional birth customs.
(c) Immunisation uptake in community.
(d) Availability of EPI vaccines across the country, especially in rural areas.
(e) Behaviour and practices in rural areas, especially general hygiene, sanitation and hand washing.

## Epidemiology

### Agent

*Clostridium tetani* is a strictly anaerobic, Gram positive bacillus thriving in soil and animal faeces. When subjected to adverse conditions, rounder terminal spores are formed, giving the classical 'drumstick' appearance to the bacillus (Fig-1). If cultures are more than 24 hours old, the bacteria is readily decolorized, thus appearing to be Gram negative. It is susceptible to antibiotics like penicillin, erythromycin, clindamycin, tetracycline, chloramphenicol & metronidazole. The spores however are very resistant to physical and chemical agents and can even survive boiling water, though they are very susceptible to autoclaving. (7). The spores germinate under favourable anaerobic conditions to produce a potent exotoxin (tetanospasmin), which in lethality is second only to Botulin toxin (8). The toxin acts on the motor end plates, spinal cord, brain and the sympathetic system (9), principal action being to block the inhibition of spinal reflexes.

Fig - 1 : Bacilli of **Clostridium tetani**



### Host factors

Tetanus is primarily a disease of active age (5 – 40 years), as well as neonates. In India there is a documented male preponderance for NT, with no proven medical reason for increased male susceptibility. This male (sex) bias has been attributable to a social factor of aggressive health care seeking behaviour for a sick male neonate as compared to for a female (10). The disease has a definite rural preponderance with a predilection for individuals associated with agricultural related professions. (11). The personnel of the Armed Forces are also susceptible to tetanus, through various modes of exposure related to their profession.

### Environmental factors

The environmental and social factors are interlinked. Unhygienic customs, traditions and practices compounded by ignorance of infections and lack of primary health care facilities enhance the spread of the disease.

### Pathogenesis

*Clostridium tetani,* being anaerobic, requires low oxygen tension for germination and multiplication. In a well oxygenated, healthy tissue, germination will not occur and spores are quickly removed by phagocytosis.(12 )

Tetanus exotoxin enters the nervous system from adjacent muscle tissue, where it has been generated. It may also be disseminated by lymphatics and blood. Reduced inhibitions of the neuromuscular junctions and the GABA inhibitory neurons result in disinhibited motor neuron discharge, which gives the characteristic features of muscle rigidity and spasms. Muscle groups with shortest neuronal pathways are affected first, hence trismus and dysphagia are common early symptoms (13). The toxin also causes uncontrolled sympathetic and parasympathetic discharges.

### Types of Tetanus

Tetanus can occur in various forms, depending upon its mode of entry and targeted damage:

(a) **Traumatic Tetanus** : This is a major cause, sometimes resulting even from trivial wounds.

(b) **Puerperal Tetanus** : A major form of tetanus predominantly following abortions done under compromised conditions. It is rarely seen in normal labour in institutional deliveries, but non-institutional deliveries done with unhygienic practices cause a lot of cases.

(c) **Otogenic Tetanus** : Mainly a paediatric problem, which occurs through introduction of infection through the aural canal, by unhealthy practices inserting pencils, matches etc in the external auditory canal.

(d) **Idiopathic tetanus** : Mainly due to microscopic trauma, but many hold a view that it may be due to absorption of the tetanus toxin through the intestinal tract or the respiratory tract.

(e) **Tetanus Neonatorum** : Kills 85 % of those affected .

### Signs and Symptoms

There is an incubation period of 7-10 days, but this is variable and many patients cannot recall any injury. The disease is characterized by muscular rigidity and spasms. When it is confined to muscle groups adjacent to the site of wound, it is localized tetanus or cephalic tetanus, and generalized tetanus when it involves the whole body. In mild forms of tetanus, rigidity may be the only symptom. Spasms are most pronounced during the first 2 weeks of the disease and occur spontaneously or as a result of stimuli such as loud noises, bright lights or physical manipulation. Spasms can be strong enough to cause vertebral fractures and tendon avulsions, besides being excruciatingly painful. The classic reverse bending of a human spine during peak of spasm of the back and neck muscles, resembling a bow is seen. This is called 'opisthotonus'(Fig-2). Characteristic facial muscle involvement causes the 'risus sardonicus' or the 'sardonic smile'. Laryngeal spasms can lead to asphyxia.(1,4,14)

The advent of mechanical ventilation has led to a marked reduction in mortality from respiratory failure, but in doing so has unmasked another major cause of mortality; the syndrome of autonomic overactivity. This becomes evident during the second week of illness and expresses itself as sustained labile hypertension and tachycardia, pyrexia and profuse sweating (15). Autonomic dysfunction affects the GIT leading to diarrhoeas and is also associated with Acute Renal Failure.

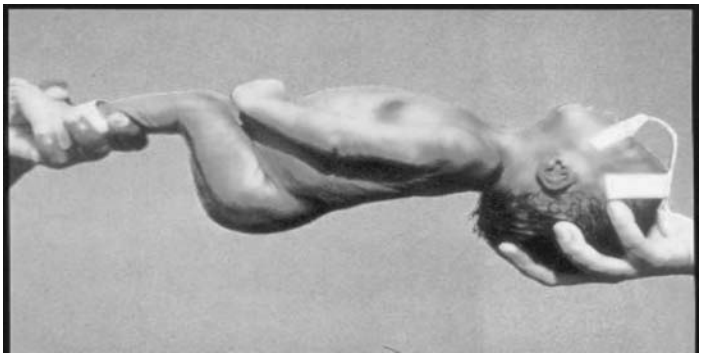
Fig - 2 : 'Opisthotonus' Painting by Sir Charles Bell- 1809

### Neonatal Tetanus

The symptomatology is generally similar to that of adults. As the name goes, mainly affects neonates (up to 28 days of age). It is seen that the neonates whose mothers have been vaccinated, experience a milder disease and better prognosis. Main symptoms among the neonate include stiffness(Fig-3), inability to feed and spasms.(1)

The diagnosis of tetanus is primarily clinical and a high degree of suspicion must be maintained by the treating physician, based on the history and the findings.(1,4)

Fig - 3 : Tetanus Neonatorum



### Prevention of Tetanus

Prevention of tetanus encompasses everything from educating the masses, provision of immunization facilities, early diagnosis and treatment of cases. It aims at decreasing the burden of disease on humanity as a whole.

Education and awareness

Educate public on the necessity for complete immunization with Tetanus Toxoid, the hazard of contaminated wounds, faulty practices and traditions

which propagate the disease. This also includes availability of TT vaccine for antenatal cases as well as newborns at all levels of healthcare. Full uptake of EPI vaccines by the community must be ensured.

Active immunization

This forms the most important preventive modality against the disease. A full course of immunization done with an adsorbed tetanus toxoid gives durable immunity for up to 10 years. The toxoid stimulates the production of an effective antitoxin. The vaccines available are the monovalent vaccines which may be either plain or adsorbed; or the combined DPT vaccine, which battles against Diptheria, Tetanus and Pertusis and forms part of the EPI vaccines. The adsorbed monovalent vaccine has Aluminium Hydroxide as adjuvant and is a cloudy uniform suspension in isotonic saline solution, which stimulates a higher and a longer lasting response than plain Toxoid. The schedule of active immunization is given in Table - 1.

While tetanus toxoid is recommended for universal use regardless of age, it is especially important for workers in contact with soil, sewage and domestic animals. Personnel of the Armed Forces also fall in a protected category due to a greater risk of occupation related traumatic injury. (1)

Passive immunisation

This can be done either by Human Tetanus Immunoglobulin (HTIG) or Anti Tetanus Serum (ATS). The HTIG is a sterile non-pyrogenic solution of hyperimmuneglobulins prepared from plasma of healthy volunteers specifically immunized against tetanus. The dose for prophylaxis in case of contaminated wounds is 250 - 500 I.U. IM. Theraupetic doses for Tetanus Neonatorum is 500 - 10,000 I.U. IM or 250 I.U. intrathecally. In adults and children also it is 500 - 10,0000 I.U. IM. The HTIG gives an effective passive protection for up to 30 days. The ATS is produced from horses and the standard dose is 1500 I.U. subcutaneously. Being equine based, ATS is documented to cause more sensitivity reaction than HTIG, so is generally avoided.

Combined immunisation

This is generally carried out for contaminated wounds in non-immunised persons or in persons whose previous immunization history is doubtful. It also serves as a guideline for all wound management (17). The schedule is as in Table - 2.

Prevention of tetanus also depends upon effective

Table - 1 : Schedule of active immunisation with Tetanus Toxoid

| Category | Primary Immunisation | | | Boosters | | |
|---|---|---|---|---|---|---|
| | 1st Dose | 2nd Dose | 3rd Dose | I | II | III |
| Epi Schedule Combined Vaccine DPT | 6th Week (DPT) | 10th Week (DPT) | 14th Week (DPT) | 16-24th Month (DPT) | 5th Year (DT) | 10th Year (TT) |
| Adults & Child above 10 Years (0.5 ml IM) | 0 Day | 4th -6th Week | 1st Year | Every 5 Years | | |
| Pregnant Woman (0.5 ml IM) | 20th Week | 24th-26th Week | | | | |

Table - 2 : Tetanus vaccination schedule for wound management

| Immunization Status | Tetanus Vaccination according to Type of wound | |
|---|---|---|
| | Clean Wound (Low Risk)* | Tetanus Prone Wound (High Risk)** |
| Documented primary series 250 DPT and reinforcing dose of TT within last ten years. | No Vaccination required | Human Tetanus Immunoglobulin (HTIG) –as I.U. in 1 ml IM in deltoid or gluteal region. > 24 hours have elapsed since injury, or risk of heavy contamination, or following burns, the recommended dose is 500 I.U. |
| Documented primary series and reinforcing dose of TT + HTIG. last dose more than 10 years | Toxoid Vaccine (TT) -0.5 ml IM. | Single reinforcing dose of Tetanus (See dosage above.) TT vaccine and HTIG must be given by separate syringes into separate sites |
| Not immunized or immunization course of TT Vaccine + HTIG status not known with certainty | 0.5 ml at intervals of not less than 4 weeks.(See dosage above) | Full course of TT Vaccine (3 doses) of |

management of wounds as described in the preceding paragraph, along with aggressive and effective wound toilet. Wound toilet is of paramount importance and special attention should be given to deep puncture wounds, burns, animal and human bites, contaminated wounds and chronic non healing wounds. Antibiotic prophylaxis is secondary to good surgical toilet as well as immunoprophylaxis. (18)

### Specific treatment

Along with concurrent active and passive immunization, under a constant watch for hypersensitivity reactions, specific treatment is required. This includes prompt debridement of wounds. Metronidazole is the drug of choice, although penicillin group is widely used. Patients treated primarily with metronidazole have lesser spasm and require lesser sedation(19). Maintain adequate airway, sedation and muscle relaxation in an isolated dark room so as to avoid provoked spasms.

### Prevention in the Armed Forces

All personnel in the Armed Forces fall in a category having a greater risk of infection with Clostridium tetani. All personnel are supposed to be immunized on entry to the Armed Forces and a booster is mandatory for all (Schedule as per Table 1). It is the responsibility of the CO of the unit, to ensure that all ranks in the unit are immunized as per schedule. The RMO / AMA of the unit ensures action on ground, and is supposed to maintain immunization record of all personnel of the unit. This is done by endorsing the individual's Personal Pay book (AB-64), Health Record card and the Immunisation register of the MI Room. The RMO / AMA is responsible for vaccinating all ranks, families and civilian employees under his medical charge. (Para 105 b, 115, RMSAF 1983). Personnel at greater risk than others like amimal handlers, military farm workers should get annual shots of the Toxoid.

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# Rabies

## Historical Background

Rabies is a very old disease, perhaps as old as humankind. The word rabies has its origin in Sanskrit, 3000 years BBC: "rabhas" means "to do violence". The Greek word for rabies, "lyssa" derives from the root "lud" which means "violent". Thus, the family of viruses to which rabies belongs is lyssa. The first description of the disease dates from the 23rd. century BC in the Eshuma Code of Babylon. Antiquity, did know rabies as well as the link between human disease and animals, especially dogs. But, it is a famous Italian scholar, Girolamo Fracastoro, born in Verona, who described the disease, which obviously he had seen in many patients, and its routes of contamination in 1530, i.e. 350 years before Louis Pasteur. In the 19th. century, canine or street rabies was a scourge everywhere, especially in Europe. Fear of rabies, related to the mode of contamination, the absence of any efficacious treatment, was almost irrational. Patients killed themselves or were killed when bitten by a dog believed to be rabid. In this world of irrational terror the first post-exposure treatment was discovered in 1885 by Louis Pasteur.

## Introduction

Rabies is a acute viral disease, which causes encephalomyelitis in virtually all the warm blooded animals, including man. The causative agent is found in domestic and wild animals and is transmitted to other animals and humans through close contact with their saliva ( bites, scratches, licks on broken skin and mucus memberanes)

## Agent

Rabies viruses belong to the genus Lyssavirus of the Rhabdoviridae family. Currently, this genus comprises 7 genotypes, type 1 of which represents the classic rabies virus.

### Structure

This RNA virus is bullet shaped round at one end and flat at the other measuring 100-300nm in length and 75 nm in diametre. The virus is covered with a lipid envelope having spike like projections. It is composed of two structural and functional units:

(a) The outer envelope covered with spike-like projections (10 nm in length) corresponding to G-protein trimers which recognize specific viral receptors on susceptible cell membranes

(b) The internal helically packaged ribonucleocapsid, which is composed of the genomic RNA intimately associated with protein N, polymerase L and its cofactor protein P (formerly named M1). The ribonucleocapsid complex ensures genome transcription and replication in the cytoplasm.

Protein M (formerly named M2) occupies an intermediate position between the ribonucleocapsid and the envelope and is responsible for virus budding and the bullet-shaped morphology.

### Susceptibility to physical and chemical agents

The rabies virus is highly resistant to cold , dryness and decay. In cadavers, it may remains infectious for weeks. This virus is highly thermolabile with a half life of approximately 4 hours at 40°C and 35 seconds at 60°C. Serum proteins and other chelating agents diminish thermal inactivation. In brain tissue, at room temperature it can survive upto 1-2 weeks. (1)

The rabies virus remains stable for several days at 0-4°C, indefinitely at -70°C and when freeze dried. The virus cannot withstand pH less then 4 or more then 10. It is also susceptible to the action of oxidizing agents, most organic solvents, surface acting agents and quaternary ammonium compounds. Proteolytic enzymes, UV rays and Xrays rapidly inactivate the rabies virus. Soaps and detergents are effective against rabies virus because of their lipid eliminating property, which destroys the outer covering of the virus.

## Epidemiology

### Global Status

In >100 countries and territories, rabies is enzootic in animal populations with more than 3.3 billion people live in these regions.. Approximately 55,000 people die from rabies each year, the vast majority of these deaths occurring in Asia and Africa. In Africa, there are estimated at 24,000 (or 4 per 1,00,000 population)deaths annually. Although all age groups are susceptible, rabies is most common in children aged below 15 years, with 30-50% of post-exposure prophylaxis given to children aged 5-14 years, the majority being male. Annually, more than 10 million people, mostly in Asia, receive post exposure vaccination against rabies.

### Rabies in India

In India alone, 20,000 deaths are estimated to occur annually, i.e. 2 per 1,00,000 population. Almost 1.8 million people annually receive post exposure-prophylaxis against rabies. With the exception of Andaman & Nicobar islands and Lakshwadeep islands, human cases of rabies are reported from all over the country round the year. 96% of mortality and morbidity is associated with dog bites. Cats, wolf, mongoose and monkeys are other important reservoirs of rabies in India. Bat rabies has not been conclusively reported in India.

## Mode of transmission

Human infection usually occurs following a transdermal bite or scratch by an infected animal. Transmission may also occur when infectious material, usually saliva, comes into direct contact with the victim's mucosa or with fresh skin lesions. The virus cannot cross intact skin. Very rarely, rabies may occur through inhalation of virus - containing aerosol or via infected organ transplants.

## Incubation Period

The incubation period varies from 2 weeks to 6 years

(average 2–3 months) depending on the amount of virus in the inoculum and site of inoculation. The proximity of the site of virus entry to the CNS increases the likelihood of a short incubation period.

### Pathogenesis

On entering the human body, The virus then either replicates in non-nervous tissues or directly enters peripheral nerves and travels by retrograde axoplasmic flow to the central nervous system (CNS). The estimated speed of virus migration is 15–100 mm per day. The virus then moves from the CNS via anterograde axoplasmic flow within peripheral nerves, leading to infection of some of the adjacent non-nervous tissues: for example, secretory tissues of salivary glands. The virus is widely disseminated throughout the body at the time of clinical onset. The first clinical symptom is usually neuropathic pain at the wound site. This is caused by virus replication in dorsal root ganglia and ganglionitis. Major clinical signs are related to the virus-induced encephalomyeloradiculitis. Two major clinical presentations are observed: furious and paralytic forms that cannot be correlated with any specific anatomical localization of rabies virus in the CNS (4). Nevertheless, peripheral nerve dysfunction is responsible for weakness in paralytic rabies. In furious rabies electrophysiological studies indicate anterior horn cell dysfunction even in the absence of clinical weakness. Without intensive care, death occurs within a few days (1–5 days) of the development of neurological signs. Rabies is inevitably fatal.

### Clinical Diagnosis

Diagnosis of rabies based on clinical grounds alone is difficult and unreliable except when specific clinical signs of hydro or aerophobia are present. Some patients present with a paralytic or Guillain-Barre-like syndrome or other atypical clinical features (5). Classical signs of brain involvement include spasms in response to tactile, auditory, visual or olfactory stimuli (e.g. aerophobia and hydrophobia) alternating with periods of lucidity, agitation, confusion, and signs of autonomic dysfunction. These spasms occur at some time in almost all rabid patients in whom excitation is prominent. However, spontaneous inspiratory spasms usually occur continuously until death and their presence often facilitates clinical diagnosis. Excitation is less evident in paralytic rabies, and phobic spasms appear in only 50% of these patients. During the early stages of paralytic rabies, notable signs include myoedema at percussion sites, usually in the region of the chest, deltoid muscle and thigh, and piloerection. Atypical or non-classic rabies is being increasingly recognized and may be responsible for underreporting.

### Post Exposure Treatment in Humans

Local treatment of wounds

Elimination of rabies virus at the site of the infection by chemical or physical means is an effective mechanism of protection. Therefore, the Consultation emphasized the importance of prompt local treatment of all bite wounds and scratches that might be contaminated with rabies virus. Recommended first-aid procedures include immediate and thorough flushing and washing of the wound for a minimum of 15 minutes with soap and water, detergent, povidone iodine or other substances of proven

Table - 1 : Type of contact, exposure and recommended post-exposure prophylaxis

| Category | Type of contact with a suspect or confirmed rabid domestic or wild[a] animal, or animal unavailable for testing | Type of exposure | Recommended post-exposure prophylaxis |
|---|---|---|---|
| I | Touching or feeding of animals Licks on intact skin | None | None, if reliable case history is available |
| II | Nibbling of uncovered skin<br>Minor scratches or abrasions without bleeding | Minor | Administer vaccine Immediately[b]<br>Stop treatment if animal remains healthy throughout an observation period of 10 days[c] or if animal is proven to be negative for rabies by a reliable laboratory using appropriate diagnostic techniques |
| III | Single or multiple transdermal bites or scratches, licks on broken skin<br>Contamination of mucous membrane with saliva (i.e. licks)<br>Exposures to bats[d] | Severe | Immunoglobulin and vaccine immediately. Stop treatment is animal remains healthy throughout an observation period of 10 days or if animal is found to be negative for rabies by a reliable laboratory using appropriate diagnostic techniques |

(a) Exposure to rodents, rabbits and hares seldom, if ever, requires specific anti-rabies post-exposure prophylaxis.

(b) If an apparently healthy dog or cat in or from a low-risk area is placed under observation, the situation may warrant delaying initiation of treatment.

(c) This observation period applies only to dogs and cats. Except in the case of threatened or endangered species, other domestic and wild animals suspected as rabid should be humanely killed and their tissues examined for the presence of rabies antigen using appropriate laboratory techniques.

(d) Post-exposure prophylaxis should be considered when contact between a human and a bat has occurred unless the exposed person can rule out a bite or scratch, or exposure to a mucous membrane.

lethal effect on rabies virus. If soap or an antiviral agent is not available, the wound should be thoroughly and extensively washed with water. People who live in rabies-infected areas should be educated in simple local wound treatment and warned not to use procedures that may further contaminate the wounds. Most severe bite wounds are best treated by daily dressing followed by secondary suturing where necessary. If suturing after wound cleansing cannot be avoided, the wound should first be infiltrated with passive rabies immunization products and suturing delayed for several hours. This will allow diffusion of the antibody to occur through the tissues before suturing is performed. Other treatments, such as the administration of antibiotics and tetanus prophylaxis, should be applied as appropriate for other bite wounds.

Post Exposure prophylaxis (2)

Table - 1 should serve as a guide for post-exposure prophylaxis. In cases where exposure is questionable or a patient has a concurrent medical condition that may complicate post-exposure prophylaxis, an expert in the administration of rabies prophylaxis should be consulted.

**Rabies vaccines**

Immune response

During infection, rabies viruses are mainly intraneuronal, and antigens may therefore be concealed from immune surveillance. An antibody response is not usually detected in infected humans before the second week of illness. Modern CCVs induce a prompt and high virus neutralizing antibody (VNA) response to the G protein. Cell-mediated immunity may also play a role in protection against infection. Although a protective VNA concentration cannot be established for humans, a minimum level of 0.5 IU/mL is used as a correlate of protection. In healthy vaccinees, this level should be achieved by day 14 of a post-exposure immunization regimen, with or without simultaneous administration of RIG and irrespective of age.

Nerve tissue-based vaccines

More than 100 years ago, Louis Pasteur and his colleagues developed the first crude rabies vaccine for post-exposure prophylaxis based on attenuated virus in desiccated nerve tissue. Although continuously improved over the years, inactivated NTVs produced in the brains of sheep or goats (Semple) or suckling mice (Fuenzalida) are associated with neurological adverse reactions. Thus, in about 0.3–0.8 individuals per 1000 vaccinees, contaminating neuroproteins present in the vaccine cause severe allergic encephalomyelitis. Because NTVs are less potent than CCVs, they may require an immunization course of up to 23 daily injections. In recent years, India and Nepal have successfully phased out production and use of NTVs.

Cell culture-based vaccines

CCVs consist of virus that has been inactivated following propagation in cell cultures The human diploid cell vaccine was introduced in 1967. The more recently developed, and less expensive, purified chick embryo cell vaccine and purified Vero cell-based vaccines have characteristics comparable to the human diploid cell vaccines. CCVs are based on fixed viruses of genotype 1. The shelf-life of these vaccines is at least 3 years, provided storage at +2˚C to +8 ˚C and protection from sunlight. Under these conditions, the vaccines retain a potency of at least 2.5 IU per intramuscular dose (0.5 mL or 1 mL). Following reconstitution with the accompanying sterile diluent, the vaccines should be used immediately, or within a maximum of 6 hours when kept at +2˚C to +8˚C. The respective package inserts should be consulted for specific information and instructions regarding the individual vaccine. The internationally available CCVs have been administered to millions of people worldwide. In both pre and post exposure prophylaxis settings, they induce an antibody response in >99% of vaccinees. Prompt post exposure use of modern vaccines combined with proper wound care and RIG is nearly 100% effective in preventing rabies, even following high-risk exposure. However, delays in starting or failure in completing correct prophylaxis, especially with severe lesions on the head, neck, hands or multiple wounds, may result in death.

Factors that should be taken into consideration when deciding whether or not to initiate post exposure prophylaxis include the likelihood of the concerned animal being rabid, category of exposure (I–III), clinical features of the animal, as well as its availability for observation and laboratory testing. In most situations in developing countries, the vaccination status of the offending animal should not be taken into consideration to withhold prophylaxis.

Post Exposure Prophylaxis

**Intramuscular administration (3)**

The post exposure vaccination schedule is based on IM doses of 1 ml or 0.5 ml, depending on the manufacturer. The recommended regimen consists of either a 5-dose or a 4-dose schedule.

(a) The 5-dose regimen (Essen regimen): prescribes 1 dose injected into the deltoid muscle (or anterolateral thigh in children aged <2 years) on each of days 0, 3, 7, 14 and 28.

(b) The 4-dose regimen ("2–1–1" or Zagreb regimen): prescribes 2 doses on day 0 (1 in each of the 2 deltoid/thigh sites) followed by 1 dose on each of days 7 and 21.

**Intradermal administration**

The high cost of CCVs by the volume required for the standard IM route is prohibitive for widespread use in many areas where dog rabies is endemic. For some CCVs, equal immunogenicity has been demonstrated by ID using at least 60% less vaccine than by IM vaccination. ID vaccination offers a safer and more effective alternative to the use of NTVs and a more economical alternative compared with the IM use of CCVs. Since 1991, WHO has recommended the ID route of administration for rabies pre- and post-exposure prophylaxis. ID regimens have been successfully introduced for post-exposure prophylaxis in developing countries such as India, the Philippines, Sri Lanka and Thailand. Either the 8-site or the

2-site regimen should be used, as recommended by the respective vaccine manufacturer.

(a) The 8-site ID regimen: prescribes on day 0, injections of 0.1 ml given at 8 sites (1 in each upper arm, 1 in each lateral thigh, 1 on each side of the suprascapular region, and 1 on each side of the lower quadrant region of the abdomen); on day 7, 1 injection in each upper arm and each lateral thigh; and on each of days 30 and 90, 1 injection in one upper arm (6) The1 dose on day 90 may be replaced by 2 ID injections on day 30.

(b) The 2-site ID regimen prescribes 1 injection of 0.1 ml at 2 sites on days 0, 3, 7 and 28 (7).

**Previously Vaccinated Individuals**

For rabies-exposed patients who have previously undergone complete pre-exposure vaccination or postexposure prophylaxis with a CCV, 2 IM or ID doses of such a vaccine administered on days 0 and 3 are sufficient. RIG is not necessary in such cases. The same rules apply to people vaccinated against rabies who have demonstrated VNA titres of at least 0.5 IU/ml. Vaccination cards carefully recording previous immunizations are invaluable for correct decision-making.

**Rabies immunoglobulin for passive immunization**

RIG should be administered in all category III exposures and in category II exposures involving immunodeficient individuals. Given its relatively slow clearance, human rabies immunoglobulin (HRIG) is the preferred product, particularly in cases of multiple severe exposures. However, HRIG is in short supply and available mainly in industrialized countries. Where HRIG is not available or affordable, purified equine immunoglobulin (ERIG) or highly purified F(ab´)2 products of ERIG should be used. Most of the new ERIG preparations are potent, highly purifi ed, safe and considerably less expensive than HRIG. However, they are of heterologous origin and carry a small risk of hypersensitivity reactions.10 There are no scientific grounds for performing a skin test prior to administration of ERIG because testing does not predict reactions, and ERIG should be given whatever the result of the test. RIG for passive immunization should not be injected later than 7 days after the initiation of post-exposure vaccination.

**Dosage and administration**

The dose for HRIG is 20 IU/kg body weight, and for ERIG and F(ab´)2 products is 40 IU/kg body weight. As much of the recommended dose of passive immunization products as is anatomically feasible should be infiltrated into and around the wounds. Multiple needle injections into the wound should be avoided. If a finger or toe needs to be infiltrated, care must be taken not to cause a compartment syndrome, which can occur when an excessive volume is infiltrated under pressure and blood circulation is impaired. In the event that a remainder of passive rabies immunization product is left after all wounds have been infiltrated, it should be administered by deep intramuscular injection at an injection site distant from the vaccine injection site.

Animal bite wounds inflicted can be severe and multiple, especially in small children. In such cases, the calculated dose of the passive rabies immunization product may not be sufficient to infiltrate all wounds. In these circumstances, it is advisable to dilute the passive immunization product in normal saline to a sufficient volume to be able to inject all wounds. A full course of vaccine should follow thorough wound cleansing and passive immunization.

**Post-exposure prophylaxis of HIV-infected people and HIV/AIDS patients**

Several studies of patients with HIV/AIDS have reported that those with very low CD4 counts will mount a significantly lower or no detectable neutralizing antibody response to rabies. In such patients and those in whom the presence of immunological memory is no longer assured as a result of other causes, proper and thorough wound treatment as described above and antisepsis accompanied by local infiltration of a passive immunization product are of utmost importance. Immunocompromised patients with category II exposures should receive rabies immunoglobulin in addition to a full post-exposure vaccination series as listed above. An infectious disease specialist with expert knowledge of rabies prevention should be consulted.

**Pre Exposure vaccination**

Pre exposure vaccination should be offered to

(a) People at high risk of exposure such as those working in rabies diagnostic or research laboratories

(b) Veterinarians, animal handlers (including bat handlers), animal rehabilitators and wildlife officers

(c) People (especially children) living in or travelling to high-risk areas

Intramuscular administration

Pre-exposure rabies vaccination requires IM doses of 1 ml or 0.5 ml, depending on the vaccine type, given on days 0, 7 and 28 (day 28 preferable, but administration may be advanced towards day 21 if time is limited). For adults, the vaccine should always be administered in the deltoid area of the arm; for children aged <2 years, the anterolateral area of the thigh is recommended. Rabies vaccine should not be administered in the gluteal area, where the induction of an adequate immune response may be less reliable.

Intradermal administration

ID administration of 0.1 ml volumes on days 0, 7, and 28 (day 28 preferable, but administration may be advanced towards day 21 if time is limited) is an acceptable alternative to the standard IM route. However, ID administration is technically more demanding and requires appropriate staff training and qualified supervision.

Booster injections

Periodic booster injections are recommended only for people whose occupation puts them at continuous or

frequent risk of rabies exposure. In such cases, a booster dose should be given at intervals ideally dictated by regular testing for antirabies antibodies. Potential laboratory exposures to high concentrations of rabies virus motivates testing as often as every 6 months; VNA (Virus neutralizing Antibodies) titres of at least 0.5 IU/ml indicate protection. Where serological testing is unavailable, booster vaccination every 5 years may be an acceptable alternative.

A rabies pre-exposure certificate should be completed and given to the vaccine indicating the type of vaccine and vaccine regimen used, lot number of vaccine, and any adverse reactions that occurred during vaccination.

### Control of rabies in dogs

Canine rabies can be eliminated, as has been demonstrated in North America, western Europe, Japan and many areas in South America. However, canine rabies is still widespread, occurring in over 80 countries and territories, which are predominantly in the developing world. In more than 99% of all human rabies cases, the virus is transmitted from dogs; half of the global human population lives in canine rabies-endemic areas and is considered at risk of contracting rabies. Effective animal vaccines that provide a considerable duration of immunity have been developed and mass parenteral vaccination programmes remain the mainstay of canine rabies control. Dog destruction alone is not effective in rabies control. Canine rabies control programmes should incorporate three basic elements, with priorities varying according to the prevailing social, cultural and economic factors. The basic elements are:

(a) Epidemiological surveillance
(b) Mass vaccination
(c) Dog population control

**Epidemiological surveillance** : Rabies should be a notifiable disease within national health and veterinary systems. Rabies surveillance is still inadequate in many countries and this deficit should be addressed by national authorities, with the support of international agencies. Rabies can only be reliably diagnosed by laboratory tests and it is strongly recommended that, in countries where diagnostic facilities are inadequate or lacking, laboratory capacity be developed to permit effective rabies surveillance.

**Canine mass parenteral vaccination campaigns :** Mass canine vaccination campaigns have been the most effective measure for controlling canine rabies. At least 70% of the dog population in each community should be vaccinated in areas where canine rabies is endemic. High vaccination coverage (70% or higher) can be attained through strategies consisting of well-designed educational campaigns, intersectoral cooperation, community participation, local commitment in planning and execution, availability of recognized quality vaccine, media support and effective general coordination and supervision of the activities by the health services (9, 10). All dogs and cats, when presented, should be immunized, regardless of their age, weight or state of health. Given the high birth rates of many populations, particular attention should be paid to ensuring adequate vaccination coverage of puppies (8).

Supplementary measures

Oral vaccination of dogs

Oral vaccination of dogs offers a new approach that may significantly improve dog vaccination coverage (especially of free-roaming and poorly supervised dogs) when applied either exclusively or in combination with parenteral vaccination. As dog accessibility to vaccination by the parenteral route is one of the major obstacles for canine rabies control in many different parts of the world. Although the preferential vaccine for dog immunization should be parenteral (inactivated tissue-culture vaccines), oral vaccination should be used whenever there is high population of inaccessible dogs.

Dog population management and animal birth control (ABC) programmes

There is no evidence that removal of dogs alone has ever had a significant impact on dog population densities or the spread of rabies. The population turnover of dogs may be so high that even the highest recorded removal rates (about 15% of the dog population) are easily compensated for by increased survival rates. In addition, dog removal may be unacceptable to local communities. However, the targeted and humane removal of unvaccinated, ownerless dogs may be effective when used as a supplementary measure to mass vaccination. Three practical methods of dog population management are recognized:

(a) Movement restriction
(b) Habitat control
(c) Reproduction control.

### Laboratory diagnosis

Collection, preservation, packing and transportation of specimens

The acute infection nature of rabies does not require further elaboration . Therefore, in the collection of specimen from suspected cases of rabies-human or animal, it must be born in mind that highly dangerous material is being handled. It is imperative to follow all precautionary measures during collection, packing transportation and handling of specimen to avoid any serious mishap.

Specimen from human beings

From a clinical case (hydrophobia) the antemortem specimen that may be collected include saliva, corneal smear, skin biopsy, hair follicles, blood and cerebrospinal fluid. Postmortem specimen shall usually be if brain of spinal cord and sometimes other organs too. The specimens are collected as follows :

**Saliva / Sputum**

Saliva is collected from under the tongue:

(a) Wet a sterile cotton swab with tissue culture

medium or physiological saline and remove excess medium by squeezing on the sides of the vial.

(b) Swab under the tongue, rinse in the tissue culture medium or physiological saline containing two percent normal horse serum (NHS).

(c) Take another swab similarly and make two.

(d) Air dry the glass slides for 10 minutes.

(e) Discard the swabs in suitable disinfectant.

(f) Treat the slides immediately with chilled acetone and process or wrap in paper and dispatch to the laboratory.

Often due to dehydration, there is very little saliva in the mouth. The patient, if responsive, may be asked to cough and spit in Petri dish or beaker. Mix the sputum with a few ml of tissue culture medium or two percent NHS in physiological saline and transfer to a screw capped vial.

**Corneal smears**

(a) Retract the eyelids with thumb and one finger and press a clean marked slide against the cornea.

(b) Prepare two smears on each slide taking care to apply sufficient pressure to the smear.

(c) Avoid exerting too much pressure as it may damage the eye.

(d) Air-dry the smears for 10-15 minutes at room temperature.

(e) Treat with chilled acetone and process further.

**Skin biospy**

With very fine sharp scissors, collect small pieces of skin from the site of bite and the face near the mandible. Preserve in a vial containing 50 percent glycerol saline (prepared by mixing equal volumes of glycerol and physiological saline and sterilized by autoclaving).

**Hair Follicle**

Pluck a few hairs with the help of a forceps from the face and or behind the ear. Put in a vial containing 50 percent glycerol saline.

**Cerebrospinal fluid (CSF)**

The CSF in acute phase of the diseases is processed foe isolation of the virus and in the later phase for antibodies. It is collected by lumber puncture. Usually no preservative is used but, if required, 50 percent glycerol saline may be used.

**Blood**

Acute phase venous blood specimen is collected as soon as possible with the usual aseptic precautions. If the patient survives foe several days, a second sample is taken. In case the patient recovers another blood sample is taken before discharging the patient.

**Urine**

(a) Collect in wide-mouth containers.

(b) Mix with equal quantity of tissue culture medium.

(c) Centrifuge immediately and discard the supernate.

(d) Mix sediment with 2-3 ml of tissue culture medium and transfer to screw capped vials.

**Brain**

The brain is collected at autopsy. Many times the relatives do not agree for a full postmortem. In such cases Vim-Silverman needle may be used to collect a small pice of glycerol saline.

Collection of specimen from suspected rabid animals

The specimens useful for proper diagnosis of rabies in animals are mainly brain and salivary glands. Through it is risky to collect antemortem specimen, if required saliva and corneal smears may be collected as already described. The better course, however, is to permit the animal to die a natural death unless otherwise required ( see microscopic examination). Facilities for removal of the animal brain and salivary glands are not available in the laboratory, hence the whole brain or salivary glands should be sent to the laboratory after post-mortem.

If it is not possible to send the whole brain, pieces from Ammons horn of hippocampus, cerebrum, cerebellum, pons and medulla may be included.

Preservation

If possible the sample, of brain and salivary glands may be sent in wide mouth leak proof containers preserved on ice. However, if the samples are not to be sent long distance, these may be preserved by use of following:

(a) 10 percent formal saline/ Zenkers fluid for half of the brain

(b) 50 percent glycerol saline for other half of the brain and salivary glands.

(c) Tissue culture medium two percent NHS saline of saliva, CSF, urine etc.

Labeling

All the specimens, e.g. slides, vials must be labeled with number of specimen, name of the patient, or spices of the animal, type of preservative used, etc. permanent markers should be used. The parcels should also be labeled properly.

**Information to be enclosed**

(a) Hydrophobia : name, age, sex, treatment, taken, exposure to animal, etc. may be enclosed.

(b) Animal : The species and breed of animal, contact with other animals, symptoms, mode and date of death, vaccination status, etc.

Packing

(a) It should preferably be wide-mouth leak proof plastic containers.

(b) Seal the mouth of the container with tape or sealing paraffin.

(c) Pack in plastic bags and put in thermocol box with sufficient ice.

(d) If sending by post-pack in sturdy wooden boxes with sufficient packing material (preferably absorbent cotton/saw dust paddy husk).

Transportation

(a) By courier

(b) By air / by post.

Laboratory Test

Utmost urgency should be exhibited in transportation of these because any undue delay, especially in tropical climates, shall wither way the cooling effect of ice and result into putrefaction of the sample making it unsuitable for the diagnosis.

Several tests are necessary to diagnose rabies ante-mortem (before death) in humans; no single test is sufficient. Tests are performed on samples of saliva, serum, spinal fluid, and skin biopsies of hair follicles at the nape of the neck.

(a) Saliva : Tested by virus isolation or reverse transcription followed by polymerase chain reaction (RT-PCR).

(b) Serum and spinal fluid : Tested for antibodies to rabies virus.

(c) Skin biopsy specimens : Examined for rabies antigen in the cutaneous nerves at the base of hair follicles.

Techniques for intra vitam diagnosis of Rabies in humans

The sensitivity of techniques for rabies diagnosis varies greatly according to the stage of the disease, antibody status, intermittent nature of viral shedding and the training of the technical staff. While a positive result is indicative of rabies, a negative result does not necessarily rule out the infection. Brain biopsy taken solely for the diagnosis of rabies is not recommended (11).

**Antigen detection**

Viral antigen may be detected by using the FA test on skin biopsies from patients with clinical rabies. Skin biopsies are usually taken from the nuchal area of the neck, with hair follicles containing peripheral nerves.Examination of at least 20 sections is required to detect rabies nucleocapsid inclusions around the base of hair follicles. The quality of skin biopsy samples is of paramount importance. Though sensitive, this technique may not be practical in all settings, because of the need for a cryostat to prepare frozen tissue sections. FA testing on corneal impressions is rarely reliable in most clinical settings and is therefore not recommended.

**Virus isolation**

Rabies virus isolation can be performed using neuroblastoma cells or the intracranial inoculation of mice. Virus isolation is preferably performed on saliva samples or other biological fluids such as tears and cerebrospinal fluid. The success rate depends upon the antibody status (more positive results are obtained in antibody-negative patients) and on the intermittence of viral shedding. It should be noted that infectious virus may be absent from these specimens even during the late stage of the disease.

**Antibody titration**

Neutralizing antibodies in the serum or cerebrospinal fluid of non-vaccinated patients can be measured using a virus neutralization test such as the rapid fluorescent focus inhibition test (RFFIT) or the fluorescent antibody virus neutralization (FAVN) test. Virus-neutralizing antibodies in serum tend to appear on average 8 days after clinical symptoms appear. Rabies antibodies are infrequently found in cerebrospinal fluid.

An ELISA using purified rabies glycoprotein has been used to determine antiglycoprotein antibody levels in the serum of humans and of some animal species. This assay can be useful when the RFFIT is not available.

**Molecular techniques**

Molecular detection by polymerase chain reaction and nucleic acid sequence based amplification techniques has the highest level of sensitivity but requires standardization and very stringent quality control (12). Rabies virus RNA can be detected in several biological fluids and samples (e.g. saliva, cerebrospinal fluid, tears, skin biopsy sample and urine). Serial samples of fluids (e.g. saliva and urine) should be tested, owing to intermittent shedding of virus. Such techniques can produce false positive or false negative results, and should only be used in combination with other conventional techniques.

Techniques for postmortem diagnosis of rabies in animals and humans

**Antigen detection**

The fluorescent antibody (FA) technique is a rapid and sensitive method for diagnosing rabies infection in animals and humans (13). It is the gold standard for rabies diagnosis; however, the accuracy of this test depends upon the expertise of the examiner, and the quality of anti-rabies conjugate and the fluorescence microscope. The test is based upon microscopic examination under ultraviolet light of impressions, smears or frozen sections of tissue after they have been treated with anti-rabies serum or globulin conjugated with fluorescein isothiocyanate. Impressions (or smears) of tissue samples from brainstem, thalamus, cerebellum, and the hippocampus are recommended for increased sensitivity of the test.

Detection of lyssavirus nucleocapsid antigen by enzyme-linked immunosorbent assay (ELISA) has been described and used for many years in some laboratories (13).It is rapid and can be useful for epidemiological surveys

**Virus isolation**

Virus isolation may be necessary to confirm the results of antigen detection tests and for further characterization of the isolate (13). Virus isolation can be performed on neuroblastoma cells or upon intracranial inoculation of mice. Murine neuroblastoma (NA C1300) cells are more susceptible to field isolates of rabies virus than are other cell lines tested. Virus isolation in cell culture (with neuroblastoma cells) is at least as efficient as mouse

inoculation for demonstrating small amounts of rabies virus. It also reduces the time required for diagnosis from 10–15 days for the mouse inoculation test to 1–2 days using neuroblastoma cells.When compared with the FA technique, the gold standard, the sensitivity of virus isolation in neuroblastoma cells is higher than 98%.

**Detection by molecular techniques**

The use of the polymerase chain reaction (PCR) and other amplification techniques is not currently used for routine postmortem diagnosis of rabies. However, these molecular techniques can be applied for epidemiological surveys in laboratories with strict quality control procedures in place and that have experience and expertise with these techniques.

**Negri bodies examination**

This test is simple and quick in diagnosis of rabies and can be performed easily and a quick report can be given. The intracytoplasmic inclusion bodies called ' Negri bodies' can be detected by using various stains of which seller's stain is the simplest and the widely used. Both impression smears and section of tissues can be stained. The presence of these bodies depends on the time of death and the course of the disease. The chances of detection of Negri bodies increases if the animal is permitted to die its natural death. Nearly 70%of the specimen from rabid animals can be diagnosed by this test. Few characteristics of Negri Bodies are as follows.

(a) Oval, round or elongated

(b) Size 3-20 J.. µm

(c) Presence of basophilic inner granules and heterogenous matrix

(d) Mostly abundant in hippocampus.

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# Leptospirosis

## Introduction

Leptospirosis is a zoonosis spread throughout the world. Often under reported, the disease is now a prominent re - emerging infection and surveillance data suggests that it may be the most common zoonosis in the world (1). It is primarily an infection in rodents and several other wild and domesticated animals. Leptospirosis occurs worldwide but is most common in tropical and subtropical areas with high rainfall. The disease is found wherever humans come into contact with the urine of infected animals. Occupational exposure probably accounts for 30 - 50% of human cases (1-3). Most human infections are asymptomatic and the disease presentation can vary from extremely mild illness to fatal illness (4).

## History

The severe form of the disease was first described by Adolf Weil as a disease entity in four men who had fever, haemorrhage and severe jaundice in 1886 in Heidelberg (5). His name is still attached to a serious form of leptospirosis called Weil's disease. Inada and Ido identified the causal organism in 1916 in Japan.

## Epidemiology

### World

Leptospirosis is endemic throughout the world. However, the incidence of the disease is significantly higher in tropical countries as compared to temperate regions. This is as attributed to both the favourable climatic conditions in tropical countries as well as the fact that the tropics have a greater proportion of developing countries which provide greater opportunities for exposure of the human population to infected animals. The peak incidence of the disease is in summer or fall in temperate regions, and during rainy seasons in warm - climate regions (6). The number of human cases worldwide is not known precisely. The World Health Organization estimates that incidences range from approximately 0.1 - 1 per 1,00,000 per year in temperate climates to 10 - 100 per 1,00,000 in the humid tropics. During outbreaks and in high - exposure risk groups, disease incidence may reach over 100 per 1,00,000 (7). Increased awareness of the disease has led to increased recognition (8).

### India

Though Leptospirosis is widespread in India, the true extent of the disease is not known because no large scale serological surveys have been carried out. However, a number of studies have reported outbreaks in different parts of the country since 1930 (9 - 18). Several epidemics of leptospirosis have occurred in Andaman and Nicobar islands and in southern and western parts of India during the past century. For the past 10 years, the city of Mumbai has been witnessing a seasonal increase in the number of cases of Leptospirosis (19). Large outbreaks have occurred following the monsoon flooding in the city. A post - cyclone outbreak was reported in Orissa, India in 1999.

## Agent

*Leptospira icterohaemorrhagiae* is the causal organism for Leptospirosis. It is a slender, closely wound, very actively motile spirochete varying in length from 6µ to 20µ. Before 1989, the genus Leptospira was divided into two species. *Leptospira interrogans* which were the pathogenic strains and *Leptospira biflexa* which were the saprophytic strains in the environment. Over 12 species with over 250 serologic variants (Serovars) of the pathogen have been identified. Serovars that are antigenically related have traditionally been grouped into serogroups. The serogroups are useful for epidemiological understanding (20 - 24).

## Hosts

A wide variety of animal species, primarily mammals, serve as the animal hosts for the pathogen and are the primary sources for human infection. Small mammal species, notably feral and peridomestic rodents (rats, mice) and insectivores (shrews and hedgehogs) are the most important hosts for maintaining the infection in nature. Domestic animals like cattle, pigs, dogs, sheep and even larger mammals like horses and buffaloes can be infected. Reptiles and amphibians have also been detected to carry leptospires.

Humans are a "dead end" for leptospires as they do not form an infection reservoir. Adult males are most affected due to occupational exposure. Occupations such as livestock farmers, sewer workers and abattoir workers are most affected. The names for some forms of Leptospirosis like rice field fever, cane cutter's disease, swineherd's disease, dairy farm fever, mud fever reflect transmission conditions. Some recreational activities like swimming in natural waters may also result in exposure. Children may acquire infection from dogs. People living in cities may also be exposed to animal hosts notably rats. Outbreaks of leptospirosis have been reported following natural disasters such as flooding and hurricanes (7).

## Environmental Factors

The pathogenic organisms can survive for weeks in soil and water contaminated with urine and faeces of reservoir animals. Poor housing, improper sewage disposal and unsafe water supply increase the risk of transmission. Warm, humid conditions are ideal for survival of the leptospires and consequently the disease shows a seasonal variation in India.

## Transmission

The leptospires have the ability to penetrate mucosa but not intact skin. However they can enter the body through broken skin and some researchers have suggested that they can penetrate through waterlogged skin. Human leptospiral infections result primarily from either direct contact with urine or tissue of infected animals or indirect contact through soil, water or vegetation that is contaminated with animal urine. They may occasionally

enter the human body via the inhalation of droplets of urine or via drinking - water. They can be transmitted from human to human by sexual intercourse, transplacentally from the mother to the fetus and via breast milk to a child. The urine from a patient suffering from leptospirosis should be considered infectious (7).

### Pathogenesis

On entering the human body, the organisms are carried by blood to all parts of the body. The leptospiremia can spread to any part of the body but particularly affects the liver and kidney. It causes a systemic vasculitis which allows entry of the spirochetes into different organs and tissues which accounts the broad spectrum of clinical presentation. Despite the possibility of severe complications, the disease is mostly self - limited and nonfatal.

### Clinical Features

The incubation period is usually between 5 - 14 days but can range from 2 to 30 days. The clinical presentation of the disease can be extremely variable. Most cases present with symptoms of sudden headaches, fevers, nausea and bodyache. 90% of cases have an acute febrile illness with a biphasic course, non - specific signs and symptoms and an excellent prognosis. The first stage is called the septicemic or leptospiremic stage. During this stage, which lasts about 4 - 7 days, the patient develops a nonspecific illness characterized by fever, chills, weakness, and body ache. These symptoms abate during a one to three day period. The fever subsides and the patient may become completely symptom free. The return of fever heralds the onset of the second stage. This stage is called the immune or leptospiruric stage. Disease referable to specific organs is seen. These organs include the meninges, liver, eyes, and kidney. About three fourths of patients complain of headache.

Less than 10% of patients suffer from Icteric leptospirosis or Weil's disease. The presentation includes fever, jaundice, renal failure and hemorrhage. Other organ systems (pulmonary, cardiac, central nervous) also are involved frequently. Weil's disease carries a mortality rate of 5 to 30% (4, 6, 7).

### Diagnosis

As the manifestations of Leptospirosis are non specific, laboratory investigations are essential to confirm the diagnosis. Routine blood and biochemical tests also reveal abnormalities that do not confirm the diagnosis. Patients will have raised ESR. Blood counts reveal thrombocytopaenia and leucocytosis while biochemical asssys may show hyperbilirubinaemia, elevated serum creatinine, elevated creatinine kinase and elevated serum amylase (19, 25-27).

Direct visualization, culture and serology have all been used to confirm the diagnosis of Leptospirosis. Dark field microscopy is required for direct visualization of spirochetes because of their size. Slides may be made from both blood and urine. Immunofluorescence staining and silver staining are used. However dark ground microscopy suffers from low sensitivity and specificity both. Samples for culture from blood, CSF or peritoneal fluid should be collected before antibiotic treatment has been started. Cultures take very long as initial growth is very slow, and hence are not a practical means of confirming the diagnosis. The most reliable serological test is the microscopic agglutination test (MAT). A four fold rise in the MAT titre or a single titre of at least 1:800 are diagnostic. Other tests include an indirect hemagglutination test and ELISA for specific IgM antibodies. Rapid commercial tests for leptospira antibodies have recently become available. PCR may be used for molecular diagnosis for epidemiological studies.

### Differential Diagnosis

The diseases which should be considered in the differential diagnosis of leptospirosis are : Influenza; Dengue and Dengue haemorrhagic fever; Yellow fever and other viral haemorrhagic fevers; Rickettsiosis; Borreliosis; Brucellosis; Malaria; Pyelonephritis; Aseptic Meningitis; Chemical poisoning; Food poisoning; Typhoid fever and other enteric fevers; Viral Hepatitis; (7).

### Treatment

The spirochetes are sensitive to several antibiotics. There is no need to wait for the conformation of diagnosis before starting antibiotic treatment. Severe cases of leptospirosis should be treated with high doses of intravenous penicillin. Less severe cases can be treated with oral antibiotics such as amoxycillin, ampicillin, doxycycline or erythromycin. Third - generation cephalosporins, such as ceftriaxone and cefotaxime, and quinolone antibiotics also appear to be effective. Aggressive supportive care with strict attention to fluid and electrolyte balance is essential. Peritoneal or haemodialysis is indicated in renal failure (2, 3, 7). Doxycycline 200mg orally once a week has been used for chemoprophylaxis. The drug should be given for a few weeks at a time.

### Prevention and Control

The control of Leptospirosis in reservoir animals is impossible because of their sheer variety and numbers. Prevention of human cases may be achieved by use of personal protective measures, avoidance of high risk exposure, immunization and chemoprophylaxis. Some degree of reservoir control can be achieved by rodent control and by reducing infection in domestic animals such as dogs or livestock by immunization (28). Risk of infection is minimized by avoiding contact with animal urine, infected animals or an infected environment. Protective clothing should be worn and wounds covered with waterproof dressings to reduce the chance of infection if occupational or recreational exposure is likely (29 - 33). In case of an outbreak, persons exposed to animal urine (wading through flood waters etc) may be given doxycycline chemoprophylaxis.

Killed vaccine is available against Leptospirosis. Due to the large number of serovariants, the effectiveness of the vaccine is limited. Protective antibodies are produced only against the serovars present in the particular vaccine used.

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# Brucellosis

## Introduction

Brucellosis is a zoonotic infection of domesticated and wild animals, caused by organisms of the genus Brucella. It is transmitted from animals to humans by ingestion of infected food products, direct contact with an infected animal, or inhalation of aerosols. It is known by several names like Malta Fever and Undulant Fever. In 1954, Brucella were the first bacteria to be weaponised as biological warfare agents because aerosols are a remarkably efficient method of disease transmission. However, it's relatively long and variable incubation period and the fact that many infections are asymptomatic, has made it a less desirable agent for biological warfare. Four species of Brucella are known to cause human disease. They are *Brucella melitensis, Brucella abortus, Brucella suis* and, *Brucella canis*.

## History

Descriptions of the disease date back to Hippocrates. Brucellosis in humans has a strong association with military medicine (1) The disease was first described in 1751 by Cleghorn, a British army surgeon stationed on the island of Minorca. He described cases of chronic, relapsing febrile illness among the British soldiers stationed on the island (2). The early descriptions of the disease and the discovery of the causative organism come largely form British army doctors working on the Mediterranean island of Malta in the second half of the nineteenth century. In 1861, Marston described the clinical characteristics of the disease (3). In 1887, a British army doctor David Bruce, isolated the causative organism from the spleens of five fatal cases (4). The species was named Brucella after him. The term Undulant Fever was given by ML Hughes (5). Bang identified *Brucella abortus* as a cause of abortion in cattle in 1895 (6).

## Epidemiology

Brucellosis is a worldwide zoonosis. The highest incidence is seen in areas where cattle or other animal rearing is carried out. High rates of disease are observed in the Middle East, Mediterranean region, China, India, Peru and Mexico. Abortus fever occurs sporadically in all parts of the world including India. No epidemics have been reported from any part of the world but upsurge of the sporadic cases occurs in various parts from time to time. With the advent of animal vaccines and improvements in hygiene in animal rearing, the disease has declined in developed countries. However, the global burden of human brucellosis remains large. It is estimated to cause more than 5,00,000 infections per year worldwide. The number of reported infections is much lower because the diagnosis is often not confirmed.

In India, cattle in Maharashtra, Karnataka, Madhya Pradesh, Tamil Nadu and Orissa have been found infected. Very few surveys have been made. A few surveys in dairy farms show low incidence.

## Agent

Brucellae are small, nonmotile, nonsporing, nontoxigenic, nonfermenting, aerobic, Gram - negative coccobacilli. The outer cell membrane is similar to that of other Gram - negative bacilli with a dominant lipopolysaccharide (LPS) component and three main groups of proteins. Brucella species do not harbor plasmids naturally although they are known to readily accept broad - host - range plasmids (6, 7, 8).

The metabolism of the brucellae is mainly oxidative and they show little action on carbohydrates in conventional media. They are aerobes but some species require an atmosphere with added $CO_2$ (5 to10 percent). Multiplication is slow at the optimum temperature of 37°C and enriched medium is needed to support adequate growth. Brucella colonies become visible on suitable solid media in 2 - 3 days. The colonies of smooth strains are small, round and convex but dissociation, with loss of the O chains of the LPS, occurs readily to form rough or mucoid variants (9, 10).

Among the four species that cause disease in humans, *Brucella melitensis* is the most virulent and causes the most severe and acute cases. *Brucella suis* infection causes a prolonged course of illness and may be associated with suppurative destructive lesions. Mild - to - moderate sporadic disease, rarely associated with complications is the characteristic of *Brucella abortus*. Infection with *Brucella canis* results in a disease course that is similar to *Brucella abortus* infection. The onset of disease is insidious, marked by frequent relapses and does not commonly cause chronic disease.

## Host

Each Brucella species has a specific animal reservoir. The infection in the animal hosts result in chronic disease that persists for life. The organisms tend to localize in the reproductive organs of the animals, causing sterility and abortions. They are shed in large numbers in the urine, milk and placental fluid of the infected animals. This localization is responsible for the efficient spread of infection to workers who come in contact with these liquids. The specific animal reservoirs for the various Brucella species are shown in Table -1.

Human brucellosis is predominantly a disease of adult males. Farmers, shepherds, butchers, abattoirs workers, veterinarians and laboratory workers are particularly at special risk because of occupational exposure.

## Environment

The organism can survive for weeks under favorable conditions. High humidity, overcrowding of herds and poor hygienic conditions of milk and meat production are favorable for the transmission of infection.

## Transmission

Animals shed large amounts of Brucella organisms during septic abortion, at the time of slaughter and in their milk.

Table - 1 : Animal Reservoirs of Brucella

| Organism | Animal reservoir | Geographic distribution |
|---|---|---|
| *B melitensis* | Goats, sheep & camels | Mediterranean, Asia & Latin America |
| *B abortus* | Cattle,buffalo, and camels | Worldwide (Eliminated in Japan, Israel & several European nations) |
| *B suis* | Domestic & feral swine | South America, Asia & mid-western United States |
| *B canis* | Canines | Cosmopolitan |

Source (11)

The incidence of human disease is closely linked to the prevalence of infection in sheep, goats and cattle and to practices that allow exposure of humans to potentially infected animals or their products (12-15).

Brucellae can gain entry into humans through breaks in the skin, mucous membranes, conjunctiva, respiratory and gastrointestinal tracts. Ingestion of the organisms with milk or other contaminated animal products or by contact with contaminated fingers is the most common route of infection. Inhalation of aerosols containing the bacteria, or aerosol contamination of the conjunctivae, is another route. Percutaneous infection through skin abrasions or by accidental inoculation is a rare mode of transmission of infection (16).

**Pathogenesis**

On entry into the human host, Brucellae are rapidly phagocytosed by polymorphonuclear leukocytes. Brucellae possess the ability to survive and multiply within the phagocytic cells. It is believed that the organism can survive and multiply in these cells because they inhibit the bactericidal myeloperoxidase - peroxide - halide system by releasing 5' - guanosine and adenine. Soon after infection, the organisms become localized in the organs of the reticulo - endothelial system such as the spleen and lymph nodes. In animals the organisms also localize in the reproductive organs. The presence of meso - erythritol in the testicles and seminal vesicles of bulls, rams, goats and boars and in the products of conception in pregnant ruminants and pigs stimulates enormous multiplication of brucellae. Erythritol represents a potent localizing factor in the relevant species, but is absent in humans (17-20). Large granulomas serve as a source for persistent bacteremia. The specific host defenses against brucellae are similar to those against other intracellular bacteria and are both humoral and cell - mediated. Macrophages process brucellar antigen and present this to T lymphocytes which produce lymphokines. T cell - derived lymphokines are also involved in attracting cells to the foci of infection. This leads to granuloma formation.

**Incubation period**

The incubation period is extremely variable. Symptoms usually begin insidiously within two to four weeks but may start after as long as 6 months or more.

**Clinical Features**

The presentation of brucellosis is characteristically variable. Symptoms of brucellosis are protean in nature. The onset is usually insidious but rarely may be abrupt. Subclinical infections are common. The symptoms are non specific. Patients develop fever, malaise, headache, loss of appetite. Bodyache may be unusually severe. Sweating, including malodorous sweat and fatigue are common. The leukocyte count may be normal or reduced, with a relative lymphocytosis. Splenomegaly may often be the only clinical finding. If the disease is not treated, the symptoms may continue for 2 to 4 weeks and a characteristic undulant pattern of fever can be discerned. Many patients will then recover spontaneously but others may suffer a series of exacerbations. Most affected persons recover entirely within 3 to 12 months but some will develop complications marked by involvement of various organs and a few may enter an ill - defined chronic syndrome. Complications include arthritis, often sacroiliitis and spondylitis, central nervous system effects including meningitis, uveitis and occasionally, epididymoorchitis. In contrast to animals, abortion is not a feature of brucellosis in pregnant women (6). Depression, out of proportion to the symptoms has often been reported.

**Diagnosis**

Cases of Brucellosis are often not diagnosed because of the non specific presentation of the disease. A high index of suspicion and a detailed history of possible exposure, either occupational or during travel or of ingestion of contaminated foods are essential. However, at times patients can present several years after initial exposure making diagnosis difficult.

Definitive diagnosis is made by isolation of the organism. Blood culture is the method of choice but specimens need to be obtained early in the disease and cultures may need to be incubated for up to four weeks. Despite these precautions, failure to grow the organism is common, especially in cases of *B abortus* infection. Culture from bone marrow and from presenting foci may be successful. Presumptive identification of cultures can be made from morphology and slide agglutination with specific antiserum. Serology is the most commonly used method for confirming the diagnosis. However interpretation of the results should be done carefully. The tube agglutination test, which tests for anti-O- polysaccharide antibody is considered the best. A titer of 1:160 or higher of specific IgG and IgM is considered diagnostic. Most patients already have high titers at the time of clinical presentation, so a 4 - fold rise in titer may not occur. IgM rises early in disease and may persist at low levels for several months after treatment. While the SAT titers commonly decline after recovery from infection and antiglobulin test levels are maintained much longer, the

IgM antibody that is commonly measured by the SAT does not fall away as regularly as in some infections. Nevertheless, persisting levels of antibody may indicate a remaining focus of infection and specific IgG levels rise again with a true relapse (21). The diagnosis of the chronic Brucellosis Syndrome, without specific localization is difficult. If the cultures are negative and the results of serology are equivocal a confident diagnosis may not be possible (22, 23).

**Treatment**

The organism is susceptible to a variety of antibiotics. Doxycycline is usually drug of choice. Other antibiotics that may be used are Rifampicin, Gentamycin and Streptomycin. The use of a single drug has been found to have a high relapse rate, so combined regimens should be used whenever possible (24). A 6- week regimen of doxycycline 200 mg/day administered orally, with the addition of streptomycin 1 g/day administered intramuscularly for the first 2 to 3 weeks is effective therapy for adults with most forms of Brucellosis (25). The WHO recommended treatment regime is a combination of both rifampcin 600 to 900 mg/day & doxycycline 200 mg/day given orally for six weeks (6, 26). Some worker have reported that treatment with a combination of streptomycin and doxycycline may result in less frequent relapse than treatment with the combination of rifampin and doxycycline (27, 28). Endocarditis needs longer duration of treatment. Doxycycline along with a combination of two more drugs for six weeks may be required. Central nervous system disease also needs prolonged treatment with drug combinations like rifampcin and trimethoprim / sulfamethoxazole. In children below eight years of age, trimethoprim + sulfamethoxazole may be used. An alternate treatment in children is a five day course of gentamicin (29-32).

**Control**

Animals

Eradication of the infection from animal reservoirs is the most important means for preventing human brucellosis. Eradication of brucellosis from domestic animals reduces dramatically the threat to humans and has been successful in several countries. Vaccination of animals and improving the hygiene of slaughterhouses can markedly reduce the disease in animals. Animal vaccines are available against several strains of Brucella. Detection of infected herds and individual animals and their elimination are also important control measures.

Humans

A live vaccine is available only against a particular stain of *Brucella abortus* (Strain 19 BA). Early diagnosis and treatment of cases is important. Protection of dairy products and pasteurization or boiling of milk is also required for control of transmission. Personal protective measures in the form of wearing impermeable clothing, rubber boots, gloves and face masks, care during handling of carcasses and safe laboratory procedures also help in control.

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# Plague

## Introduction

Plague is one of the oldest diseases known to man. (1) It is primarily a zoonotic disease that exists in nature between small mammals, usually wild rodents, and the fleas that they harbour. (2). Plague is endemic in many parts of the world and exits in many small natural foci. It is widely distributed in the tropics and subtropics and in warmer areas of temperate countries. The causative bacteria, *Yersinia pestis* can also infect humans. It is transmitted between animals and humans by the bite of infected fleas, direct contact, inhalation and rarely, ingestion of infective materials. Untreated plague can be a very serious disease with case fatality rates between 30% and 60% (3). Recent outbreaks have shown that plague may reoccur in areas that have long remained silent (1).

## History

Plague has been known as a dreaded killer from times immemorial. The first plague epidemic has been described in the Bible as the outbreak among the Philistines in 1320 BC. Over the last two millennia, plague has become widespread, affecting a large number of countries on most continents during several pandemics. The first pandemic, also called the Justinian plague took place in the sixth century and is reputed to have killed nearly a hundred million victims. The second plague pandemic is known as the "Black Death" of the fourteenth century which caused 50 million deaths. A quarter of the population of Europe is said to have been wiped out by this pandemic. The third pandemic began in Hong Kong in 1894. Within 10 years this pandemic had spread to all the continents. This pandemic resulted in 13 million deaths in India (1, 4).

During the third pandemic, the causal agent, *Yersinia pestis* was discovered In1894. It was also established that rats contract plague and that the rat flea *Xenopsylla cheopis* is the common vector (1, 4)

## Epidemiology

### Worldwide

The number of cases of human plague reported to the World Health Organization has remained stable in the recent past. The WHO believes that the number of cases officially notified is considerably lower than the actual number (5). Plague exists in natural enzootic cycles involving wild rodents and their fleas in several parts of the world. These natural cycles are usually hidden with no transmission to humans. Epidemics of plague occasionally occur when the disease spreads from wild rodents to rats that live in close proximity of human habitation.

Between 1989 and 2003, a total of 15 year period, 38,310 cases with 2845 deaths were recorded in 25 countries. In these 15 years the highest number of human plague cases was reported in 1991 and the lowest number 1989. Eight countries reported human plague almost every year. These countries were the Democratic Republic of the Congo, Madagascar and the United Republic of Tanzania in Africa; Peru and the United States in the Americas, and China, Mongolia and Viet Nam in Asia. An increase in the incidence of human plague has become apparent since the early 1990s, particularly in Africa. Three geographical areas experienced outbreaks of human plague after silent periods of about 30–50 years : India in 1994, Indonesia in 1997 and Algeria in 2003 (5-7). The total number of human plague cases reported to WHO in 2002 was 1925, of which 177 were fatal. In 2003, nine countries reported 2,118 cases and 182 deaths. 98.7% of those cases and 98. 9% of those deaths were reported from Africa. Today the distribution of plague coincides with the geographical distribution of its natural foci (3, 5).

### India

India suffered very large number of deaths during the third Plague pandemic. Plague outbreaks continued to occur, but with decreasing frequency during the first half of the 20th century. This is often attributed to the collateral benefit from the extensive insecticide spraying done as a part of the National Malaria Programme. India remained plague free for almost 30 years after the last human case was reported from Karnataka in1966.

In August–October 1994 human plague was reported in India. During this outbreak, 876 cases with 54 deaths were characterized as presumptive plague. Most cases were reported from Maharashtra (596), 151 from Gujarat, 68 from Delhi, 50 from Karnataka, 12 from Madhya Pradesh, and 10 from Uttar Pradesh. Almost all the deaths were reported from Gujarat. Several reasons have been put forth to explain this outbreak. Rat–fall was first reported from Mamla village in the Beed district of Maharashtra on 5 August 1994. This was followed by reports of flea nuisance. Three weeks later, suspected cases of bubonic plague were reported from Mamla village followed by reports from other villages in Beed and other districts. Beed has had sylvatic plague in the past. Ecological changes created by the earthquake in September 1993 and large scale storage of foodgrains probably contributed to a gradual growth of the rat population. The resurgence of plague in Surat, Gujarat, was related to a record high rainfall during the September monsoon. Floods in the Tapti river resulted in inundation of large areas. Many rodents were found dead when the water floods receded. Based on the clinical picture and the plague outbreak in neighbouring Maharashtra the outbreak in Surat was declared as pneumonic plague on 21 September 1994 (1, 8-12).

In February 2002, an outbreak of pneumonic plague (16 cases, 4 deaths) occurred in Hat Koti village, Shimla district, Himachal Pradesh. The outbreak is believed to have started after a person acquired the infection in the forest, which then spread to others through person - to - person contact. (5). Since 2002 there has been no

confirmed case of plage in India.

**Agent**

*Yersinia pestis* is a gram - negative coccobacillus. Yersinia was formerly classified in the family Pasteurellaceae, but has been now reclassified as members of the Enterobacteriaceae family. Though there are 11 species in the genus Yersinia, only three are considered important human pathogens. The bacteria is small (1.0 to 2.0 mcm x 0.5 mcm), pleomorphic and is seen as single cells or short chains in direct smears. They are nonmotile, nonsporulating, non-lactose fermenting facultative anaerobes (13-15).

**Vector**

*Yersinia pestis* is most commonly transmitted between animal reservoirs and to humans through the bites of infected fleas. There are more than 1,500 flea species, of which about 30 are known to be vectors for *Y pestis*. The major flea vectors include the following (15) :

(a) *Xenopsylla cheopis* (the oriental rat flea; nearly worldwide in moderate climates)

(b) *Oropsylla montanus* (United States)

(c) *Nosopsyllus fasciatus* (nearly worldwide in temperate climates)

(d) *Xenopsylla brasiliensis* (Africa, India, South America)

(e) *Xenopsylla astia* (Indonesia and Southeast Asia)

(f) *Xenopsylla vexabilis* (Pacific Islands)

To be an efficient plague vector, the flea must be able to ingest the *Yersinia pestis* with its blood meal. It must also live long enough for the pathogen to multiply in sufficiently large numbers. It must be able to transfer the pathogen to an animal or human host in sufficient concentrations to cause an infection. *Xenopsylla cheopis* is the most important vector of plague. A high incidence of plague infected *X. cheopis* in a given focus, greatly increases the risk of transmission to humans (1). *Pulex irritans*, the human flea may be responsible for human to human transmission of Plague (1, 16).

**Host**

More than 200 mammalian species have been known to be naturally infected with *Yersinia pestis*. However, plague is primarily a disease of rodents. The infection is maintained in natural foci of the disease in wild rodent colonies through transmission between rodents. The animal hosts of plague are classified as enzootic (maintenance) hosts and epizootic (amplification) hosts (1). Enzootic hosts are characterized by relatively mild illness, and low mortality rates. Voles and mice have been suggested as maintenance hosts. Epizootic rodents are associated with susceptibility and high mortality. Highly susceptible or epizootic plague hosts include various species of mice, rats, voles, gerbils, ground squirrels and marmots. Rats have historically been a primary carrier of plague (1, 15, 17-20)

**Transmission**

The most common mode of transmission of *Yersinia pestis* to humans is by the bite of infectious fleas. Other, less common modes of transmission include direct contact with infectious body fluids or tissues while handling an infected animal or inhaling infectious respiratory droplets (13). The mode of entry of the organism has marked clinical significance.

**Clinical Features**

Infection by *Yersinia pestis* causes a severe febrile illness characterized by headache, myalgia, malaise, shaking chills, prostration and gastrointestinal symptoms. The three commonest clinical presentations of plague are bubonic, septicemic and pneumonic (1, 13, 15). Less common forms of plague include pharyngeal and meningeal plague.

Bubonic Plague

For bubonic plague the mode of entry of the organism is by a flea bite. The infection spreads via the lymphatics to the regional lymph nodes causing inflammation and swelling in one or several nodes forming the classic buboes. Buboes may occur in any regional lymph node sites including inguinal, axillary, and supraclavicular. After an incubation period of 2 to 6 days, a patient experiences sudden onset of illness characterized by headache, chills, fever, malaise and pain in the affected regional lymph nodes. Progression of symptoms is usually rapid with the regional lymphadenitis becoming tender and painful. With specific treatment in uncomplicated cases, fever and general clinical symptoms usually resolve over 3 to 5 days.

Septicemic Plague

Septicemic plague occurs when *Yersinia pestis* invades and continues to multiply in the bloodstream. It can occur secondarily to bubonic plague or can develop without detectable lymphadenopathy. The host response may result in a wide spectrum of pathological events including disseminated intravascular coagulopathy, multiple organ failure and adult respiratory distress syndrome. Complications include plague pneumonia, plague meningitis and hepatic or splenic abscesses.

Pneumonic Plague

Pneumonic plague is the least common but most dangerous and fatal form of the disease. It can develop as a secondary complication of septicemic plague or result from inhalation of infectious droplets. The incubation period is usually varies from one to three days. There is sudden onset of chills, fever, headache, body pains, weakness and chest discomfort. This progresses rapidly to severe pneumonia accompanied by high fever, dyspnea, and often hemoptysis. If specific antibiotic therapy is not begun within 18 - 24 hours of onset, the patient is unlikely to survive. Pneumonic plague must be considered highly contagious, although person - to - person transmission is most likely in cold humid environments coupled with overcrowding. As the transmission occurs through infected droplets (and not airborne droplet nuclei), person - to - person transmission requires close contact.

Differential Diagnosis

Differential diagnosis of bubonic plague includes bacterial lymphadenitis, infectious mononucleosis, lymphatic filariasis, tick typhus, tularemia and other causes of acute lymphadenopathy. Involvement of intra - abdominal lymph nodes may mimic appendicitis or acute cholecystitis. Pneumonic plague may be confused with other causes of acute, severe community - acquired pneumonia, such as pneumococcal, streptococcal, or Haemophilus influenzae pneumonia (1).

## Diagnosis

Plague is diagnosed clinically based on exposure history and the symptoms of the patient. Presence of the classical buboes leads to suspicion of plague. Septicemic plague is resembles other gram - negative septicemias and is, therefore more difficult to diagnose on clinical grounds. Pneumonic plague can similarly be mistaken for other pneumonias. if possible, samples for confirmation of plague should be taken before treatment is begun. However, treatment should not be delayed by waiting for the laboratory results (15). Collection and transport of specimens is dealt with in detail in a separate chapter.

Routine blood tests show Leucocytosis with a predominance of neutrophils. Total WBC counts may be as high as 25,000/ml. The degree of leucocytosis is proportional to the severity of illness. Peripheral blood smear may show toxic granulations. Thrombocytopenia is common (21)

The laboratory diagnosis of plague is based on bacteriological and/or serological evidence. Diagnostic specimens for smear and culture include whole blood, sputum, aspirates from suspected buboes, pharyngeal swabs and cerebrospinal from suspected plague meningitis cases (1). Smears stained with Gram, Giemsa, Wright, or Wayson stain can provide supportive but not confirmatory evidence of a plague infection in the form of bipolar staining Gram - negative bacilli.

The diagnosis of plague is confirmed by the culture of *Y. pestis* from body fluids or tissues. *Y. pestis* grows on solid media as grey - white, translucent colonies, usually too small to be seen as individual colonies at 24 hours. After incubation at 37˚C for 48 hours, colonies are about 1 - 2 mm in diameter. After 48 - 72 hours of incubation colonies are raised and have an irregular appearance. Cultures are definitely identified as *Y. pestis* by specific phage lysis (1, 22).

Plague can be also be confirmed serologically by a four - fold or greater change in titre to the *Y. pestis* F1 antigen by passive haemagglutination testing of paired serum specimens. The specificity of a positive passive haemagglutination test can be confirmed by the F1 antigen haemagglutination - inhibition test. Some patients of plague seroconvert as early as 5 days after onset of symptoms, most seroconvert between 1 and 2 weeks after onset, while a few seroconvert 3 weeks or more after onset. Less than 5% do not seroconvert. After seroconversion, positive serological titres usually diminish gradually over months to years. Enzyme - linked immunosorbent assays (ELISAs) for detecting IgM and IgG antibodies may also be used for diagnosis. Detection of the F1 antigen in tissues or fluids by direct fluorescent antibody testing provides presumptive evidence of plague (1, 15)

In the recent past rapid diagnosis of plague has become available using the F1 antigen diagnostic assays based on dispsticks. These tests make a bedside diagnosis available within 15 minutes using bubo aspirate, serum and urine specimens (23).

A summary of laboratory diagnostic categories for human plague is as follows (From (1))

**Suspect plague**

(a) Compatible clinical and epidemiological features; and

(b) Suspicious organisms seen or isolated from clinical specimens.

**Presumptive plague**

(a) *Y. pestis* F1 antigen detected in clinical materials by direct fluorescent antibody testing, or by some other standardized antigen detection method; or

(b) Isolate from a clinical specimen demonstrates biochemical reactions consistent with *Y. pestis* or PCR positivity; or

(c) A single serum specimen is found positive for diagnostic levels of antibodies to *Y. pestis* F1 antigen, not explainable on the basis of prior infection or immunization.

**Confirmed plague**

(a) Isolate identified as *Y. pestis* by phage lysis of cultures; or

(b) A significant (4 - fold) change in antibody titre to the F1 antigen in paired serum specimens.

## Treatment

When a diagnosis of human plague is suspected, appropriate specimens for diagnosis should be taken immediately and the patient should be started on specific antibiotic treatment without waiting for laboratory confirmation. All patients suspected of having bubonic plague should be placed in isolation until 2 days after starting antibiotic treatment. Suspect plague patients with evidence of pneumonia should be placed in isolation and managed under respiratory droplet precautions.

Streptomycin is the drug of choice. The dose of streptomycin is 30 mg/kg/day (Not more than of 2 g/day) in divided doses given intramuscularly. Streptomycin must be given for a full course of 10 days or until 3 days after the temperature has returned to normal. Chloramphenicol is a suitable alternative. The dose of chloramphenicol is 50 mg/kg/day administered in divided doses either parenterally or orally for 10 days. Tetracyclines are effective in the primary treatment of patients with uncomplicated plague. An oral loading dose of 15 mg/kg tetracycline (not to exceed 1 g total) should

be followed by 25 - 50 mg/kg/day (up to a total of 2 g/day) for 10 days. Tetracyclines may also be used adjunctively with other antibiotics. Fluoroquinolones, such as ciprofloxacin are also effective (1, 15, 21)

### Prophylaxis

Close contacts of cases with pneumonic plague, or persons suspected to have had direct contact with body fluids or tissues of a *Y. pestis* - infected mammal, or exposed during a laboratory accident to known infectious materials should receive prophylactic antibiotics if the exposure was in the previous six days. Tetracycline and chloramphenicol are the antibiotics of choice for prophylaxis (1).

### Prevention and Control

Control of transmission is directed at controlling the rodent reservoirs and flea vectors of the disease. Trying to eliminate fleas and wild rodents from the natural environment in plague - infected areas are impractical. However, controlling rodents and their fleas around places where they are in close proximity of human beings is very important. Environmental sanitation and public health education are effective means of achieving these ends. Rodent and flea control measures are discussed in detail in the Chapters on Entomology and Rodents.

#### Surveillance

An effective surveillance system to provide early warning can abort epidemics. Effective plague prevention and control programmes require up - to - date information on the incidence and distribution of the disease. The surveillance programme must be designed to collect, analyse, and interpret clinical, epidemiological, and epizootiological data on plague. Surveillance should identify cases and epizootics as quickly as possible so that steps can be taken to control disease spread(1). Surveillance must include reporting of human cases, ecological and environmental observations, and surveillance of rodent populations. Readers may refer to the WHO Plague Manual (1) for details on human and rodent surveillance including precautions to be observed by health care workers.

#### Flea indices (from (1))

The most basic information obtained from flea and rodent surveys is the number of fleas of different species found on various species of hosts. This raw data can be used to calculate various indices. The important flea indices in use are :

**Total flea index** = Total number of fleas collected (regardless of species), divided by the total number of hosts of species examined

**Specific flea index** = Number of fleas of species A collected from host species divided by the number of individuals of host species examined (multiplication of this index by 100 gives the percentage index)

**Percentage of hosts infested** = Number of hosts of species infested with flea species divided by the total number of hosts of species examined, multiplied by 100.

**Burrow (or nest or house) index** = Number of fleas of species collected from burrows (or nest or house) of host species divided by the total number of burrows (or nest or house) of host species examined.

The specific flea index is the most widely used of the above indices. It has been reported that a specific flea index of greater than 1 for *X. cheopis* on rats represents a potentially dangerous situation with respect to increased plague risk for humans.

#### Vaccination

Plague vaccines were widely used in the past but have not proven effective in the control of plague. Both live attenuated and formalin - killed *Y. pestis* vaccines have been developed. The vaccines are variably immunogenic and moderately to highly reactogenic. They do not protect against primary pneumonic plague. Vaccination is of little use during human plague outbreaks, since a month or more is required to develop a protective immune response. Vaccines are, therefore, not recommended for immediate protection in outbreak situations. Vaccination is only recommended as a prophylactic measure for high - risk groups like laboratory personnel who are constantly exposed to the risk of contamination. (1, 16, 24)

The killed or inactivated plague vaccine is prepared from *Y. pestis* organisms grown in artificial media and then inactivated in formaldehyde. It is administered intramuscularly as a series of three primary doses. The initial dose of 1 ml is followed 1 to 3 months later by a 0.2ml dose. A third primary injection of 0.2 ml is given 5 to 6 months after the second. Two booster doses of 0.2ml are administered at 6 - month intervals, and additional boosters may be given every 1 to 2 years (15). Adverse reactions following injection of the first dose of plague vaccine generally are mild, but the frequency and severity of such events can increase with repeated doses.

Live *Y. pestis* vaccines composed of presumably avirulent strains also have been developed. However, none of these vaccines is commercially available, and their safety and

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Lt Col VS Grewal

# Hazards due to Snakes

## Introduction

There are over 20 families of snakes in the world with above 3000 species. All the venomous snakes are however distributed across four families namely; Atractaspididae, Elapidae (including Hydrophiinae), Colubridae and Viperidae. A bite from a venomous snake can lead to disability or death. All snakes are carnivorous, eating animals smaller than it, including rodents, birds, eggs, insects and even snakes. Some have a venomous bite, used to incapacitate the prey before eating. Some snakes kill their prey by constriction and some swallow their prey live, as they cannot chew, so they have a flexible lower jaw (1).

A snake has always been associated with human symbolism. In Christianity the snake makes its infamous appearance in the Genesis in front of Adam and Eve. In India the snake is worshipped and associated with the Hindu Gods Shiva and Vishnu. Snakes are often associated with fertility and nagpanchami is celebrated every year. A snake is also one of the twelve celestial animals of the Chinese zodiac. The Nile Cobra adorning the crown of the Egyptian pharaoh and the depiction of Medusa in Greek mythology as having snakes instead of hair show the deep association of the reptile across human civilizations.

Serpents and medicine have also been symbolically associated. Snakes are seen in three medical symbols, namely the Rod of Asclepius (single snake), staff of Caduceus (two snakes entwined) and the Bowl of Hygea (symbolizing pharmacy). The Rod of Asclepius has been incorporated in the badge of the Army Medical Corps.

## Classification of Snakes

Study of snakes is called as ophiology. Dr Patrick Russell (1727 - 1805) is regarded as the father of Indian ophiology. Snakes now are classified morphologically by the arrangement of their scales (Lepidosis), dentition, osteology, mycology, sensory organs, the form of hemipenes and increasingly by sequence analysis of DNA encoding important mitochondrial and other enzymes (1). Snakes of medical importance primarily belong to four families only and are described in brief in the succeeding paragraphs (2). The common names of snakes of these families are listed in Table - 1.

## Venom Apparatus in Snakes

### Elapids

Generally found in tropical or sub - tropical regions of the world including Indian Sub - continent and the pacific. They are highly venomous and possess a set of hollow fixed fangs through which they inject venom.

### Viperadae

They are found all over the world except Australia and Madagascar. They have long hinged fangs, permitting deep injection of venom. When not in use the fangs fold back against the roof of the mouth and are enclosed in a membranous sheath. These snakes are highly venomous.

### Colubridae

It is a broad family including more than half the species of snakes of the world. A colubrid body is nearly fully covered in scales. Majority of the colubrids are harmless, non - venomous, but the ones listed in Table - 1 are venomous and have caused human fatalities. The colubrids are morphologically not a natural group and it is said that the family has been a dumping ground for snakes that do not fit anywhere.

### Atractaspididae

It is a family of venomous snakes found in Africa and Middle - east countries. This family includes many genera formerly classified in other families on the basis of dentition. Taxonomy of this family still is highly contentious.

## Snakes in India (3, 4)

Venom apparatus in Snakes

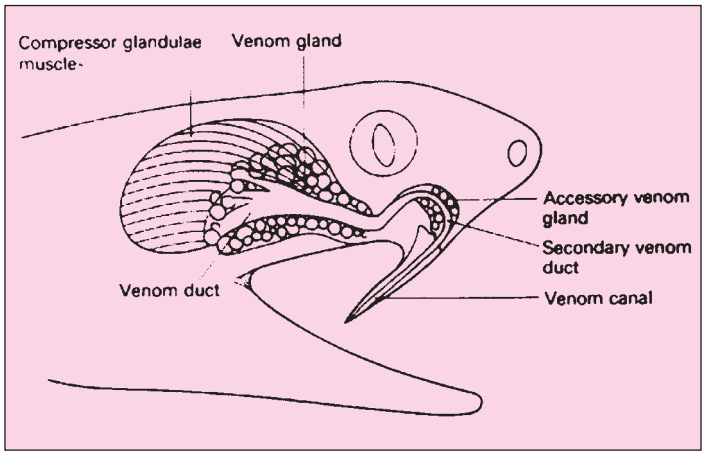


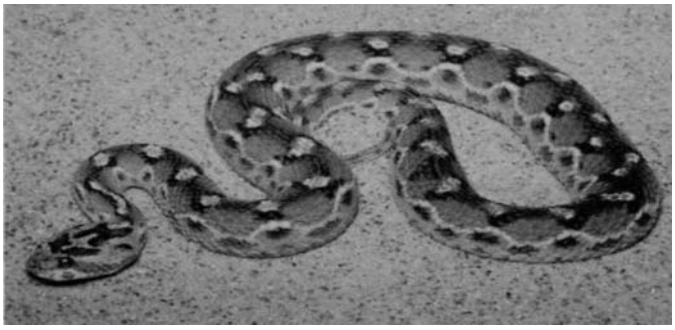

Table - 1 : Families of Venomous Snakes with common names

| Family | Common names |
|---|---|
| Elapids | Cobras, king cobras, krait, mamba, Australian copperheads, sea-snakes, coral snakes |
| Viperids | Russel viper, Saw-scaled viper, Hump nosed Pit Viper, Rattle snakes, Cottonmouths, Adders, Bushmasters |
| Colubrids | Boomslangs, Treesnakes, Vinesnakes, Mangrove snakes ( not all Colubrids are venomous) |

The Indian Cobra (*Naja naja*)

The Common Krait ( *Bungarus caeruleus*)

Russells Viper ( *Daboia russelli*)



The Saw Scaled Viper (*Echis carinatus*)

India has 216 species of snakes. For many decades the concept of the 'Big 4' snakes of medical importance in India have reflected a view that 4 species are responsible for Indian snake bite mortality - The Indian Cobra (*Naja naja*), Common Krait (*Bungarus caerulus*), Russells Viper (*Daboia russelli*) and the Saw - scaled Viper (*Echis carinatus*). The most recent discovery now has been the Hump - nosed Pit Viper (*Hypnale hypnale*), which till date was being confused with the Saw - scaled Viper. So now India is home to 5 main venomous snakes which cause mortality. The main features of the Indian snakes are given in Table - 2.

**Epidemiology of Snake Bite**

Snake bites take their toll the world over and India leads the race. It is said that India accounts for more than 50 % of the world's mortality due to snake bite. There are more than 2,00,000 bites per year across the country with over 35,000 deaths per year (2, 5). However no reliable database is available. In Maharashtra the highest incidence of snake bite is reported (70 bites per 1,00,000 population and mortality of 2.4 / 1,00,000 per year) (6). The other states in India which show high incidence include Tamil Nadu, Uttar Pradesh and Kerala (7). Personnel of the Armed Forces, especially Army, are very prone to snake bites during field exercises and maneuvers. Majority of bites in India occur in rural India (82%), where common places of occurrence is workers in fields and people sleeping outdoors at night (8). Snake bites have also shown a male preponderance, which suggests a special risk of outdoor activity (9, 10).

**Snake bite as an occupational hazard**

It is documented by the WHO that snake - bites across the world and especially in the SEARO is an occupational hazard. It mostly occurs due to access by humans to the snake's natural environment, occurring across various occupations. Some of the common occupations are:

(a) Farmers (especially paddy)

(b) Plantation workers (coffee, rubber)

Table - 2: Features of Indian Snakes (4)

| | Common Krait (*Bungarus caeruleus*) | Indian Cobra (*Naja naja*) | Russells Viper (*Daboia russelii*) | Saw Scaled Viper (*Echis carinatus*) |
|---|---|---|---|---|
| FEATURES | Medium sized, smooth, glossy scales, jet black, usual distinct white cross lines | Medium sized to large, smooth, shiny scales, wide head and neck, distinctive hood marking | Medium sized to large, strongly keeled scales, distinctive bright chain pattern, large triangular | Small, strongly keeled scales, head wider than neck, dull colour, cross mark on head distinctive |
| AVERAGE LENGTH | 1 m, At birth 25 cm, Max-1.75 m | 1m, At birth 25 cm, Max-2 m | 1m, At birth 25 cm, Max- 1.8 m | 30-50 cm, At birth 8 cm, Max- 80 cm |
| DESCRIPTION | Smooth glossy, bluish black, rounded head slightly different from neck. Adults have approx 40 thin white cross bands. The underside is white. | Smooth scaled snake, black eyes, wide neck and head and medium body. Colour varies from black to dark brown to yellowish white. Body has speckled patterns forming ragged bands | Heavy rough scaled snakes, vertical eye pupils, very bright pattern Colour is brown or yellowish with pattern of dark round spots edged with black and white. The spots are distinctly symmetrical. Underside is white and speckled. Short fat body abd with triangular shaped head | Rough scaled, large eyes, wider head than neck and stocky body. Colour brown, grayish or sandy, dark zigzag pattern and lance cross on head .Underside speckled white. Smallest venomous snake in India |
| DISTRIBUTION | Most of India, sea level up to 1700m, uncommon in Bengal, Assam Orissa where Banded Krait is common | Throughout India, sea level upto 2000 m | Hills and plains throughout India upto 3000 m | Through out India, upto 1500 m, plentiful in Maharashtra, Rajasthan, Punjab, Tamil Nadu & Andhra Pradesh. |
| HABITAT | Sandy soil, termite mounds, burrows, piles of bricks, rubble | More common in rice growing areas, due to availability of rodents. Granaries, termite mounds, earth dams and rock piles are favourite haunts. | Equally at home in the open areas of hilly country and plain scrub jungles bordering farmlands. Termite mounds, rock crevices are favourites. Also found in pandanus bushes (Kewda) and | Dry, sandy and rocky terrain. Not found in dense forests. Rest under rocks and dry plants. Areas of light scrub jungle are favourite. |
| HABITS | During day kraits hide, mostly nocturnal, territory consciousness present among males. They are short fanged snakes | Usually live in rat holes, near human habitat, shy in nature. Warning mechanism consists of spreading neck ribs (hood), hissing with sharp expulsion of air. | Looks sluggish, but capable of fast movements in short spurts. They hiss loudly and bite in defence. They are timid and less likely to be commensal with man | Nocturnal, also called 'Phoorsa,, rarely seen in daylight, active on humid / rainy nights, prefers warm roads and beated paths after dark. Produces hissing sound by rubbing |
| YOUNG | Lay 8-12 eggs in Mar- May which hatch in May-Jul. Female stays with eggs during incubation | Between May-Jul, female lays 12-30 eggs, stays during incubation (60 days) | May – Jul, females produce 6 -63 living young (Not eggs), they are viviparous-so the name vipers | 4-8 living young, Apr – Aug |
| FOOD | Other snakes, lizards and rodents. They are true cannibals | Insects, lizards, frogs, toads, rodents and other snakes. They maintain their grip till the prey becomes immobile | Young are cannibalistic, also eat lizards, rodents, scorpions and insects. Adults are predominantly rodent eaters. | Mice, Lizards, frogs , scorpions and other arthropods |
| STATUS | Very common and abundant. Thrive near human habitat | Hunted and killed for skins as also, worshipped and revered across the country | Major source of skin industry in South India, in some areas have been | Abundant, though collected in large numbers for skin |
| VENOM | Extremely neurotoxic. No local symptoms of envenomation seen | Neurotoxic venom, usually less than fatal amounts are injected | Bite is considered one of the most dangerous of all snakes, mainly due to amount of venom and vasculotoxicity | Cause largest number of bites, though bite rarely fatal. If fatal dose injected it takes days to die, generally treatment is available |

(c) Herdsmen
(d) Hunters
(e) Snake handlers
(f) Fishermen and fish farmers
(g) Army personnel (during field maneuvers)

### Determinants of severity of envenomation

Not all bites by venomous snakes are lethal and there are many factors which influence the severity of bite by a venomous snake. Some of the factors are:

(a) Dose dependency: Lethality depends upon the amount of venom injected by the snake.
(b) Species of snake
(c) Season and age of the snake
(d) Health, age, size and specific immunity of the victim (human).
(e) Nature and timing of First - Aid and subsequent treatment offered.

### Venom composition (2, 11)

Snakes have the most complex of all venoms. They contain more than 20 components. More than 90 % of dry weight is protein, comprising a rich variety of enzymes, non - enzyme polypeptide toxins and non toxic proteins such as nerve growth factor. Non-protein component includes carbohydrates and metals. The variation of venom occurs from species to species and within a single species throughout its geographical distribution, at different seasons of the year and also as result of the snake ageing. This is explained by the clinical diversity of the snake bite. Certain important venom constituents causing specific clinical problems are listed below:

(a) **Procoagulant Enzymes (viperidae)** : They stimulate blood clotting but result in incoagulable blood. The venom contains several procoagulants which activate different steps of the clotting cascade. The result is the formation of fibrin in the blood stream. Most of this is immediately broken down by the body's own fibrinolytic system. Eventually, depending on the dose of venom injected, the levels of clotting factors become so depleted that the blood will not clot (Consumption coagulopathy).
(b) **Haemmorrhagins (Zinc metalloproteinases)** : They damage endothelial lining of the blood vessel wall causing spontaneous systemic hemorrhage.
(c) **Cytolytic and Necrotic Toxins** : These digestive hydrolases (Proteolytic enzymes and Phospholipase A) and polypeptide toxins increase the permeability resulting in local swelling. They destroy cell membranes and tissues.
(d) **Hemolytic and Myolitic Phospholipase A2** : These enzymes damage cell membranes, endothelium, skeletal muscle, nerves and blood cells.
(e) **Presynaptic Neurotoxins** : (Elapidae and Viperadae) Phospholipase A2 that damages nerve endings, initially releasing acetylcholine transmitters, then subsequently, interfering with release.
(f) **Post Synaptic Neurotoxins** : They compete with acetylcholine for receptors at neuro - muscular junctions and lead to curare like paralysis.

### Identification of Venomous Snakes (4)

There is no simple rule for identifying a dangerous venomous snake. Many harmless snakes have evolved, and behave in a manner identical to a venomous snake. However some of the most venomous snakes can be recognized by their size, shape, colour, patterns and markings, their behavior when threatened. The defensive behavior of the cobra is well known: they rear up, spread a hood, hiss and make repeated strike towards the aggressor. The blowing hiss of a Russell's viper and the grating rasp of a Saw - scaled Viper are warning and identifying sounds. Vipers are also identified by their repeated and colourful dorsal pattern.

The identification of a dead snake by looking at the scales is not fool - proof and requires expertise. The criteria for species identification by external morphology of the dead snake is beyond the scope of the book, however reference can be made in "The Indian Field Snake Guide". It is also important that the identification should not form the basis of treatment which should solely be based on the clinical profile of the patient.

### Signs and symptoms of snake bite (1, 2)

#### When venom has not been injected

Many people are bitten by non - venomous snakes, or do not get injected by venom during a bite of venomous snake. There are some who imagine that they have been bitten, even with a mere contact of a snake. It has been documented that quite a sizeable number of such victims develop striking signs and symptoms, quite resembling envenomation. This is said to be a result of the understandable fear of consequences of a real venomous bite. Some common features seen are anxious tetany of the hands and feet, dizziness, vasovagal shock, bradycardia and collapse. Agitation and irrational behaviour are also seen.

Another source of resemblance of signs of envenomation is due to aggressive and wrong First - aid methods combined with traditional methods of treatment. Constricting bands and tourniquets may cause pain, swelling and congestion. Ingested remedies may produce vomit. Instillation of irritant plant juices in the eye may cause conjunctivitis. Forcible insufflations of oils in respiratory tract may cause aspiration, bronchospasm and pneumothorax. Local incision and cauterization may cause injuries.

#### When venom has been injected

Sometimes bites by venomous snakes, especially of kraits and sea snakes, may be virtually painless and cause negligible local reaction. A sleeping person may not even wake up and no detectable fang mark may be seen. However there are a plethora of signs and symptoms associated with envenomation, which may be clinically helpful to detect snakebite. Snake bite produces localized, generalized as well as species specific signs and

symptoms. Localized signs and symptoms are fang marks, local pain, local bleed, bruising, lymphangitis, lymph node enlargement, blistering, local infection, necrosis.

Generalized signs and symptoms

Some common signs and symptoms observed are nausea, vomit, malaise, abdominal pain, weakness, drowsiness and prostration.

Species specific symptomatology

Envenomation is known to be species specific and if carefully examined clinically, zeroing in on the species of the snake can be done based on clinical and laboratory findings. The specific signs and symptoms are mentioned against the alphabetical codes which can be compared from the table for the species in Table - 3.

**Alphabetical codes (Table - 3)**

**(A) Cardiovascular**

Dizziness, fainting, visual disturbances, collapse, shock, hypotension, cardiac arrhythmias, pulmonary oedema and conjunctival oedema.

Table - 3 : Species specific signs and symptoms

| Family and species | Code - Signs & symptoms |
|---|---|
| **Viperidae** | |
| Russells viper | A, B, C, D, E, F |
| Saw scaled viper | A, B, E |
| **Elapidae** | |
| Indian cobra | C |
| Common krait | C |
| Sea snakes | C, D, E |

**(B) Bleeding and clotting disorders**

Increased bleed from recent wounds (including fang marks and venepunctures) and from old partially healed wounds. Spontaneous systemic bleed from gums, epistaxis, hemoptysis, hematemesis, malena, hematuria, vaginal bleed, petechiae, purpurae and ecchymossis; conjunctival and mucosal bleeds, Intracranial bleeds, Sub Arachnoid bleeds, lateralizing signs and coma.

**(C) Neurological signs**

Drowsiness, parasthesiae, sensory abnormalities (especially taste and smell), ptosis, external ophthalmoplegia, cranial nerve palsies, aphonia, ascending paralysis, bulbar palsy, respiratory paralysis and generalized paralysis.

**(D) Skeletal muscle breakdown**

Generalised pain, stiffness, tenderness of muscles, trismus, myoglobinuria, hyperkalemia, cardiac arrest and acute renal failure.

**(E) Renal involvement**

Loin pain, hematuria, hemoglobinuria, myoglobinuria, oliguria, anuria and uremia.

**(F) Endocrine involvement**

Acute pituitary and adrenal insufficiency, hypoglycemia. Chronic phase (months to years after the bite) may lead to weakness, loss of secondary sexual hair, amenorrhoea, testicular atrophy and hypothyroidism.

Long term complications

At the site of bite; loss of tissue, sloughing, necrosis, chronic ulcers, infection, osteomyelitis, arthritis and even malignant transformation of ulcers are noted. Chronic Renal failure, chronic pan hypopituitarism and Diabetes insipidus especially after the bite of a Russell's viper are observed.

**Management of snake bite**

Prompt and proper management of a venomous snake bite is often the dividing line between life and death. Mortality due to snake bite is affected by many factors besides the envenomation itself. The important aspects to consider are

(a) First - Aid
(b) Transportation of the patient
(c) Rapid clinical assessment and resuscitation
(d) Laboratory support and investigations
(e) Antivenom treatment
(f) Supportive care and treatment

First - aid

This primarily aims at retarding the systemic absorption of venom, preserving life and preventing complications; before a patient can receive medical care. The following first - aid must be promptly offered:

(a) Reassure the patient and try to allay anxiety
(b) **Immobilize the limb** : Immediately immobilize the bitten limb with a makeshift splint / sling as any movement or muscular contractions will enhance the absorption of venom into the bloodstream and lymphatics.
(c) **Consider pressure immobilization**: (Especially Elapid bites) Ideally an elastic, stretchy crepe bandage approximately 10 cm wide and 4 m long. Otherwise any long strip of cloth can be used. The bandage is to be wound firmly around the bitten limb, starting distally around the fingers / toes and moving proximally to include a rigid splint (piece of wood, board, metal pipe etc). The bandage is bound as tight as would be for a sprained ankle, but not so tight so as to occlude peripheral pulses. Pressure immobilization is not recommended for viper bites due to its venom having local necrotic effects which may aggravate / enhance causation of local injury. Tight arterial torniquets are not recommended as they can cause more harm than benefit. They have often resulted in gangrenous limbs.

Transportation

It is of vital importance, as it decides the survivability of the victim. One should avoid undue movement of the bitten limb, with secure and proper splintage. Always attempt to carry the patient by whichever means available.

**Warning**

(i) Do not attempt to kill the snake as it may be dangerous

(ii) If the snake is dead, carry in a strong sealed box

(iii) Carefully handle a dead snake, never with bare

The victim should avoid walking on his own at all costs.

Antivenom (2)

**What is antivenom**

It is an immunoglobulin (usually the enzyme refined F (ab) 2 fragment of IgG) purified from the serum or plasma of an animal (usually horse) that has been immunized with the

**Rapid clinical management for envenomation**

(i) Try to identify snake as venomous or non - venomous but do not waste to much precious time in doing so.

(ii) See for rapid early extension of local swelling from site of bite.

(iii) See for early enlargement of local lymph nodes.

(iv) See for early systemic symptoms: Collapse, nausea, vomiting, diarrhoea, severe headache, drowsiness, heaviness of eyelids, ophthalmoplegia etc.

(v) See for signs of spontaneous systemic bleeding

(vi) See for ANAPHYLAXIS due to envenomation and treat expeditiously.

(vii) Establish good intravenous access. (Preferably two)

(viii) Secure airway if required

venoms of one or more species of snakes. The Antivenom production is based on the endemicity of the species of snake in the geographical area. If antivenom is for a single specific species, it is monovalent. Similarly bivalent and polyvalent antivenins are also made. In India, where predominantly 4 species are present across the length and breadth of the country, the Antivenom produced is polyvalent against the 'Big 4' mentioned in earlier paragraphs. Antibodies raised against the venom of one species may have a cross - neutralizing activity against other venoms, usually from closely related species. This is known as 'Paraspecific activity'. The Antivenom available in the Armed Forces is a PVMS supply of Section 2 of PVMS List having number 020001.

Indication for administering antivenom

Antivenom should only be administered on specific indications of envenoming, and not merely on the occurrence of snakebite. One important clinical method to accurately assess need for antivenom, especially in bites by vipers is the 20 Minute Whole Blood Clotting Test (see box) (12)

**Polyvalent antivenom production centres in india**

1. Central Research Institute, Kasauli (Himachal Pradesh)
2. Haffkine Biopharmaceutical Company Ltd, Acharya Doude Marg, Parel, Mumbai
3. Kings Institute of Preventive Medicine, Guindi, Chennai
4. Serum Institute of India Ltd, Hadapsar, Pune

How to administer antivenom

This is the most crucial part of management of snakebites. If indicated, Antivenom must be administered immediately. However, antivenom has proved effective even days after neurotoxic bites, while it can even be given

**20 WBCT**

1. Put 1 - 2 ml of blood in a new, clean glass test tube. Do not use a tube that has been washed since left - over detergent may prevent clotting of normal blood.
2. Leave alone for 20 minutes - do not agitate or keep picking up to inspect since this will alter rate of clotting.
3. After 20 minutes, invert once.
4. If the blood flows freely, and there is no clot, then the test is positive and Antivenom is indicated. The presence of even a small clot indicates that at least the clotting system is partially functioning and that there is a low risk of serious hemorrhage. Antivenom is therefore not indicated.
5. Positive tests : Repeat 6 hours after giving Antivenom. There is little point repeating before this time since it takes 6 hours for the liver to reconstitute the clotting system after neutralization of the venom components.
6. Negative test : Observe the patient carefully for other signs of envenoming and bleeding. Repeat

weeks after a viperine bite. The commonly used polyvalent ASV, available as a lyophilized powder, is reconstituted with sterile water. Frothing is avoided while reconstituting. The clear reconstituted fluid is further diluted in 250 – 500 ml of 5 % dextrose and given as a slow IV push over 20 - 30 minutes. Always keep a watch out for features of anaphylaxis as a result of antivenom. Antivenom is administered under supervision till all clinical and laboratory parameters indicate normalcy. Systemic envenomation may recur hours / days after initial favourable response due to continuous slow absorption of venom from site of bite. Hence it is important to keep constant supervision of the patient for 3-4 days. Neurotoxic envenomation may require ventilatory support. Reactions to antivenom may start 10 - 180 minutes after starting and use of steroids is beneficial.

**Prevention of snakebite in Armed Forces**

Snakes have been established to be shy creatures, which will bite only in some form of self defence, in case it feels threatened. Accidental contact with humans, across various occupations, which interfere and cut across the snakes natural ecosystem and habitat, are the most common causes of bite. The Armed Forces are regularly exposed to snakes during field exercises as also in

military cantonments, which offer a more favourable ecosystem for snakes to cohabit with humans. However, some measures, if religiously implemented, will markedly reduce the incidence of snakebites.

(a) Always be vigilant regarding the possibility of encountering a snake.

(b) Know about the local species of snake and its common habitat and take proactive measures in reducing such places.

(c) Educate troops and families about snakes, their habitat and First - aid measures for snake bite.

(d) Always carry a light / torch at night, especially sentries and patrols moving out at night.

(e) Encourage use of boots, especially with anklets, socks with long trousers, as the maximum incidence of snakebite is on the lower limb.

(f) Snakes if seen, should not be handled, attacked or disturbed.

(g) Avoid sleeping on ground.

(h) Instruct troops to:

(i) Dust and invert bedding/sleeping bag every time before lying down.

(ii) Invert and shake shoes / boots every time before wearing them.

(iii) Wear shoes / boots while moving in the dark and never walk barefoot.

(iv) Use mosquito nets, especially in camp sites, as it also prevents access of the snake near the human.

(j) Dig snake trenches - Trenches 60 cm deep and wide with vertical edges are a deterrent for the snake to enter inside a tent. This should be strictly implemented in campsites.

(k) Keep area of living clean, litter and rubble free, which will prevent rodent ingress and not attract snakes.

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# Hazards due to Rodents

## Introduction

Rodents are characterised by two continuously growing incisors in the upper and lower jaws which must be kept short by gnawing.

Forty-percent of mammal species are rodents, and they are found in vast numbers on all continents. Common rodents include mice, rats, squirrels, chipmunks, gophers, porcupines, beavers, hamsters, gerbils, and guinea pigs. Rodents have sharp incisors that they use to gnaw wood, break into food, and bite predators. Most eat seeds or plants, though some have more varied diets. They have historically been pests, eating human seed stores and spreading disease. Rodents evolved some time around the end of the Cretaceous period, 65 million years ago.

Rodents are part of man's environment. Some of them live close to him. They are the reservoir and source of at least 20 percent of Zoonoses known up till now. They form more than one third of all the living species of mammals and exceed any other mammalian order in the number of individuals. All rodents are without canine teeth, but they have strongly developed incisors, which grow throughout the life of the animal, the front incisors covered with enamel are sharp and chisel like.

Family Muridae is the most extensive family of rodents. This is divided into several sub-families. Sub-family Murinae, which includes the Genus Mus (mice) and the Genus Rattus (rats); is the most important in human ecology and medicine. Mice can be distinguished from rats by their smaller size and the presence of a notch on the inner side of the upper incisors. There are many species of rats and mice. The different species of rats are identified by their colour, length of ears, body, tail, and hind feet; shape of the head; texture of pelage; number of mammae; and by the skull and teeth (1).

## Distribution

Most of them remain indigenous and local. *Mus musculus*, the common house mouse, *Rattus rattus*, the roof rat, and *Rattus norvegius*, the sewer rat follow man to all parts of the world. The genus Rattus has more than 250 species and several hundred sub-species, the principal populations of which are in Asia. *R. norvegicus* has spread throughout Europe and to practically every country and island in the world with human traffic, but *M. musculus* and *R. rattus* are generally limited to tropical and sub-tropical regions. There are approximately 110 species of rodents in India. These are broadly classified into two groups. The first group comprises domestic rodents which include *Rattus rattus* (the black rat), *Rattus norvegicus* (Norway rat) and *Mus musculus* or the common house mouse. The second group consists of wild rodents like *Tatera indica, Bandicota bengalensis, Bandicota indica,* and *Tatera meltada.* The commonest species in India are *Rattus rattus, Rattus norvegicus* and *Mus musculus* (2).

## Morphology

Brief description of commonest species is given below. For further studies standard works should be consulted.

(a) *Rattus norvegicus*

It is a brown rat of large size, with a blunt nose and small opaque ears which barely cover the eyes when laid forward. The tail is shorter than the length of the head and body together. The female has 12 mammae. It is essentially an outdoor rat frequenting sewers and the fields. When it enters houses, it usually invades only the ground floors. It feeds on sewer and house rubbish, garbage and other decaying material. It gnaws even the rusty iron sheets or bars.

(b) *Rattus rattus*

It is a more delicately built rat with slender body and pointed head. It is often black in colour, but reddish brown varieties are abundant in many parts of India. The ears are translucent and large, and reach beyond the middle of the eye when laid forward. The tail is more delicate and much longer than the length of the head and body. The female has 8 or 10 mammae. It is essentially a dweller in human habitations, and being a good climber it nests in roofs. It feeds mainly on man's food, garbage or swill. It gnaws fabrics, wiring, leather, woodwork and so on.

## Importance of rodents to human health and ecology

### Rodents and Disease

Rodents act as hosts to several ectoparasites and endoparasites causing human and animal diseases. The flea is the most important ectoparasite from medical point of view. Rodents also serve as hosts in the life cycle of ticks and mites. Rat louse helps migration of some endoparasite from rodent to rodent. *Yersinia pestis* causing bubonic plague is the most important, if not the commonest, of all the pathogenic organisms; *P. tularensis* and certain *salmonella* species are the other bacterial infections associated with rodents. The three species of Rickettsia, viz. *O. tsutsugamushi, typhi* and *R. rickettsia* causing scrub, endemic and tick typhus respectively; the three species of spirochaetes, viz. *Leptospira icterohaemorrhagica, Spirillum minus* and *Borrelia recurrentis* and *duttoni*, causing weils disease, rat bite fever and relapsing fever respectively; the viruses of lymphocytic choreomeningitis, haemorrhagic fever, encephalitis, and certain parasites causing leishmaniasis, chagas disease, histoplasmosis, and mellioidosis are other important infections. Rat is an intermediary host of *Trichinellla spiralis*, while *Hymenolepis diminuta* and amoebiasis can also be caused by it. Majority of these infections are transmitted through the ectoparasites. A dead rat is as dangerous as a living rat because the ectoparasites leave the cooling body and attack other animals and man, causing disease. *Spirillum minus* causing rat-bite fever is transmitted through rat bite. Tularaemia and mellioidosis occur by ingesting food

Table - 1 : Diseases Directly Transmitted by Rodents

| Disease | Agent | How does the Disease Spread | Where does the Disease Occur |
|---|---|---|---|
| Hemorrhagic fever with renal syndrome | Virus | Breathing in dust that is contaminated with rodent urine or droppings<br>Direct contact with rodents or their urine and droppings<br>Bite wounds, although this does not happen frequently<br>The disease may spread through direct contact from person to person, but it is extremely rare. | Primarily in eastern Asia, Russia, Korea, Scandinavia, western Europe, and the Balkans. |
| Leptospirosis | Bacteria | Eating food or drinking water contaminated with urine from infected animals<br>Contact through the skin or mucous membranes (such as inside the nose) with water or soil that is contaminated with the urine from infected animals | Worldwide |
| Lymphocytic Chorio-meningitis (LCM) | Virus | Breathing in dust that is contaminated with rodent urine or droppings<br>Direct contact with rodents or their urine and droppings<br>Bite wounds, although this does not happen frequently. | Worldwide |
| Plague | Bacteria | Bite of an infected flea<br>Direct contact with infected animal | Western US, S. America, Africa, Asia |
| Rat-Bite fever | Bacteria | Bite or scratch wound from an infected rodent, or contact with a dead rodent<br>Eating or drinking food or water that is contaminated by rat feces. | Worldwide; *Strepto-bacillus moniliformis* in North America and Europe; *Spirillum minus* in Asia and Africa. |
| Salmonellosis | Bacteria | Eating or drinking food or water that is contaminated by rat feces. | Worldwide |
| Tularemia | Bacteria | Handling infected animal carcasses<br>Being bitten by an infected tick, deerfly or other insect<br>Eating or drinking contaminated food or water<br>Breathing in the bacteria, *F. tularensis* | Worldwide |

Table - 2 : Diseases Indirectly Transmitted by Rodents

| Disease | Agent | Rodent(s) involved | Vectors | How the Disease Spreads |
|---|---|---|---|---|
| Babesiosis | Parasite | Deer mice and voles | Tick | Bite from an infected tick. |
| Colorado tick fever | Virus | Deer mouse, bushy-tailed woodrat, ground squirrel, porcupine, chipmunk | Tick | Bite from an infected tick. |
| Cutaneous leishmaniasis | Parasite | Wild woodrat | Sand fly | Bite from an infected sand fly. |
| Human granulocytic anaplasmosis | Bacteria | Deer mouse, dusky-footed woodrat, Mexican woodrat, white-footed mouse | Tick | Bite from an infected tick. |
| Lyme disease | Bacteria | Peromyscus spp. (white-footed mouse) in the northeastern and mid-western USA and other rodents (tree squirrel) in the western USA | Tick | Bite from an infected tick. |

Table - 2 (Contd.)

| Disease | Agent | Rodent(s) involved | Vectors | How the Disease Spreads |
|---|---|---|---|---|
| Murine typhus | Bacteria | Rats | Flea or mite | Bite from an infected flea or mite.<br>Contact of broken skin or wound with infected flea or mite or their droppings. |
| Scrub typhus | Bacteria | Rats | Mite | Bite from an infected mite. |
| Rickettsialpox | Bacteria | Mice | Mite | Bite from an infected mite. |
| Relapsing fever | Bacteria | Wild rodents | Tick | Bite from an infected tick. |
| Rocky Mountain spotted fever | Bacteria | Wild rodents | Tick | Bite from an infected tick. |
| Western equine encephalitis | Virus | Ground squirrel and snowshoe hare | Mosquito | Bite from an infected mosquito. |

contaminated by rats. Salmonellosis is transmitted mechanically through dropping by contamination of food. Similarly many disease of cattle and other animals of importance to human ecology are due to rats and their parasites (3).

### Rodents and Human Ecology

Rats are voracious consumers and great destroyers of food grains and standing crops; they spoil and render food grains unfit many times more than they consume. They are menace to eggs and poultry, which they eat and destroy more than all the other wild mammals. They burrow and cause damage to buildings, dams, embankments and other structures. They gnaw articles of clothing, furniture, leather, electric wire and even rusty iron pipes. The destruction of food, crops, household articles, property, masonry, buildings and merchandise caused by rodents is so great that this alone would justify active measures to exterminate them at any cost, even if rodent related human and animal diseases were to be controlled by alternative methods such as the control of ectoparasites and immunization. On the ships, they act not only as harassing menace, consumers and destroyers of food, damagers of structures and fitting of ships and personal belongings, and as health hazard to the ship's crew and passengers, but also constitute international conveyers of epidemic disease like plague. The great plague epidemics of the past were due to migration of infected rats on ships from China to India, Middle East and Europe and South America.

### Bionomics

#### Growth Potential

Reproduction occurs all the year round, but in some places there may be maximum births in spring and late autumn. The percentage females at a time varies between 18 to 40. The pregnancy rate per annum per female and the birth rate per pregnancy varies between four to eight. The weanling rate is about nine per females. The annual death rate among weanlings is about three per annual brood. Changes in rat population mainly depends upon death rates than upon the birth rates. The death rate is determined by competition among rats for food and harbourage available. Fierce fighting permits a few rats to dominate the others. These aggressive rats feed and reproduce inhibiting growth and reproduction of the inferior ones. Destruction by poisons, traps, cats and so on are rarely sufficiently intense and sustained to keep the population perpetually down. Actually, these procedures, as generally practiced, make room for other rats to grow up and reproduce. Even very intensive poisoning campaigns reduce the rat population only temporarily. They will rapidly increase to the level upto the capacity of the area to support them and then remain at that level.

#### Nesting Habits

When present along with *R. norvegicus*, which is a larger, more vicious and aggressive rat, the *R. rattus* usually nests in the upper parts of the building and in burrows, in dark and moist places over the false roof, in and behind cupboards, under wooden doors, and behind wall paneling. In tropical climates they also nest in trees. Although *R. norvegicus* prefer underground places, their nests may frequently be found inside the buildings, even in the upper parts where there is abundant harbourage. In temperate climates all the rodent species, including the mouse, infest the fields at considerable distance from buildings.

#### Locomotion

Norway rats are not as agile as the other species and are less expert climbers. In the open, rats have defective vision; by daylight they move slowly and uncertainly. In contact with the wall they run in great speed. This fact suggests that the vibrissae (whiskers) serve as feelers and that they are extremely sensitive.

#### Rat Runs

Rats prefer narrow places and overhead pipes and beams

as highways, and habitually follow the same course. These highways or 'runs' are useful in tracing their nesting and hiding places, in discovering defects that allow passage to such places, and are also available guides for placing traps and poisoned baits.

Feeding Habits

Rats are omnivorous but, as a group, grains are their food of choice. Roof rats prefer fruits and vegetables. Rats learn to eat the foods of the locality in which they live and will often ignore food selected by rats in other places. On the other hand, those of the same species and locality may show great divergence in their choice of foods. Most rats will take fresh meat, and dried meat which when mixed with grain is the best bait; dried coconut and pakoras also form good baits. Rats cannot vomit and hence poisons which have emetic effect on all other mammals e.g. red squill, can be used against them. They are however, very suspicious and any strange thing is shunned by them; even a strange smell deters them.

Migration

Rats, like other mammals, normally tend to remain within a limited area of home 'range' for long periods of time, provided enough food supply is constantly available and an undisturbed harbourage is ensured. They stay within 10 to 20 m, while house mice live within an area of only 4 to 5 m diameter for many months, unless there are radical conditions, denying nesting, feeding and breeding. In urban residential areas the diameter of the home range may be about 20 to 40 m. Overland mass migration of rats have been reported from country to country especially when food supplies are depleted. Ships and trains have been the commonest vehicles for migration. Movements of rats from houses and barns to the fields take place in the spring with the harvesting of crops, and there is a return during rains and winter months. Similar migrations occur from urban areas to rural areas. Rats liberated in a strange place may travel long distance in search of a new home, but after finding a suitable place they also remain within a circumscribed area for many months or until there is a change in the environment. Rats may enter vessels when they berth at docks and many of them are carried abroad in cargo. Now-a-days rat proofing is included as a standard requirement in building of new ships and vessels.

**Rodent control (4-6)**

The best way to prevent a rodent infestation and contact with rodents is to remove the food sources, water, and items that provide shelter for rodents.

The preventive and control measures can be summarized into the three following measurses:

**(a) Seal Up**

Seal up holes inside and outside the home to keep rodents out

**(b) Trap Up**

Trap rodents around the home to help reduce the population

**(c) Clean Up**

Avoid illness: Take precautions before and while cleaning rodent-infested areas

Before the various techniques, methods or strategies of controlling or managing rodents are described the general principles involved need to be discussed. An understanding of these principles by all those involved will assist in devising specific control strategies for a given situation. It will also help when explaining the need for certain activities to the staff actually executing the control work.

In Armed Forces rodents pose a continuous problem because of the climatic conditions, uninterrupted food supply and relatively open structures. Therefore the control of rodent pests should be approached as a management problem much more so than a simple and single poisoning action. For a control strategy to be effective staff responsible need to be trained and informed, their activities must be co-ordinated, responsibilities confirmed, inputs and equipment readily available and the entire action must be planned.

Control strategies should aim at preventing losses and thus require a pro-active rather than the more normal reactive approach. Once a large population of rodents has established itself in a store considerable losses, that cannot be retrieved, have already occurred and subsequent control action is expensive. It should be stressed that information from different sources should be incorporated into a control or management strategy and not just the techniques.

There are many more techniques and methods of controlling rats than are described here.

An important element of any rodent programme is monitoring. Usually it means surveillance for the presence of rodents. However it should also mean looking for features in the environment which would encourage rodents to migrate into it. Control of a rodent infestation is rarely completely successful; but if it is, it is usually only for a very short period. Therefore there is a need for continuous monitoring even after a successful control campaign regardless of the techniques and bait used.

If an area is made rat-free due to good management and/or effective control measures, rats from near-by areas will migrate into it. It is therefore more efficient if control campaigns are conducted in several adjacent areas simultaneously. In the case of a village, all households should be motivated and organised to control rats at the same time. While control in one household will still benefit the owner, benefits increase as the number of participating neighbors increases.

In the case of stores, large and small, surrounding areas including other stores should also be disinfested. This means that all the store keepers or managers involved should coordinate and synchronise their rodent control activities for maximum effect.

Rodent control measures can be broadly classified as:

**(a) Permanent Measures**

(i) Anti-rodent Engineering
(ii) Rodent Exclusion
(iii) Anti-rodent Hygiene

**(b) Temporary Measures**

(i) Trapping
(ii) Rodenticides
(iii) Biological Control

Permanent Measures

The rodent control is best achieved by denying them ingress; denying them nesting, breeding and hiding places; denying them food; and destroying them. Practical methods to achieve these measures are the anti-rodent engineering; anti-rodent hygiene; anti-rodent house keeping; and health education. Scientific and healthy town planning is essential to keep rats out of the blocks of human habitations. Good planning, designing and construction of buildings keep them out of dwelling, factories, shops, godowns and places like slaughterhouses, granaries and stores. Environmental tidiness, sanitation, high standard of living and good housekeeping are essential adjuncts to anti-rodent engineering. Education and civic sense are essential so that people take all these steps with understanding. Permanent rodent control in urban areas, can be achieved only by these methods, because rat destruction alone rarely reduces their population to an appreciably low level and it rapidly builds up to the original level. Furthermore, this still does not improve the living and sanitary conditions.

**Anti-rodent Engineering**

Rats enter through drainpipes left open; through doors and windows, especially from alleys; through basement windows and outside fittings; through the lower parts of the doors, ventilators, sky lights, unused chimney flues, down the electric wire casings and so on. The doors and windows should be tight fitting and reinforced with metal sheets to keep the rats from gnawing through the basement and upper windows; the other places of ingress such a ventilators, skylights, unused chimney flues, and opening around water, sewer, gas and steam pipes, and electric wires must be suitably protected. Screens to prevent rats wandering from one place to another in large group of buildings should be provided. Foundation walls laid without a break around the entire building, flush with the under surface on the floor above, and extending not less than 45 cm beneath the surface of the surrounding ground, prevents rats burrowing through. Floor joists should be embedded in the wall or the spaces between the joists filled in and completely closed up to the floor level. Floor should be concreted with a layer of at least 7 to 8 cm of thickness and finished with a soling surface of cement about 1 to15 cm thick or tiles. All water and drainpipes should be surrounded by concrete where they pierce the walls. If the lower portion of all the walls are made of glazed tiles or tinned with galvanized non-corrugated iron sheets, rats do not enter buildings.

**Rodent Exclusion**

(a) All openings greater than 1/4" should be sealed to exclude mice, but it may be impossible to seal all openings.
(b) All openings greater than 1/2" should be sealed to exclude rats.
(c) Likely access points for rodents are where utility lines come into walls, as well as openings around air conditioning, drain pipes and vents. Look for broken basement windows, warped doors, and unscreened vents as possible points of entry. All spaces beneath doors should be checked if the opening is too large and reduced if needed. Roofs should be checked to see that shingles are down tight and sheathing is complete. Also check roof ventilators, screen vents and wall vents.
(d) Hardware cloth may be used to seal openings such as attic vents. Install 1/4-inch wire mesh (hardware cloth) over attic, roof, and crawl space vents in order to prevent entry of birds, bats, squirrels, rodents, and other wildlife. Metal flashing may be used to seal up openings around the gutters
(e) Use Stuff It Copper Mesh around pipes and utility lines stuffing into the openings such as openings where pipes and wires enter the foundation and siding, e.g., around outdoor faucets, receptacles, gas meters, clothes dryer vents, and telephone/cable TV wires.

The chief sanctuaries for rats in cities are the provision houses, markets, warehouses, slaughterhouses, dairy farms, restaurants, bakery, shops, candy factories and human dwellings. In the rural areas, corn godowns, barns, granaries, cattle sheds, fodder rooms, piggeries, horse stables are the chief places which afford nesting, breeding and feeding sanctuaries for rats. The field rats in rural areas cannot be controlled by rat proofing for there is continual abundance of exterior food. Raising the flooring on piers 15 cm or more above the ground surface reduces rat harbourage under them. Rat burrows can be closed with a mixture of cement, sand and broken glass. Provision stores should be built in such a way that the height of each step is more than 25 cm. The tiles covering the steps should be jutting out. In urban and rural areas alike, the access of rats to places where they can secure nesting facilities, food or water should be barred.

**Anti-rodent Hygiene**

Rodents require food and shelter. Therefore it is most important to reduce the availability of these two key factors, which should be central in devising any kind of strategy. In the case of buildings the most effective method of rodent prevention is the improvement of hygiene or sanitation in and around them. Primarily this means sweeping the area and keeping both it and the

surrounding area neat and tidy, i.e. free from any objects such as empty containers, idle equipment or discarded building materials, which could provide cover or nesting places for rodents. Observations have shown over and again that these simple actions, even in the tropics, are the most effective preventative measures that can be taken.

(a) In a tidy store any infestation will be noticed at a very early stage, making other control measures far more effective. With reduced access to food and no places to hide, rats will not become established, that is live and breed, inside a building. Regular disturbance is something rats and mice avoid.

(b) Control procedures should take the life history and behaviour of species present into account. Rats avoid clear spaces. Therefore by keeping a strip of two or more metres around a building clear of vegetation will reduce the chance of rats entering the building.

(c) This should be augmented by keeping a strip of about one metre on the inside from the wall totally clear and swept. Branches overhanging the building should be lopped off to prevent climbing species to enter from above.

(d) All solid wastes must be disposed off hygienically. Slaughterhouse waste, in particular, should be incinerated. Very high standard of environmental sanitation, general neatness and tidiness in and about the houses, godowns, factories, provision stores, market places, slaughter houses deprives rats of places for nesting, breeding and resting.

(e) All rubbish piles and refuse must be eliminated and properly disposed.

(f) Landscaped areas need to be properly maintained with wood piles elevated off the ground.

(g) All garbage containers and dumpsters should have a tight fitting cover.

(h) Rodents can live on the spilled and surplus food from bird feeders and pet food.

(j) It is difficult to completely eliminate all food and shelter sources. However, the more food and shelter the mice have, the higher a mice population or infestation could occur. With the higher population, the harder it will be to control them. Rats require a lot more food and water. They also require more shelter. When there is a severe infestation of rats, it is usually indicative of a sanitation problem.

Temporary Control

Temporary measures are not as effective as the permanent control measures. These only bring down the rat population for a short period which soon builds up to the original level unless the permanent measures are also simultaneously adopted.

**Trapping**

It can reduce the population of domestic rats quickly, only if the traps are properly set and baited. Sewer rats or large population of house rats do not respond well to trapping. The proper method to attack is to use a large number of traps at the same time in an infested area; and when maximum results have been achieved, to shift the traps to a new area. The traps should be placed either near the burrows or along the rat runs. The break back traps can kill only one rat at a time but the catching trap can trap a number of them at the same time, without killing.

Another method of trapping is the use of lithographic varnish, 'ratsticker'. The varnish is spread on a board with a piece of cheese or other material as a bait on the center. On coming in contact with varnish, the rat becomes hopelessly entangled and its squeal attracts other rodents to the rescue so that they in turn become trapped.

Sticky or glue traps are another way of catching rats and mice. They are boards made of wood, hard- or cardboard covered with very sticky material. There are different types of glue available and they should be checked for suitability (stickiness, and usability in humid or dusty conditions) before large quantities are ordered. The boards are placed in the same way as traps, and normally there is no need for bait to attract rats. These traps should be checked daily, but are not regarded as very 'humane'.

Flushing rodents out of their burrows, with smoke or by flooding them with water, can be very effective and suitable in some situations. Ultrasonic devices are mentioned regularly, particularly by manufacturers of these devices, as a good repellent of rats and mice in buildings. However there is no scientific evidence of their effectiveness. It appears that rats become habituated to the sound or stay in 'sound shadows'

The most efficient bait for any locality is determined by trials. Dried meat, fish heads, coarse flour or ground grain, fresh vegetables, fruits, tomatoes, coconuts, pakoras are generally good baits.

**Rodenticides**

These are of two types i.e. acute or single dose and cumulative or multiple dose poisons. The former group are lethal to the rats after a single feeding, while the later, as the name suggests, require repeated feedings. The WHO Expert Committee in 1973 grouped the rodenticides as follows: -

**(a) Acute Rodenticides**

(i) Those requiring ordinary care such as Red squill, norbromide and zinc phosphide.

(ii) Those requiring maximal precautions-such as sodium fluoroacetate (1080), fluoroacetamide (1081) and strychnine.

(iii) Too dangerous for use such as arsenic-trioxide, phosphorus, thallium sulphate, ANTU and gophacide.

(iv) Calciferol : leaches calcium from bone into the blood.

**(b) Multiple Dose Rodenticides**

(i) Warfarin-Its dose varies from 250-500 ppm.
(ii) Diphacinone-Its dose varies from 50-250 ppm
(iii) Coumafuryl.
(iv) Pindone.
(v) Coumatetralyl

**(c) Bromadialone**

The latest acute anticoagulant which can be used in domestic areas.

**Choice of Rodenticide**

Among the many available rat poisons, red squill is favourite because its emetic action protects animals that can vomit; strychnine and thallium are used at times but are somewhat dangerous; zinc phosphide is seldom used because of erratic results and danger to human population; barium carbonate is used in Armed Forces, mainly due to its comparative safety, simplicity of use and availability. ANTU is specific for Norway rats but kills dogs and cats does not kill roof rats. Sodium fluoroacetate is a powerful poison but its use has been prohibited in many places because of human deaths. Warfarin is an anticoagulant that has a large safety margin because of the very low dosage (0.1 per cent) that is required to be given for four days to kill a rat. It keeps the rat population in area constantly low over a long period, provided it is used continuously. It is dangerous to household pets and is chiefly used on board the ships.

**Baiting Procedures**

The poisoning campaign should be carried out in three stages as follows: -

**(a) 'Trial baiting'**

It is the first step in the poisoning programme. Rats are usually accustomed to eat the 'bait base' of plain food such as bread crumbs or coarse atta. This should be placed along runways and at their visiting places for a day or two. Any other food commonly eaten by the local people may also be tried.

**(b) 'Pre-baiting'**

This should be carried out with the most acceptable materials without mixing the poison. The pre-baits are kept under supervision and replenished daily for 5 to 7 days.

**(c) 'Poison baits'**

These are prepared by adding poison to the bait base and are laid in the same manner and at the same places for the next one week or more.

The technique of pulsed baiting was introduced with the new single-dose anticoagulants, such as bromadiolone and brodifacoum. This contrasts with saturation baiting, in which bait is available to rats continuously over long periods until the population has declined to near zero. Pulse baiting is not necessarily more effective, but it is certainly cheaper, because the amount of labour and the quantity of bait required is much lower than in saturation baiting.

As mentioned earlier, death is delayed by three or more days after ingestion (depending on the species of rat and the type of rodenticide). This means that rats will continue to feed on bait even though they have received a lethal dose, which would be a waste of bait. In addition in some species (e.g. *R. norvegicus*), animals of lower hierarchal ranking cannot feed until 'higher' animals are removed from the population.

This behavioural characteristic is exploited by baiting in pulses. Poisoned bait is laid for 13 days (depending on the rodenticide) and discontinued for about a week, allowing the first batch of animals to die and thus be removed from the population. The next baiting pulse will remove another batch of rats. Normally three baiting pulses are sufficient to remove almost the entire population. The intensity of baiting periods (pulses) depends on the rat population in and around the building and the rate of immigration from neighbouring areas. In spite of the above, the intervals between and number of pulses has to be decided each time based on the results of monitoring.

The idea of perimeter baiting is to place bait in a circle around and outside the immediate area of interest and hopefully prevent rats from immigrating. However it is very difficult to give exact guidelines on the diameter of the circle, the distance between baiting points and the quantity of bait to use. The idea has its merits and an operator should experiment with this technique; for example, by placing baiting points between the store and places through which rodents might reasonably be expected to immigrate.

**Preparation of Baits**

**(a) Barium Carbonate**

It is mixed with three times the quantity of floor or bread mash, made from the grain which have been found to be readily consumed by the rats. Sufficient water is added to the mixture to make a fairly firm paste and rolled into pills weighing one gram each.

**(b) Zinc Phosphide**

It is usually not made into pills but mixed as a dry meal baited with 1/5th to 1/8th the quantity of the poison and left at the baiting stations in bait-boxes which are not approachable by children and pet animals. This is used on docks, warfs, godowns, granaries and such other places.

**(c) Warfarin**

It is similarly used in dry meal of bread crumbs, roasted grains or crushed chapatti in the proportion of 1:19 and left in bait trays or boxes. This is used mainly on board the ships and also in granaries where constant anti-rodent measures are very essential.

**(d) ANTU (Alphanaphthylthiourea)**

It is sprinkled in and around rat holes, rat runways and burrows. The rats lick their feet after running through it and can swallow enough poison to kill them. Poison may be sprinkled on and around the baits such as ground grain, sliced apples or melons, chopped meat, chicken or turkey heads and left in the evening in thin layers in each rat infested areas.

**(e) Coumatetralyl**

The compound is available as Racumin tracking powder(0.75%). The powder should be scattered into the rodent burrows and on rodent runways. Racumin ready made bait and wax blocks(0.0375%) are also available. For field rodents, Racumin oil concentrate(2.0%) is mixed with whole grains in 1:50 ratio. Any other food material can be mixed with racumin (1:19) for domestic use.

Fumigants

Fumigation may kill rats with certainty in any enclosed places, like ships, godowns, granaries and rodent burrows on embankments. Sulphur dioxide, carbon disulphide, calcium cyanide (cynogas or cymag) carbon monoxide and methyl bromide are usually used.

The control of rodents by fumigation can be very effective, but it may be expensive and dangerous. It should be remembered though that the gas must have access to burrows, if these are present in the building. That is the burrows should be open and the fumigant used must be heavier than air.

If the species concerned makes burrows which are easy to spot (e.g. *R. norvegicus, B. bengalensis* or *P. natalensis*), they can be fumigated directly. The simplest method is to use a powder which releases hydrogen cyanide, or aluminium (magnesium) phosphide tablets which release phosphine when placed into the burrows. The gases are generated when the powder or tablets come into contact with moisture in the soil. Alternatively, methyl bromide gas may be pumped into the burrow system.

As soon as the fumigant has been applied, all burrows must be closed by filling the entrance holes with earth. However, fumigants cannot be used in loose or sandy soils as too much gas escapes, and the treatment may not be effective. Occasionally, rats have been known to block tunnels and prevent complete distribution of the gas, so that some individuals survive.

All enclosed spaces are opened to allow penetration of the gases and exits are closed. The gases are then pumped in or mechanically released. Cyanogas has been extensively used in India for the fumigation of rats burrows. Aluminium phosphide tablets (3 gm/ rodent burrow) provide effective rodent control in peri domestic area and agricultural fields. The rodent burrows should be closed after bait placement with wet soil.

Only trained and properly qualified operators should be employed to use fumigants. They should be seen to be observing the following basic principles of fumigation:

(a) Two operators must always be present at a fumigation site
(b) Suitable respirators must be worn
(c) Operators should stand upwind when gassing
(d) Fumigants should not be used in strong winds or when it is raining
(e) Fumigants must not be used near buildings inhabited by man or animals as open burrows may be inside
(f) Operators should know about first aid and have appropriate first aid equipment with them.

**Precautions**

Clean hands and dishes are necessary to avoid imparting extraneous taste and odor to the baits as rats are very suspicious. The baits should be made fresh each day and unconsumed baits should be laid systematically and with great care so as to be beyond the reach of children or domestic animals. For initial baiting, 15-20 baits for a room of size of an I.P. tent are required and for subsequent baiting 5-10 baits may be enough. At the time of baiting all sources of food and water supply should be closed and baits should be placed near the places where food is normally stored, cooked, eaten or discarded and near washing places. Pre-baiting and baiting should be done during periods of clear and calm weather, as unsettled weather conditions interfere with the normal movement of rodents. Left over baits should be counted or measured and removed the next morning to prevent pets and live stock from eating it, and replaced in the evening. Prepared baits and water must be stored in places out of reach of human pets and domestic animals. Hands should be washed thoroughly with soap and water after handling powder or prepared bait.

**Standard safety precautions when handling poisons include:**

(a) Wearing protective clothing during operations
(b) Not eating, drinking or smoking during operations
(c) Not breathing in dust during operations (wear dust mask)
(d) Keeping baits out of reach of others, especially children and domestic animals
(e) Thoroughly washing the skin, clothing and equipment after operations (7).

The potential danger to non-targets of feeding on bait (primary poisoning) or animals feeding on poisoned rats (secondary poisoning)must always be kept in mind during the baiting process.

**The danger of unwanted poisoning can be virtually eliminated in buildings if some simple rules are adhered to:**

(a) Bait should be laid so that no other animals, including man, can have no access to it; in buildings this should be fairly simple
(b) The amount of bait laid out should be adapted to the anticipated population of rats, that is as little as necessary and placed in small quantities per station
(c) Application should be late in the afternoon, just before rats become active and as birds retire; in stores this is not so important
(d) Bait should be removed entirely after a control programme is terminated
(e) Dead rats, if found, should be buried or burnt
(f) Rodenticides should be under lock and key and empty containers should be disposed of properly

(8).

Biological Control

The natural enemies of the rats are the cats, larger hawks, eagles, vultures, owls, snakes, foxes, coyotes, weasels, mongoose, minks, dogs and ferrets. However, although some of these may be helping to keep down the rat population to some extent in nature, none of them is of practicable value in the rat control programme. There are also biological agents like *Salmonella typhimurium* and *enteriditis*. These are either impracticable or unsafe in the rat control programmes.

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# Bio-Medical Sciences

## Excremental (Oro-faecal) Diseases and Helminthiasis


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# Excremental Diseases

One of the main causes of sickness in an army in the field is excremental diseases. These, as explained in Oxford dictionary, refer to the diseases related to faeces. These are caused by infectious agents and commonly include diseases like diarrhoeas, dysenteries (amoebic and bacillary), food poisoning, cholera, enteric group of fevers, poliomyelitis, viral hepatitis A and so on.

All organisms causing excremental diseases are excreted through faeces of infected persons and ingested by mouth of the recipient. Disease transmission could be direct or indirect and is described as faeco-oral. Human beings are the reservoir in most of the cases but in a few infections like salmonellosis and the tapeworms the animals are the fundamental reservoir for human infection.

## Diarrhoea and Dysentery

Conventionally diarrhoeas and dysenteries are considered together because of their similarity with respect to their clinical features, their mode of spread and similar approaches for their prevention. However a differentiation can be made on the basis of presence of blood in stool in dysentery.

Diarrhoeal diseases commonly refer to frequent passage of loose, liquid or watery stools which may range from 4-5 times to more than 20 times per day. According to World Health organization (WHO) diarrhea is the passage of 3 or more loose or liquid stools per day, or more frequently than is normal for the individual (1). Acute diarrhea is an attack of sudden onset which usually lasts for 3 - 7 days, but may last up to 10 - 14 days (2). Diarrhea that starts as an acute episode and lasts at least 2 weeks is considered persistent or chronic (3, 4). This definition excludes specific conditions like celiac disease, tropical sprue, or other congenital, biochemical or metabolic disorders.

Dysentery (formerly known as the bloody flux or simply flux) is an illness involving severe diarrhea that is often associated with blood in the feces. It is one of the most dangerous types of diarrhoea. It is, usually, more severe and more likely to result in death than other forms of acute diarrhoea. Large scale outbreaks (epidemics) of dysentery are a particular threat to public health (5).

The term "bacillary dysentery" used to describe a diarrhoeal illness with fever, abdominal pain, and blood and pus in the stool, is often used as a synonym for diarrhea caused by *Shigella*. While epidemic dysentery is caused by *Shigella dysenteriae* type 1 (Sd1), endemic dysentery is caused by a range of organisms including *Shigella* (5, 6).

Pathophysiologically, diarrhoeal diseases are mainly of 2 types:

(a) Secretory noninvasive diarrhea : such as cholera, due to impairment of water absorption mechanisms in the small bowel and inducing watery stools and dehydration

(b) Enteroinvasive diarrhea : due to alteration of the colonic muco2sa, inducing dysentery. Most cases of infectious diarrhea are acute. Some pathogens, mainly parasites, can induce chronic diarrhea.

**Definitions**

**Dysentery** - Bloody diarrhea

**Epidemic dysentery** - Large-scale outbreaks of bloody diarrhoea, almost always caused by *Shigella dysenteriae* type 1 (Sd1)

**Endemic dysentery** - A normal incidence of bloody diarrhoea, caused by a range of organisms including *Shigella*.

*Shigella* : a genus of bacteria with four species - *Shigella dysenteriae, Shigella flexneri, Shigella boydii and Shigella sonnei. Shigella* causes the most serious episodes of bloody diarrhoea.

*Shigellosis* : infection caused by one of the *Shigella* species, often (but not always) associated with bloody diarrhoea.

**Source – (5)**

### Prevalence

Acute diarrhoeas are second only to respiratory infections as a cause of morbidity and mortality worldwide. In the United States, 1 episode per child per year is estimated to occur in children younger than 5 years, with about 10% of all hospital admissions for children in this age range. In developing countries, an average of 3 episodes per child per year in children younger than 5 years has been reported, but some areas have been reported to have 6-8 episodes per child per year. In these settings, malnutrition plays an additional and important negative role by exposing children to a higher risk of acute and prolonged diarrhea (7). According to a World Health Organization (WHO) estimate about 18% of all deaths each year among children under five years of age i. e. approximately 2 million children worldwide (almost entirely from developing countries) are because of diarrhoeal illness (8).

In India, during the year 2005, about 1.07 million cases of acute diarrhoea with 2040 deaths were reported; though the actual incidence may be manifold (9).

Epidemics of dysentery caused by Shigella had been the problem of military since long (6). Military is most often afflicted during mobilization. Diarrhoeal diseases and dysentery frequently become important disease problems among forces immediately following their induction, when insufficient attention is paid to environmental sanitation (10). The disease flourishes where the standard of hygiene is low. Carelessness in camp sanitation may result in epidemics of diarrhoea and dysenteries. Quite often, outbreaks of diarrhea and dysentery cause more

morbidity in a military campaign than the actual war injuries (11).

**Epidemiological determinants**

Agent factors

A number of infectious agents including virus, bacteria, protozoa and intestinal worms, have been incriminated in the causation of diarrhoeal diseases.

(a) **Virus :** Rotavirus and Norwalk virus are the commonest of the causes of viral diarrhoea. The other virus implicated include adenovirus, astrovirus, calcivirus and corona virus. Diarrhoeas due to viral infections usually have no fever or low grade fever and no accompanying abdominal pain.

(b) **Bacteria :** Common bacteria implicated in the causation of diarrhoea include *Campylobacter jejuni, Clostridium difficile, Clostridium perfringens, E coli, Salmonella sp, Shigella sp, Vibrio sp, Yersinia enterocolitica. Shigella dysenteriae* is most often the cause of an outbreak of bacillary dysentery. Identification of the causative infectious agent in the stool should be attempted wherever possible. In the past, it was only possible in 25% of the cases but now with newer techniques it is possible in 75% of the cases

(c) **Protozoa and others :** The common protozoans causing diarrhoeal diseases are Giardia sp, Cryptosporidium sp, and Entamoeba sp. Infection with *Entamoeba histolytica*, with or without clinical manifestations is known as Amoebiasis. Occasionally diarrhoeal diseases can also be caused by intestinal worms like *Trichuris trichura*.

Reservoir

Man is the principal reservoir of the infections. Mild cases which clinically recover in a few days without going to hospital, constitute one of the chief means by which the reservoir is maintained. Patients with acute amoebic dysentery pose only limited danger to others because of the fragility of trophozoites. Asymptomatic or mild cases excreting cystic forms of *E. histolytica* on the other hand are important reservoir of infection.

Host factors

Man has no natural immunity against the organisms of diarrhoea and dysentery. Both sexes are equally susceptible. Children and the aged suffer more. Transient immunity develops against the specific strain of Shigella. Although susceptibility to infection of *E. histolytica* is general; many persons harbouring the organism do not develop the disease. Host differences such as race and age have been described as affecting susceptibility of individuals to infection. Immunity to reinfection has not been clearly demonstrated.

Diarrhoeal diseases are most common during the first two years of life. Incidence is highest at the time of weaning i. e. between 6 - 11 months. This pattern reflects the combined effects of declining levels of maternally-acquired antibodies, the lack of active immunity in the infant, the introduction of food that may be contaminated with faecal bacteria, and direct contact with human or animal faeces when the infant starts to crawl. Most enteric infections, mainly beyond 2 years of age, are asymptomatic owing to the development of active immunity. Persons with asymptomatic infections play an important role in the spread of many enteric pathogens, especially as they are unaware of their infection, take no special hygienic precautions and move normally from place to place. Undernutrition, recent measles and immuno-suppression are associated with increased incidence, severity, or duration of diarrhoea (12).

Environmental factors

Diarrhoeal diseases follow a distinct seasonal pattern. In tropical areas, rotavirus diarrhoea tends to occur throughout the year, increasing in frequency during the drier, cool months, whereas bacterial diarrhoeas tend to peak during the warmer, rainy season. The incidence of persistent diarrhoea follows the same seasonal pattern as that of acute watery diarrhoea (12).

Mode of Transmission

Infection by all organisms of this group of diseases is invariably by ingestion in food or drink i. e. , faeco-oral route. Person to person transmission plays an important role in transmission. Individuals primarily responsible for transmission are those with poor personal hygiene and who fail to cleanse contaminated hands and carry organisms under their fingernails after defaecation. Contaminated water is believed to play a major role in the transmission of amoebiasis. The organisms of bacillary dysentery do not thrive in water and are readily killed by chlorination. But amoebic cysts are not killed by chlorine in amounts normally added for water disinfection. Water can be rendered free from cyst only by sand filtration. Milk and food are contaminated by infected water or by the hands of a carrier or case or more likely by flies & cockroaches which act as vehicles. Contamination of crockery, cutlery, kitchen utensils by food handlers or by dust containing cysts in case of *Entamoeba histolytica* is a possibility. Vegetable from fields irrigated with polluted water specially those cultivated with raw sewage as practiced in improper sewage farming are liable to carry infection.

Incubation period and Period of communicability

The incubation period varies from 1 to 2 days as in case of bacillary dysentery to 2 to 4 weeks, but can be prolonged to several months, as in case of amoebic dysentery. Diarrhoea and bacillary dysentery cases are most infective during the course of clinical illness and a short period thereafter. A case of amoebic dysentery is infective mostly during the non-clinical period between the remissions of clinical attack, because it is the cystic stage of amoeba which is infective and not the vegetative form.

Prevention and control

A constant maintenance of a high standard of waste disposal and environmental sanitation; personal hygiene including food hygiene and habits; wholesome water and milk supply; extermination of flies, and health education are the measures to be relied upon for preventing the infection in a unit. The following measures should be

| Key components in the prevention of diarrhoeal diseases |
|---|
| Safe drinking water |
| Safe disposal of human excreta |
| Food safety |
| Hand washing with soap |
| Breastfeeding |

Source - (13)

taken for controlling an outbreak

(a) Isolation

All serious cases should be admitted to hospital and isolated during acute illness with rigid personal precautions by attendants. Fluid and electrolyte replacement is important along with specific drugs. This will break the chain of transmission.

(b) Oral Rehydration Therapy (ORT)

The introduction of oral fluid by WHO has established the utility of Oral Rehydration Solution (ORS) as the single most important measure in the management of acute diarrhoea due to all aetiologies, in all age groups, and in all countries. The underlying principle is based on the observation that glucose given orally enhances the intestinal absorption of salt and water, and is capable of correcting the electrolyte and water deficit in mild to moderate cases. The aim of ORT is to prevent dehydration and reduce mortality.

However, because of its improved effectiveness, WHO and UNICEF are now recommending the use of reduced osmolarity ORS solution. UNICEF, since January 2004 and India, since June 2004 are procuring only this formulation for the management of diarrhoeal diseases.

The composition of reduced osmolarity ORS, as suggested by WHO, is as follows :

Packets of oral rehydration mixture are freely available.

| Composition of reduced osmolarity ORS | |
|---|---|
| Sodium chloride (table salt) | 2.6 g |
| Glucose, anhydrous | 13.5 g |
| Sodium bicarbonate (baking soda) | 2.5 g |
| Potassium chloride | 1.5 g |
| Trisodium citrate, dehydrate | 2.9 g |
| Total weight | 20.5 g |

Source : (14)

The contents of the packet are dissolved in 1 litre of drinking water. The prepared solution should be used within 24 h. It should not be boiled or sterilized otherwise. It alone can correct mild to moderate dehydration. The inclusion of tri-sodium citrate in place of sodium bicarbonate has made the product more stable. Besides, it also results in less stool output especially in high output diarrhoea (e.g. cholera), probably because of a direct effect of trisodium citrate in increasing intestinal absorption of sodium and water.

If these mixtures of salts are not available, a simple mixture - salt and sugar solution (SSS) - consisting of table salt 5 gm and sugar 20 gm dissolved in 1 litre of drinking water may safely be used until then. The general rule is that patients should be given as much ORS solution as they want, and that signs of dehydration should be checked until they subside. If the child's weight is known, the amount of ORS solutions required for rehydration during the first four hours may be calculated by setting the deficit at approx 75 ml/kg body weight. Intravenous infusion is usually required only for the initial rehydration of severely dehydrated patients who are in shock or unable to drink. Such patients are best transferred to the nearest hospital.

(c) Breastfeeding

Because of its protective qualities, breastfeeding must be continued for sick children (14).

(d) Safe drinking water

Water supplies should be scrutinized and superchlorinated.

(e) Food safety

Food hygiene should be made stricter. Adequate storage facility for storage of food (both cooked and uncooked) and adequate water for cleaning and cooking must be provided. All crockery and cutlery must be adequately cleaned before use. Milk should be boiled and the food habits of personnel should be improved.

(f) Concurrent Disinfection

All underclothings, soiled linen, bedding, and particularly the excreta should be treated by concurrent disinfection.

(g) Personal Hygiene

Thorough hand washing with soap before handling food must be stressed.

(h) Epidemiological Investigation

Epidemiological Investigation for the source of infection and modes of transmission should be carried out and appropriate control measures instituted.

(j) Control of Flies

Control and destruction of flies is the most important method of controlling an outbreak of dysentery. Persistent attention to exterminate breeding places by proper disposal of faeces and manure, ensuring good general sanitation, prohibiting indiscriminate defaecation and the use of insecticides lead to control of flies. Health education of all personnel is very important.

## Cholera

Definition A serious acute intestinal disease caused by *Vibrio cholerae* 01 (Classical or El Tor) and characterized by sudden onset, profuse, effortless watery stools, vomiting, rapid dehydration, muscular cramps, acidosis and circulatory collapse. Fatality rates in untreated cases may exceed 30-40 per cent; inapparent and wholly asymptomatic infections are many times more frequent

than clinically recognized cases, especially *Vibrio cholerae* biotype El Tor.

**Problem statement**

For centuries cholera has been one of the most feared diseases. The German poet Heinrich Heine, who lived in Paris when cholera first appeared there in the early 1830s, wrote home to tell his countrymen of the hatred shown towards people who had contracted the disease (15) : *"I saw one of these unfortunates when he was still breathing and the old hags were just pulling the wooden shoes from their feet and beating him on the head with them till he was dead. He was quite naked and bloody and mashed; they had torn off not only his clothes but his hair, his sex, his lips and his nose, and one ruffian tied a rope to the feet of the corpse and dragged it through the streets, shouting constantly, 'Voilà le cholera-morbus!'"*

Cholera remains a global threat to public health and one of the key indicators of social development. While the disease no longer poses a threat to countries where minimum standards of hygiene are met, it remains a challenge in those countries where access to safe water and adequate sanitation can not be guaranteed for all. Almost every developing country is facing either a cholera outbreak or the threat of an epidemic (16). The changing epidemiology of *V. cholerae* O1 and O139 infections has further aggravated the situation and needs regular monitoring (17).

In India, Cholera has been present since antiquity. In 1961, an unexpected situation arose. Cholera El tor which was localized in Sulawesi in Indonesia for many decades suddenly became widespread, starting the seventh pandemic. India became involved in 1964. It has since affected more than 80 countries in Asia, Africa & Europe. In India, cholera biotype El Tor has almost completely replaced the age old classical cholera. Currently the large endemic foci of cholera are found in Maharashtra, Tamil Nadu, Karnataka, Delhi, Gujarat & Kerala, which account for 80 percent of the reported incidence in the country.

During the year 2006, a total of 2472 cases and 28 deaths were reported from 6 Asian countries. The Indian subcontinent reported 78% of all cases notified from Asia, with India notifying a total of 1939 cases and 3 deaths (16).

**Epidemiological determinants**

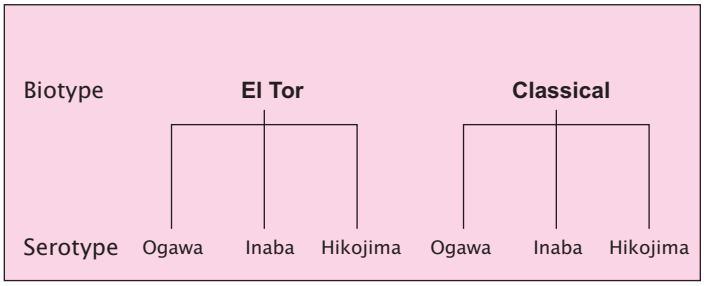
Agent factors

**(a) Agent**

The causative agent, *Vibrio cholerae* was first isolated in 1883 by Koch from the stools of patients with cholera. It is a small, curved, motile, aerobic gram - negative organism best identified by inoculating stool into taurocholate - tellurite - gelatin (TTG) agar or thiosulfate - citrate - bile salts - sucrose (TCBS) agar. *V. cholerae* colonies are relatively small on TTG agar after 24 hours and are translucent with a dark center and a cloudy zone surrounding the colonies. On TCBS agar *V. cholerae* are easily recognized as large yellow colonies on a blue - green medium. The species is identified on the basis of cultural and biochemical tests (18).

The antigenic classification of vibrios depends on the specific somatic (O) antigens. The flagellar antigen (H) is non specific and common to all. The group A vibrios which include both cholera and cholera like vibrios have been divided into six sub groups (I to VI) based on the antigenically different 'O' antigens. Cholera vibrios belong to serological O sub-group I of Gardner and Venkataraman and other serological Sub-group (II to VI) are NAG vibrios (non agglutinable to O group I antisera). The O subgroup I vibrios comprises of classical *V. Cholera* and *V. El Tor* biotype and they cannot be differentiated by serological or biochemical tests. But they can be differentiated by hemolytic property, sensitivity to lysis by Mukherjee's Group IV cholera phage, polymyxin B sensitivity and chicken red cell agglutination. Based on the O antigenic components, both classical *V cholerae* and biotype *El Tor* have been divided into 3 serotypes Ogawa, Inaba and Hikojima. The former two are common.

Classical vibrio cholerae can be distinguished from *El Tor* by the following tests :




**(b) Resistance**

Difference between Classical and El Tor Vibrio Cholerae

| Test | Classical V. cholerae | Biotype El tor |
|---|---|---|
| Chick erythrocyte agglutination | Negative | Positive |
| Polymyxin B sensitivity | Sensitive | Resistant |
| Cholera phage IV | Sensitive | Resistant |
| Haemolysis test | Negative | Positive |

Vibrio cholerae 01 can survive on a variety of foodstuffs for up to five days at ambient temperature and up to 10 days at 5-10 degrees Celsius. The organism can also survive freezing. Low temperatures, however, limit proliferation of the organism and thus may prevent the level of contamination from reaching an infective dose. The cholera vibrio is sensitive to acidity and drying, and commercially prepared acidic (pH 4. 5 or less) or dried foods are therefore without risk. Gamma irradiation and temperatures above 70°C also destroy the vibrio (19).

**(c) Toxin production**

Vibrios multiply in the lumen of small intestine and produce enterotoxins which act on adenyl cyclase - cyclic AMP system of mucosal cells and produce diarrhoea.

**(d) Reservoir of infection**

The only reservoir of infection is man, either a case or a carrier. The ratio of severe cases to mild or inapparent infections has been shown to be about 1 : 5 for classical cholera and 1 : 25 to 1 : 100 for El Tor cholera (20). Carriers in cholera are of four types viz. incubatory carriers, convalescent carriers, healthy carriers and contact carriers (21). Duration of carrier period is short, about 4 or 5 days. Chronic carriers who harbour the vibrio for more than 3 months are not many.

**(e) Infective material**

Stools and vomit of cases and carriers are infectious in nature. However, carriers excrete fewer vibrios as compared to cases.

**(f) Period of communicability**

A case of cholera is infectious for a period of 7 to 10 days. While convalescent carriers are infectious for 2 - 3 weeks, chronic carrier state may last from one month to 10 years or more.

Host Factors

Cholera usually affects persons belonging to the low socio-economic strata because of poor environmental sanitation. Their standard of personal hygiene is low. When cholera epidemic occurs in non-endemic areas, male adults are more affected. In contrast, in endemic areas, attack rate is equal in both the sexes and it is distinctly higher for children than for adults. This phenomenon is due to development of naturally acquired immunity with increasing age in the endemic areas.

Environmental factors

Contaminated water and food are the most important environmental factors in the causation of cholera. Unusually heavy rains, which have caused flooding, are blamed, at times, for the high incidence of the disease outbreak (15). Flies may carry *V. cholerae* but are not vectors of proven importance. Social factors responsible for the endemicity of the disease include poor literacy, poor personal hygiene, poor living standards and unhealthy habits in relation to water and food.

Mode of Transmission

Infection by *V. cholerae* is invariably by ingestion. Most important mode of transmission is through contaminated water. Disease may spread through food contaminated by food handlers and flies. Fruits and vegetables washed with contaminated water may transmit the infection. Person to person contact particularly in overcrowded dwellings without sanitary facilities is very important due to careless handling of human excreta under such conditions.

Incubation Period

It varies from a few hours upto 5 days, but commonly 1 to 2 days. Infectivity of cholera is high, but the disease rate is low; as a rule, although many members of family may be infected, usually one of them falls ill.

**Pathogenesis**

According to current concepts, the cholera vibrio gets through the mucus which overlies the intestinal epithelium. It probably secretes mucinase, which helps it move rapidly through the mucus. Then it gets attached or adhered to the intestinal epithelial cells, and this it probably does by an adherence factor on its surface. When the vibrio becomes adherent to the mucosa, it produces its enterotoxin which consists of 2 parts- the light or L toxin and the heavy or H toxin. The L toxin combines with substances in the epithelial cell membrane called gangliosides and this binds the vibrio to the cell wall. Binding is irreversible. The mode of action of H toxin is not fully clear. What we know is that there is a substance called "adenylcyclase" in the intestinal epithelial cells, and H toxin activates this substance. The activated adenyl cyclase causes a rise in cAMP. cAMP provides energy which drives fluid and ions into the lumen of the intestine. This fluid is isotonic and is secreted by all segments of small intestine. This increase in fluid is the cause of diarrhoea.

**Clinical features**

The severity of cholera is dependent on the rapidity and duration of fluid loss. Epidemiological studies have shown that more than 90 percent of El Tor cholera cases are mild and clinically indistinguishable from other acute diarrhoeas (22). However, a typical case of cholera shows 3 stages (23) :

(a) Stage of Evacuation

The onset is abrupt with profuse, painless, watery diarrhoea followed by vomiting. The patient may pass as many as 40 stools in a day. The stools may have a "rice water" appearance.

(b) Stage of collapse

The patient soon passes into a stage of collapse because of dehydration. The classical signs are : sunken eyes, hollow cheeks, scaphoid abdomen, sub-normal temperature, washerman's hands and feet, absent pulse, unrecordable blood pressure, loss of skin elasticity, shallow and quick respiration. The urinary output decreases and may ultimately cease. The patient becomes restless, and complains of intense thirst and cramps in legs and abdomen. Death may occur at this stage, due to dehydration and acidosis resulting from diarrhoea.

(c) Stage of recovery

If death does not occur, the patient begins to show signs of clinical improvement. The blood pressure begins to rise, the temperature returns to normal, and urine output is reestablished. If anuria persists, the patient may die of renal failure. The classical form of severe cholera occurs in only 5-10 percent of cases. In the rest, the disease tends to be mild characterised by diarrhoea with or without vomiting or marked dehydration. As a rule, mild cases recover in 1-3 days.

Epidemiologically, cholera due to *El Tor* biotype differs from *classical cholera* in the following respects :

(a) A higher incidence of mild and asymptomatic infection. This implies that the characteristic picture of rice-water stools and other signs of classical cholera described above may not be seen often.

(b) Fewer secondary cases in the affected families

(c) Occurrence of chronic carriers

(d) Since *El Tor* vibrios are more resistant than *classical cholera* vibrios, they survive longer in the extra intestinal environment.

**Laboratory diagnosis of Cholera**

The diagnosis of cholera can never be made with certainty on clinical grounds. Laboratory methods of diagnosis are required to confirm the diagnosis :

(a) Collection of Stools

A fresh specimen of stool should be collected for laboratory examination. Sample should be collected when the patient is having diarrhea, as soon after onset of illness as possible (preferably within 4 days of onset) and before antimicrobial treatment is started (24). Collection may be made generally in one of the following ways :

(i) **Rubber Catheter** : Collection by the catheter (26-28 size) is the best method but is complicated under field conditions. Soft rubber catheter sterilised by boiling should be used. The catheter is introduced (after lubrication with liquid paraffin) for at least 4-5 cm into the rectum. The specimen voided may be collected directly into a transport (holding) media. e. g. , Venkatraman-Ramakrishnan (VR) medium and alkaline peptone water.

(ii) **Rectal Swab** : Swabs consisting of 15-20 cm long wooden sticks, with one end wrapped with absorbent cotton, sterilized by autoclaving have been found to be satisfactory. Rectal swabs should be dipped into the holding medium before being introduced into the rectum. After collection, it should be sent to lab in a transport medium. If no transport medium is available, a cotton-tipped rectal swab should be soaked in the liquid stool, placed in a sterile plastic bag, tightly sealed and sent to the testing laboratory.

(iii) Stools from patients should be collected in clean containers without disinfectant or detergent residue and with tight-fitting, leak-proof lids. Specimens should not be collected from bedpans, as they may contain residual disinfectant or other contaminants. Unpreserved stool should be refrigerated if possible and processed within a maximum of 2 hours after collection. Specimens that cannot be cultured within 2 hours of collection should be placed in transport medium and refrigerated immediately (24).

(b) Vomitus

This is practically never used as the chances of isolating vibrios are much less and there is no advantage.

(c) Water

Samples containing 1-3 litres of suspect water should be collected in sterile bottles (for the filter method), or 9 volumes of the sample water added to 1 volume of 10 percent peptone water, and despatched to the laboratory by the quickest method of transport.

(d) Food Samples

Samples of food suspected to be contaminated with *V. cholerae* (or other enteric bacteria) amounting to 1-3 g are collected in transport media and sent to the laboratory.

(e) Transportation

(i) The stools should be transported in sterilized McCartney bottles, 30 ml capacity containing alkaline peptone water or VR medium should be used if larger stool specimens are collected. The specimen should be transported in alkaline peptone water or Cary-Blair medium if it is collected by a rectal swab. One gram or one ml of faeces in 10 ml of the holding medium will suffice. Rectal swabs should have their tops broken off so that caps of the containers can be replaced.

(ii) If suitable plating media are available (e. g. bile salt agar) at the bed-side, the stools should be streaked on to the media and forwarded to the laboratory with the transport media

(f) Direct Examination

If a microscope with a dark field illumination is available, it may be possible to diagnose about 80 percent of the cases within a few minutes, and more cases after 5-6 hours of incubation in alkaline peptone water. In the dark field, the vibrios evoke the image of many shooting stars in a dark sky. If motility ceases on mixing with polyvalent anti-cholera diagnostic serum, the organisms are presumed to be cholera vibrios. A presumptive diagnosis of cholera can thus be established.

(g) Culture Methods and Characterisation

On arrival at the laboratory, the specimen in holding fluid is shaken well, and about 0. 5 to 1. 0 ml of material is inoculated into Peptone Water Tellurite (PWT) medium for enrichment. After 4 to 6 hours incubation at 37°C, a loopful of the culture from the surface is subcultured on Bile Salt Agar medium (BSA, pH 8. 6). After overnight incubation, the plates are screened under oblique light illumination for vibro colonies. *V. cholerae* usually appear on bile salt agar (BSA) as translucent, moist, raised, smooth and easily emulsifiable colonies about 1 mm in diameter. The typical colonies are picked up and tested as follows :

(i) **Gram Stain and Motility** : Gram negative and curved rods with characteristic scintillating type of movement in hanging drop preparations are very characteristic of *V. cholerae.*

(ii) **Serological Test** : Slide agglutination test is done by picking up suspected colonies and making a homogeneous suspension in 0.85 percent sterile saline and adding one drop of polyvalent anti-cholera diagnostic serum. If agglutination is positive, the test is repeated with Inaba and Ogawa antisera, to determine the subtype.

(iii) **Biochemical Test** : Serologically positive colonies should be subcultured in one tube each of the sugar broths (mannose, sucrose, arabinose) and a tube of peptone water pH 7.2 for the cholera red reaction. Production of acid in sucrose and mannose, but not arabinose is characteristic of *V.*

*cholerae.*

(iv) **Further Characterisation** : Further characterisation of biotypes of *V. cholerae,* the following tests are carried out.

- The direct haemagglutination test with chicken or sheep red blood cells.
- Polymyxin B sensitivity test using 50 mcg discs.
- Sensitivity to cholera phage IV.
- V-P reaction.
- Haemolysis test.

Suspicious colonies that do not agglutinate with anticholera sera are tested further by the oxidase and string tests.

Recently developed dipsticks (sensitivity and specificity above 92 and 91%, respectively) for the rapid detection of Vibrio cholerae serotypes O1 and O139 from rectal swabs has been successfully used to diagnose cholera. This is likely to improve surveillance for cholera, especially in remote settings (25).

**Prevention & control**

Detailed guidelines on prevention and control of cholera, including management of cases, are given in the standard WHO text (26). Medical officers are advised to refer to the same.

(a) Control of cholera

Control of cholera depends on the improvement of environmental sanitation. Main aspects of environmental sanitation are adequately chlorinated and protected water supply, proper disposal of night soil/sewage and safe food supply. Food may be contaminated at the source, at different stages of processing, storing, serving and due to exposure to flies. Health education is important for improvement of personal hygiene.

(b) Immunization

The currently available saline suspension vaccines give protection in the range of 50-60 per cent and for a period of 3-6 months. Primary immunization consists of 2 equal doses of 0. 5 ml each in adults injected subcutaneously, at an interval of 4-6 weeks. If for any reasons, it cannot be carried out in 2 doses, a single 1 ml dose should be given. However in the vaccinated persons it does not reduce the severity of the illness or frequency of inapparent infection. As the efficiency of cholera vaccine is limited and duration of protection is short, it is essential that vaccine is used with discrimination and in proper time, that is anticipatory in selected place and population in face of epidemic.

Several mass vaccination campaigns using Oral Cholera Vaccines (OCV) have been performed with the support of WHO. Based on these, OCVs are now being considered as complements to traditional preventive measures (16).

The policy in the Armed Forces at present is not to give routine anti-cholera vaccination as at present it is not helpful in the prevention & control of cholera. At best they can be used as an adjunct to other preventive measures such as drug prophylaxis, proper sanitation and health education. Immunization against cholera is not regarded as an effective means of preventing the spread of cholera internationally. Cholera vaccination is not mandatory for international travel. However certain countries still insist on vaccination certificate against cholera. Before undertaking any travel one should consult the booklet issued by WHO every year "Vaccination Certificate Requirements for International Travel'.

(c) Action on Occurrence of the Disease

**(i) Isolation**

Even on the slightest of suspicion, the patient must be admitted immediately to the hospital where he must be strictly isolated in a special fly-proofed ward and diagnosis should be confirmed by identifying V cholerae 01 in the stool. Generally several cases occur at the same time; therefore, adequate arrangements for hospitalization of all cases are essential. In a large outbreak a separate hospital in the vicinity of the main hospital may have to be opened.

**(ii)Disinfection**

Soiled bedding and clothing, which cannot be sterilized, must be burnt. The floors of wards, huts and barracks must be thoroughly scrubbed with 5 per cent cresol (cresoli liquid). The place in which bed pans, urinals and soiled linen are stored should be fly-proofed or carefully covered with a sheet soaked in and kept moist with 5 per cent cresol. The stool and vomit should be poured into a receptacle containing an equal quantity of 5 per cent solution of cresol and left covered for 4 hours before its final disposal. Fresh WSP thoroughly mixed in the proportion of 1. 5 g to 1 lit of faeces/ vomitus may also be used as a disinfectant.

**(iii) Notification**

Previously, cholera was listed among the three communicable diseases - along with yellow fever and plague - whose notification to WHO was compulsory. Since 15 June 2005, the official notification of cholera is no longer mandatory but countries are required to inform WHO of public health events of international concern (16).

**(iv) Attendants**

They should be specially detailed and be isolated from the nursing staff of the main hospital. They should dip their hands in antiseptic solution after washing, after every contact with the patient, his bedding, objects or utensils. They should all be inoculated against cholera beforehand. The consumption of any food or drink by these attendants while in the cholera ward should be strictly prohibited. Gowns should always be worn while on duty.

**(v) Contacts**

They need not be isolated. All persons who are suspected of having partaken of the same infected food or drink as the patient, however remotely, should be kept under daily morning and evening surveillance for 5 days.

**(vi) Food and Drinks**

Control of food and drinks is the most important method of control of an outbreak. The following rules should be followed in the presence of an outbreak in the civilian community nearby :

- Drinking water should be super chlorinated. Washing and bathing water should be chlorinated. All rivers, ponds, wells etc. in the neighborhood should be put strictly 'out of bounds' to all troops other than authorized water duty personnel. Soda water and other drinks should be used only after the most careful investigation of their source of supply. Ice should not be used unless from an authorized source.
- Milk must be boiled. Cream and butter should be obtained only from reliable sources. Consumption of ice cream, unless its origin is absolutely beyond suspicion, should be strictly prohibited.
- Uncooked vegetables and fruits which are customarily eaten unpeeled should be avoided during epidemics. Others should always be washed and then soaked in a solution made by adding 3 scoopfuls or 6g WSP to a bucketful of water, before peeling. Cut fruits exposed for sale should not be eaten.
- All food must be protected against flies. Strict supervision of cookhouses and cooks are necessary to ensure that food is prepared, cooked stored and served under clean conditions. Golden rules for safe food preparation, as suggested by WHO (27) and given in the Box must be adhered to.

**What can I do to avoid cholera?**

By taking a few basic precautions cholera as well as most other food and water-borne diseases can easily be prevented. Main rule is : ***Always be aware of the quality of what you eat and drink when you are traveling.***

- **Drink only water that has been boiled or disinfected with chlorine.** Beverages such as hot tea or coffee, wine, beer, carbonated water or soft drinks, and bottled or packaged fruit juices are also usually safe to drink
- **Avoid ice, unless sure that it is made from safe water.**
- **Eat food that has been thoroughly cooked and is still hot when served.** Cooked food that has been held at room temperature for several hours and served without being reheated can be an important source of infection.
- **Avoid raw seafood and other raw foods**, except fruits and vegetables that you have peeled or shelled yourself. Remember : Cook it, peel it, or leave it.
- **Boil unpasteurized milk before drinking it.**
- **Ice cream from unreliable sources is frequently contaminated & can cause illness. If in doubt, avoid it.**
- **Be sure that meals bought from street vendors are**

**(vii) Mild cases**

A search for mild cases should be carried out by examination of the stools of all those who are suffering from diarrhoea. All diarrhoea cases, however, should be treated with suspicion until proved otherwise. Civilian labourers must be kept under strict supervision and given protective inoculation if considered necessary.

**(viii) 'Out of bound' places**

All villages and bazaars in the town in which a case of cholera has occurred must be placed 'out of bounds' to all troops until declared free from cholera. During an outbreak all eating and drinking places which are not absolutely above suspicion should also be placed 'out of bounds'

**(ix) Precautions**

All precautions, as given in the Box "What can I do to avoid cholera?" must be taken by all to protect oneself from cholera during an outbreak (28).

## Food poisoning

### Definition

Food poisoning is an acute gastro-enteritis caused by ingestion of food or drink contaminated with either living bacteria or their toxins or inorganic chemical substances and poisons derived from plants and animals. Food poisoning outbreaks are usually recognized by the sudden occurrences of an illness in a group of people who have consumed common food and have similar signs and symptoms. The food poisoning may occur as a result of eating any of the following :

(a) Substances containing specific poisons like eating fungi like *Amanita phylloides* instead of edible mushroom or eating sprouting potatoes which contains excess of alkaloid solanine.

(b) Food contaminated by poisons due to agricultural or industrial activities, fertilizers and pesticides in food or food contaminated with metallic poisons as a result of faulty cooking or storing such as use of cheap enamel dishes or galvanized pans.

(c) Foods infected with organisms mainly by three bacterial groups - Salmonella, Clostridium and Staphylococcus. This bacterial food poisoning is the commonest form and will be discussed in detail in subsequent paragraphs.

### Salmonella food poisoning

It is most common form of food poisoning. The causative organisms belong to Salmonella Group of which 50 are common out of over 1, 600 serotypes known. The species most commonly incriminated in human outbreaks is *Salmonella typhimurium*; others are *S. enteritidis, S. cholera-suis*. The organisms are natural commensals of rodents, pigs, cattle, poultry, ducks, eggs and also some healthy human carriers. Man acquires the infection from animals and poultry i. e. through contaminated meat, milk and milk products. Incubation period usually varies from 12 to 24 hours. On ingestion, the organism multiplies in the intestine and causes acute enteritis and colitis. The

WHO Golden rules for safe food preparation

**Cook raw foods thoroughly.** Under normal circumstances raw foodstuffs and water may become contaminated with pathogens, but in times of disaster the risk of contamination is even greater. Thorough cooking will kill the pathogens, which means the temperature of all parts of the food must reach at least 70 ˚C. Uncooked fruits or vegetables should not be eaten, unless they can be peeled. If milk has not been pasteurized, it should be boiled before use. Cooking will not necessarily destroy biotoxins.

**Eat cooked food immediately.** When cooked foods cool to room temperature, bacteria begin to grow. The longer the wait, the greater the risk. To be on the safe side, eat cooked foods as soon as they come off the heat.

**Prepare food for only one meal.** Foods should be prepared freshly and for one meal only, as far as possible. If foods have to be prepared in advance, or if there are leftovers, they should be stored cold, i. e. below 5 ˚C (in a refrigerator or in a cold box), or hot, i. e. above 60 ˚C. This rule is vitally important when it is planned to store food for more than 4-5 hours. Cooked foods that have been stored must be thoroughly reheated before eating, i. e. all parts reheated to at least 70 ˚C. Thorough reheating of foods is essential if refrigerators have ceased to operate for some hours due to power cuts.

**Avoid contact between raw foods and cooked foods.** Safely cooked food can become contaminated through even the slightest contact with raw food. This cross-contamination can be direct, e. g. when raw fish comes into contact with cooked foods. It can also be indirect. For example, preparing raw fish and then using the same unwashed cutting surface and knife to slice cooked food should be avoided, or all the potential risks of illness that were present before cooking may be reintroduced. Cross-contamination may also occur in a freezer when the power has been off for some time and this should be checked for. The juice of raw meat and poultry may drip onto other foods.

**Choose foods processed for safety.** Many foods, such as fruits and vegetables, are best in their natural state. However, in disasters and emergencies, they may not be safe and should be peeled before consumption if eaten raw. Foods that have been processed (e. g. canned food and packed dried food) and that have not been affected by the disaster may be safer. Dry rations may be easier to keep safe, as they do not need cold-storage, but they do need to be kept dry.

**Wash hands repeatedly.** Hands should be washed thoroughly before preparing, serving or eating food and after every interruption, especially after use of the toilet or latrine, changing a baby or touching animals. After preparing raw foods, especially those of animal origin, hands should be washed again before handling cooked or ready-to-eat foods.

**Keep all food preparation premises meticulously clean.** Since foods are so easily contaminated, any surface used for food preparation must be kept absolutely clean. Scraps of food and crumbs are potential reservoirs of germs and can attract insects and animals. The immediate surrounding of the temporary shelter, especially the kitchen and food storage areas, should be cleaned and sullage and solid kitchen waste should be disposed of properly. Food should be stored in closed containers to protect it from insects, rodents and other animals. Fly and rat traps should be used if necessary.

**Use safe water.** Safe water is just as important for food preparation as for drinking. If the supply of safe/potable water has been disrupted, the water intended for drinking or food preparation should be boiled. For example, condensed or powdered milk must be reconstituted with potable water only. Ice made from unsafe water will also be unsafe and may be a source of food contamination.

**Be cautious with foods purchased outside.** Sometimes food served in restaurants and by street food-vendors is not prepared under hygienic conditions. In times of disasters or emergencies, the risk that such foods are contaminated is greater. Therefore, caution must be exercised in the choice of food : only food that has been thoroughly cooked and is still hot when served should be eaten. Food bought from street food-vendors should be thoroughly cooked in the presence of the customer. Apart from fruits and vegetables that can be peeled, raw or undercooked foods should be avoided. Only water that has been boiled, or disinfected with chlorine or iodine, should be drunk. Beverages such as hot tea or coffee, wine, beer, carbonated water or soft drinks, packaged fruit juices and bottled water are usually safe to drink, if not damaged by the disaster. Avoid ice unless it is made from safe water.

**Breast-feed infants and young children.** Breast milk is the ideal source of nourishment for infants during their first months of life. It protects infants against diarrhoea through its anti-infective properties, and minimizes their exposure to foodborne pathogens. In times of epidemics and disaster situations, when foods may be contaminated or scarce, breast milk will ensure a safe and nutritionally adequate food for infants from birth up to the age of 4-6 months. Continued breast-feeding after this age can also contribute to the prevention of food-borne infections in older infants and

Source : (27)

onset is generally sudden with chills, fever, nausea, vomiting and profuse watery diarrhoea. The illness lasts for 2 to 3 days. Convalescent carriers are known to occur.

### Staphylococcal food poisoning

It is as common as food poisoning caused by salmonella. The causative organism is coagulase positive *Staphylococcus aureus* which causes the illness by production of heat stable entero-toxins. At least 5 different types of toxins have already been identified, and a sixth one is likely to exist (29). The toxin resists boiling for 30 minutes. Staphylococcus are ubiquitous in nature and are found in nose, throat and on the skin surface of human beings. They are common agents for pyogenic infections in man and animals. Cows suffering from mastitis have been responsible for the outbreaks. Tinned meat or fish inadequately processed, pickled meats, creams, milk, and milk products contaminated with staphylococcus have been incriminated in various outbreaks. The incubation period varies from 1 to 6 hours.

The disease manifests as sudden onset of vomiting with abdominal cramps and diarrhoea. In severe cases blood and mucous may appear. Fever is uncommon and so is mortality.

**Clostridium perfringens food poisoning**

*Clostridium perfringens (welchii)* is found in faeces of man and animals; and in soil, water and air. The spores of the organism are heat resistant and survive cooking, and if the cooked meat and poultry are not cooled enough, the spores germinate and produce a variety of toxins which cause the illness. The usual story is that the food is cooked 24 hours before consumption, allowed to cool down slowly and then heated just before the serving. The incubation period varies from 6 to 24 hours. The commonest symptom is diarrhoea with abdominal cramps. Fever and vomiting are usually absent. Illness is of short duration. Recovery is fast and mortality is rare.

**Botulism**

The food borne botulism (the others being wound botulism and infant botulism) is caused by *Clostridium botulinum* -a gram-negative, strict anaerobe, spore forming bacillus whose natural habitat is soil. It produces at least seven types of exotoxins of which type A, B and E are incriminated in food poisoning in humans. The foods most frequently responsible are home preserved foods such as smoked or pickled fish, home made cheese and similar low acid foods. The toxin is preformed in food under suitable anaerobic conditions and acts on parasympathetic nervous system. Incubation period is usually 12 to 36 hours. Clinical features include dysphagia, diplopia, ptosis, blurring of vision, dysarthria, muscular weakness and even quadriplegia. Gastrointestinal symptoms are very slight, fever is usually absent. Condition is frequently fatal - death occurring 4 to 8 days later due to respiratory or cardiac failure.

**Bacillus cereus food poisoning**

*Bacillus cereus* is an aerobic, spore bearing, motile, gram positive rod. It is ubiquitous in soil, and in raw, dried and processed foods. The spores survive cooking and germinate when the food is held at favourable temperature. It produces 2 types of entero-toxins - the emetic form with an incubation period of 1 to 6 hours, which produces upper gastrointestinal symptoms; and the diarrhoeal form with an incubation period of 12 to 24 hours, which produces lower intestinal tract symptoms. Recovery within 24 hours is usual.

**E. coli O157 food poisoning**

Food poisoning due to *E. coli* O157 has grown to prominence as an emerging public-health hazard since the first cases were reported in the early 1980s. Although far less common than *Salmonella* and *Campylobacter*, *E coli* O157 can survive for up to 6 months in mud and is far more likely to cause severe symptoms. While most food-poisoning events are short-lived and resolve without intervention, 2-7% of individuals (and up to 15% of children) infected with *E coli* O157 develop haemolytic uraemic syndrome, which leads to renal failure and potentially death (30).

Distinctive Features Of Common Food Poisonings

| Entity | Incubation period | H/o Fever | Vomiting | Diarrhoea |
|---|---|---|---|---|
| Staphylococcus | | 1-6 | - | |
| + | + | | | |
| Salmonella | 12-24 | + | + | + |

**Food poisoning Vs Cholera**

Majority of the food poisoning cases present with diarrhoea and, at times, it becomes difficult to differentiate it from cholera. But, while most of the food poisoning cases recover on their own, cases of cholera need active management, failing which the case may end fatally. Hence, there is a need to differentiate the two conditions. The distinctive features are given in the Table - 1

**Prevention and control of epidemics of food poisining**

The common measures recommended for the prevention and control of epidemics of food poisoning in Armed Forces include the following :

(a) **Meat and Meat Products** : Animals should be slaughtered in a hygienic, rat proof, vermin free butchery. Strict supervision should be kept on the whole cycle of meat processing.

(b) **Milk and Milk Products** : Milk should be pasteurized or boiled and every care should be taken against subsequent contamination.

(c) **Protection of Foods** : Adequate precautions should be taken against contamination of food during storage or during processing. The food items should not be left overnight in warm pantries and those not eaten immediately should be kept in cold storage to prevent bacterial multiplication and toxin production.

(d) **Food Handlers :** They should be periodically examined and those suffering from boils, ulcers, throat or eye infections and with history of having suffered from enteric fever or diarrhoea in recent past should not be employed as food handlers. A high standard of personal hygiene among food handlers must be maintained. Food handlers should be educated in matters of clean habits and personal hygiene.

(e) **Hazard Appraisal and Critical Control Point (HACCP) evaluation** - A simple and effective method for preventing food borne illnesses is by undertaking a detailed analysis of the steps in which food items are procured / prepared / stored / served, followed by identification of critical points where hygiene and sanitation can be breached / contamination can be introduced and finally making a check list of these critical control, points for taking acton for control / preventive action. The system has been recommended by the WHO. The golden rules for food safety issued by WHO are shown in the box on previous page

Table - 1 : Differences between food poisoning and cholera

| | Cholera | Food poisoning |
|---|---|---|
| Epidemiology | Occurs often in epidemic form associated with other cases in the neighbourhood. Secondary cases occur. | Often single group of persons who shared common meal are affected No secondary cases. |
| Incubation period | From few hours to 5 days | 1 to 24 h |
| Onset | With purging | With vomiting |
| Nausea and retching | None | Present |
| Vomiting | Projectile, effortless, watery & continuous | Often single severe vomit, mucus & blood soaked |
| Stools | Copious, rice watery & in -offensive | Frequent, may contain mucus blood |
| Tenesmus | None | Present |
| Abdominal tenderness | None | Present |
| Dehydration | Very marked | Distinct |
| Muscular cramps | Constant and severe | Less constant |
| Surface temperature | Subnormal | 100-102°F |
| Headache | None | Often present |
| Urine | Suppressed | Seldom suppressed |
| Blood | Leucocytosis | Normal |

## Enteric Group of Fevers

### Definition

This is a group of clinically similar, but immunologically distinct fevers, characterized by typical continuous fever for 3-4 weeks, relative bradycardia, with involvement of lymphoid tissues and considerable constitutional symptoms. The disease vary in severity, and many mild cases occur. The term 'enteric fever' includes both the typhoid and paratyphoid fevers.

### Geographical Distribution

Enteric fever occurs in all parts of the world, but the incidence of the disease has declined greatly with the provision of clean water and good sewage systems in Europe and the USA since the early 20th century, but the disease remains a serious public - health problem in developing countries (31). *S. paratyphi* is becoming predominant in some provinces in China and increasing numbers of cases are reported from Pakistan (32).

### Incidence

Few established surveillance systems for typhoid exist in the developing world, especially in community settings, so the true burden is difficult to estimate. According to an estimate of US Centers for Disease Control and Prevention there are 21. 6 million typhoid cases annually, with the annual incidence varying from 100 to 1000 cases per 100 000 population. The incidence is highest in the age group of 5 - 19 years but population based studies from South Asia suggest that the incidence is highest in children aged less than 5 years, with higher rates of complications and hospitalization (33). The overall ratio of disease caused by *S typhi* to that caused by *S paratyphi* is about 10 to 1 (33) to 4 to 1 (34). Enteric fevers are not notifiable diseases throughout India and hence the correct incidence is not known. Limited studies in the country reveal more than three lac cases and more than 650 deaths (approx) annually in our country. In Armed Forces, due to better hygiene and sanitation, safe water supply and systematic immunization, the incidence is low.

### Epidemiological determinants

Agent factors

**(a) Agent**

Typhoid fever is caused by Salmonella enterica serovar Typhi (*S. typhi*), a Gram negative bacterium. Paratyphoid

fever - a similar but often less severe disease - is caused by *S paratyphi A* and, less commonly, by *S paratyphi B* (Schotmulleri) and *S paratyphi C* (Hirschfeldii) (33). They are readily killed by heating at 60ºC, drying, pasteurization and common disinfectants.

**(b) Reservoir**

Man is the only reservoir of infection. The case may be mild, moderate or severe and is infectious as long as the bacilli are excreted in stool or urine. The carriers (or chronic) are more important. Convalescent carriers excrete the bacilli for 6 - 8 weeks. Chronic carriers are those who excrete the bacilli for more than one year after clinical attack. A chronic carrier may excrete the bacilli for several years, either continuously or intermittently. *S. typhi* once lodged in human carrier may persist for 20-50 years. Faecal carriers are commoner than urinary carriers. The carrier state is commoner in middle aged persons; females predominating over males. The famous case of "Typhoid Mary" who gave rise to more than 1, 300 cases is a good example of a chronic carrier. She is said to have spent the last 15 years of her life in quarantine in a New York hospital (35) Urinary carriers, though less common, are more dangerous to the community than faecal carriers because of greater chances of contamination of hands during micturition. Detection of carriers is by isolation of organisms from faeces or urine of suspects, agglutination tests are much less reliable.

**(c) Source of Infection**

The sole source of infection is the faeces or urine of cases and carriers. The bacilli are excreted for varying periods in faeces and urine.

Host factors

**(a) Age**

Enteric fever can occur at any age. Highest incidence of this disease occurs in the 5-19 years of age group but population based studies from South Asia suggest that the incidence is highest in children aged less than 5 years, with higher rates of complications and hospitalization (33).

**(b) Sex**

More cases are reported among males probably as a result of increased exposure to infection but carrier rates are more common in females.

**(c) Immunity**

An attack of the disease gives lasting immunity; second attacks however are not uncommon. The Armed Forces personnel, due to routine inoculation, constitute a relatively immune population.

**(d) Genetic factors**

Involvement of host genetic factors has also been implicated in the pathogenesis of typhoid fever. HLA-DRB1*12 is associated with protection against complicated typhoid fever (36).

Environmental factors

Enteric fevers are observed all through the year. The peak incidence is reported during July-September. This period coincides with the rainy season and an increase in fly population. Outside the human body, the bacilli are found in water, ice, food, milk and soil for varying periods of time. Typhoid bacilli do not multiply in water; many of them perish within 48 hours, but some may survive for about 7 days. They may survive for over a month in ice and ice-cream and up to 70 days in soil irrigated with sewage under moist winter conditions. Food being a bad conductor of heat, provides shelter to the bacilli in which they may multiply and survive for sometime. Typhoid bacilli grow rapidly in milk without altering its taste or appearance in anyway. Vegetables grown in sewage farms or washed in contaminated water are a positive health hazard. These factors are compounded by such social factors as pollution of drinking water supplies, open air defecation and urination, low standards of food and personal hygiene and health ignorance. Typhoid fever may therefore be regarded as an index of general sanitation in any country.

Incubation period and period of communicability

It is usually 10-14 days but in many cases it may well be outside the range. When the disease is water-borne, the incubation period tends to be longer. The incubation period for paratyphoid is 4 to 5 days. The case is infectious during the later part of incubation period and for a variable period thereafter.

Mode of Transmission

Enteric fever is spread chiefly through the medium of contaminated water, food, milk and vegetables. Flies constitute an important subsidiary vehicle for sporadic incidence. A small proportion of cases may occur due to direct transmission of infection from an actual case / carrier through contamination of hands, while handling patients or their excreta. The mode of transmission for explosive outbreaks of any considerable size, is, however water, milk or milk products adulterated by contaminated water or handling by carriers.

**Prevention**

The fundamental preventive measures are

(a) Provision of protected, clarified and chlorinated water supply
(b) Efficient pasteurization or boiling of milk
(c) Proper sanitary disposal of night soil
(d) Strict anti-fly measures
(e) Protection and cleanliness of fruits and vegetables
(f) High standard of food handlers' hygiene
(g) Personal hygiene and food habits
(h) Protective inoculation

Immunization

(a) **TA Vaccine** : Out of all the vaccines available, the rigidly carried out protective immunization with TA vaccine of all ranks has proved the most important and effective single preventive

measure. The immunization state of every unit at any time must be 100 percent. The records must be scrutinized every month. Those who are due or are likely to be away when next due, must be immunized immediately. Families of Armed Forces personnel and civilians employed in the Armed Forces must be similarly protected.

(b) **Vi polysaccharide vaccine :** This vaccine is licensed for use in individuals older than 2 years and is given in a single subcutaneous or intramuscular dose. The vaccine is moderately effective for about 3 years after vaccination (37). Revaccination is recommended every 3 years. The Vi vaccine can be given simultaneously with other vaccines relevant for international travellers such as yellow fever and hepatitis A.

(c) **Live Oral Vaccine :** This live oral vaccine available in enteric-coated or liquid formulation is approved for use in people 6 years of age and older. The liquid formulation for younger children is currently marketed in only a few countries. Three doses are recommended each given 2 days apart. Antimicrobials should be avoided for 7 days before or after vaccination. The vaccine is moderately effective for up to about 3 years after vaccination (38). A booster dose is recommended every 3 years in endemic areas and travellers should be revaccinated annually. The vaccine can be given simultaneously with other vaccines and with antimalarial prophylaxis. The vaccine is still under consideration for introduction in the Armed Forces.

(d) **Managing outbreak :** On the occurrence of an outbreak or increasing incidence all the preventive measures must be tightened. A search for carriers and missed cases, by stool and urine culture, blood culture and serological methods may be made within the unit, particularly among the cooks, mess waiters and other food handlers. Restaurants, cafes and other such places should be placed "out of bound' to all ranks. If only few cases have occurred the chances of tracing the source are good. Immunization is the most important measure in arresting the progress of an outbreak. The occurrence of a case in the unit warrants scrutiny of the inoculation state of the unit followed by immediate protection of those who are due within the next quarter and of all doubtful cases. Inoculation may not prevent the disease in those who are incubating the infection, but it will do them no harm and definitely arrests the outbreak.

#### Action on occurrence of a case

(a) **Hospitalization** : The patient should be admitted immediately to hospital and treated in a fly proof ward. The food handlers should be discharged from hospital when their stool and urine culture show negative result.

(b) **Disinfection** : Concurrent and terminal disinfection should be done. Faeces and urine can be disposed of directly into sewer without preliminary disinfection where adequate sewage disposal systems are available.

(c) **Notification** : It should be carried out as per existing order.

(d) **Personal Hygiene/Protection** : Attendants should be protected by TA vaccine, wear gowns and wash hands scrupulously whenever they handle the patients.

(e) **Close Contacts** : They should be kept under daily medical surveillance for 21 days.

## Viral Hepatitis

#### Introduction

Viral hepatitis is defined as an infection of the liver caused by hepatotropic virus and is clinically characterized by an acute or sub acute febrile illness associated with nausea, anorexia, abdominal discomfort, dark coloured urine, light coloured stools and appearance of jaundice in sclera or skin.

The known hepatotropic viruses commonly include hepatitis viruses A, B, C, D, E and G. However, the term hepatotropic is itself a misnomer. Infections with hepatitis viruses, especially hepatitis virus B and C, have been associated with a wide variety of extrahepatic manifestations. Infrequent causes of viral hepatitis include adenovirus, cytomegalovirus, Epstein-Barr virus, and, rarely, herpes simplex virus infection.

Hepatitis A virus (HAV); hepatitis B virus (HBV); hepatitis C virus (HCV); hepatitis D virus (HDV), which requires coexisting HBV infection; and hepatitis E virus (HEV) cause approximately 95% of cases of acute viral hepatitis. Whether hepatitis G virus (HGV) is pathogenic in humans remains unclear.

Among these the most common types are viral hepatitis A and viral hepatitis B. Distinguishing features between the two is given in Table - 2.

#### Geographical Distribution

HAV has a world wide distribution. The risk of infection is inversely proportional to levels of sanitation and personal hygiene (39). In developing countries with poor environmental hygienic conditions, nearly all children are infected with HAV before the age of 9. There is substantial underestimation of hepatitis A cases in these areas, because HAV infections for young children are mostly asymptomatic and therefore unrecognized. As sanitary conditions improve, transmission shifts to older age groups and the incidence of symptomatic disease increases. In most developed countries, endemic HAV transmission is unlikely. Epidemics of hepatitis A often evolve slowly, involve wide geographic areas and last many months, but common source epidemics (e. g. faecal contamination of drinking water) may evolve explosively.

HBV also has world wide distribution where 66 percent of the world's population is living in areas where there are high levels of infection. More than 2 billion people world

Table - 2 : Difference between Hepatitis A and B

| Character | Viral Hepatitis A | Viral Hepatitis B |
|---|---|---|
| Incubation period | 15 to 50 days | 50-180 days |
| Type of onset | Acute | Insidious |
| Fever over 100. 4°F | Common | Uncommon |
| Age preference | Children & young adults | Any age |
| Virus in stools demonstrated | Found in acute phase | Not |
| Route of infection (usual) | Faeco-oral (usual) parenteral (uncommon) | Parenteral |
| **Duration of Carrier State** | | |
| Blood | Unknown | May be as long as 5 yrs |
| Faeces demonstrable | Atleast 4 weeks | Not |

wide have evidence of past or current HBV infection and 350 million are chronic carriers of the virus, which is harboured in the liver. The virus causes 60-80 per cent of all primary liver cancer, which is one of the three common causes of cancer related death in East and SEAR, the Pacific Basin and Sub-Saharan Africa. Infection with HBV is a major cause of morbidity and mortality in the SEAR. More than one-third of the population has been infected with HBV, and it is estimated that there are 80 million HBV carriers (about 6% of the total population). Many are life long carriers, although not all are infectious, and some will clear the virus after intervals varying from many months to years. Transmission of HBV infection by blood transfusion and in other medical interventions in both modern and traditional health practices is also common in the Region (40). In India, the carrier rate of HBsAg in hospital staff has been found to be higher than in voluntary blood donors and in the general population. Sero-epidemiologic studies from Armed Forces also suggest that hepatitis carrier state is an important issue (41).

HCV is prevalent in 0. 5-2% of populations in nations around the world. It has been shown to be the major cause of parenterally transmitted non-A, non-B (PT-NANB) hepatitis. Approximately 170 million individuals are chronic carriers and are at risk of developing liver cirrhosis or liver cancer.

Hepatitis D or Delta hepatitis is also widespread and the infection always occurs in association with Hepatitis B. HDV is believed to infect approximately 5% of the world's 300 million HBsAg carriers. The sharing of contaminated needles in intravenous drug use is thought to be the most common means of transmitting HDV. Persons who use intravenous drugs and are also positive for HBsAg, have been found to have HDV prevalence rates ranging from 17-90%. Sexual and perinatal transmissions are also described.

HEV is transmitted via the fecal-oral route. HEV appears to be endemic in some parts of the lesser-developed countries. Anti-HEV antibodies are observed in as many as 60% of Indian children younger than 5 years. Sporadic infections are observed in persons traveling from western countries to these regions.

HGV can be transmitted by blood transfusion. HGV co-infection is observed in 6% of chronic HBV infections and in 10% of chronic HCV infections. However, whether HGV is actually pathogenic in humans remains unclear.

### Incidence

In peace time the incidence of the HAV & HEV disease which have a faeco-oral route of transmission is low but in war time and field service with the movement of troops into endemic areas and lowering of standards of sanitation, there is often a local high incidence. HBV, HCV & HDV which have a parenteral route of spread have a high incidence in a set up where proper sterilization is not maintained in surgical procedures or in injection rooms or in blood transfusion banks.

### Agent factors

Agent

**(a) HAV**

HAV, first identified in 1973, is a nonenveloped, spherical, positive stranded RNA virus with a diameter of 27-32 nm, classified within the genus hepatovirus of the picornavirus family (42). HAV strains recovered from widely separated regions of the world are antigenically similar. In humans, a single serotype of HAV exists. The virus is fairly resistant to heat and chemicals. It withstands heating to 60º C for one hour and is not affected by chlorine in dose of 1 ppm usually employed for chlorination of water.

**(b) HBV**

Discovered by Blumberg in 1963, Hepatitis B virus is a 42 nm double stranded DNA virus of the Hepadnaviridae family. It is present in human blood of patients and carriers. Antigenically it is very complex and has at least 3 separate antigen- surface antigen (HbsAg), core antigen (HbcAg) and antigen (HbeAg). The virus has not yet been grown in the organ culture system. It is killed by heat sterilization in an autoclave for 30 to 60 min or easily destroyed by sodium hypochlorite.

**(c) HCV**

HCV is a Flavivirus with a diameter of 55 nm. It has one serotype and multiple genotypes. At least 6 major genotypes and more than 80 subtypes are described. The genetic variability of HCV hampers the efforts of scientists to design an effective anti-HCV vaccine.

**(d) HDV**

HDV is also called the 'Delta Agent' / 'Defective Virus'/'Dane Particle' It is a single-stranded RNA virus with a diameter of 36 nm and contains HDAg and the RNA

strand. It uses HBsAg as its envelope protein. Thus, HBV co-infection is necessary for the packaging and release of HDV virions from infected hepatocytes.

**(e) HEV**

HEV is a Calicivirus. It is 27-34 nm long non-enveloped RNA virus

Reservoir of Infection

Man is the reservoir for all the viruses. However non human primates may also serve as reservoir of hepatitis A virus (chimpanzees and marmoset monkeys) but this reservoir is epidemiologically not of much relevance.

**Host factors**

HAV

HAV infection, usually, is commoner and milder in children than in adults. However any age group can be affected, if susceptible. Degree and duration of homologous immunity after attack are unknown but presumed to be long lasting.

HBV

Though infection can be contracted in any age, acute hepatitis occurs in approximately 1% of perinatal, 10% of early childhood and about 30% in those above 5 years of age. Development of chronic hepatitis is inversely related to age and occurs in about 95% of persons infected perinatally. Certain occupational categories have been identified as associated with an excess risk of hepatitis B infection. The categories include dentists, nurses, laboratory technicians and the work areas include haemodialysis units, blood banks, surgical intensive care units. Higher mortality rate has been reported in hepatitis B developing after blood transfusion.

While the host factors for HCV and HDV are similar to those of HBV, the host factors for HEV are similar to those of HAV. However HEV has a propensity to induce acute fulminating form of disease in pregnant women with a mortality that may reach about 80%.

**Environmental factors**

The tendency of viral hepatitis A&E to occur among children in endemic areas with poor environmental sanitation but amongst adults with better sanitation standards and of a socio-economically higher class has been observed. Sporadic cases occur from person to person through intimate contact evenly spread all round the year with seasonal upsurge in the fly breeding season. Explosive outbreaks as experienced in Delhi during 1955-56, may occur due to massive pollution of water supplies with sewage or of milk through milk handlers or water used for adulteration.

Hepatitis B, C & D cases have been traced to clinics among patients who have received parenteral inoculations from contaminated and inadequately sterilized syringes and needles.

**Communicability period**

Maximum infectivity for hepatitis A & E is during the later half of incubation period continuing through early acute phase of infection during the first 1-2 weeks or longer.

In hepatitis B, C & D blood remains infective many weeks before the onset of symptoms, through the acute clinical course of the disease and during the chronic carrier state.

**Mode of transmission**

Typical patterns of virus transmission are as follows, with + symbols indicating the frequency of transmission (more + symbols indicated increased frequency) :

**Fecal-oral transmission**

HAV (+++), HEV (+++)

**Parenteral transmission**

HBV (+++), HCV (+++), HDV (++), HGV (++), HAV (+)

**Sexual transmission**

HBV (+++), HDV (++), HCV (+)

**Perinatal transmission**

HBV (+++), HCV (+), HDV (+)

**Sporadic (unknown) transmission**

HBV (+), HCV (+)

**Source : (43)**

**Incubation period**

The average incubation period for various viruses :

| Type of virus | Incubation period (IP) |
|---|---|
| HAV | 15 to 45 days; usually 25 to 30 days |
| HBV | 45 to 180 days; usually less than 100 |
| HCV | 8 weeks (Approx) |
| HDV | Co-infection with HBV |
| HEV | 2 to 9 weeks |

Many persons may be carriers without having experienced a clinically recognized attack.

**Prevention and control**

HAV (& HEV)

As almost all HAV infections are spread by the faecal - oral route, good personal hygiene, high quality standards for public water supplies and proper disposal of sanitary waste are the mainstay of prevention and control of infective hepatitis.

(a) The patient should be admitted to hospital. He can be kept in sub-acute medical ward provided flies do not get access to faeces, urine and sputum ;

(b) Concurrent and terminal disinfection as for any other excremental diseases should be ensured;

(c) Notification of the disease is essential ;

(d) Attendants should take all precautions;

(e) Immunisation

(i) **Passive Immunisation :** Contacts may be given normal human immunoglobulin (16 % solution) at 0.02 to 0.12 ml per kg of body weight intramuscularly as soon as possible after exposure to prevent or attenuate clinical illness.

(ii) **Active Immunization** : Several inactivated or live attenuated vaccines or a combination vaccines containing inactivated hepatitis A are licensed but not in use in the Armed Forces as of now.

(f) Water supply should be safeguarded against faecal contamination. Even superchlorination may not kill the virus, unless water is very efficiently chlorinated and a half an hour contact period is ensured. Water should be preferably boiled during an outbreak. For small bodies of troops or on individual basis, especially during ops and similar situations, use of out fit water sterilizing must be ensured.

(g) Sanitation should be kept at a very high level. Methods of proper disposal of human wastes and strict anti-fly measures should be reinforced.

(h) Personal hygiene must be maintained at an extremely high level. All ranks must be persuaded to wash their hands with soap and water after defaecation and before handling or consuming food, particularly so in case of cooks and food handlers.

HBV (& HCV & HDV)

Preventive measures for HBV infection include the following :

(a) Immunization

(i) **The plasma derived vaccine** : It is a formalin inactivated sub-unit viral vaccine for intramuscular injection. It is given in 3 doses of 1 ml each at 0, 1 & 6 months. It gives 95 percent protection up to 3-5 year after which booster doses may be given.

(ii) **The RDNA :** Yeast derived vaccine is as effective in protection but more cost effective than the above vaccine. The schedule is 0, 1 & 6 months. Protection is up to 15 year and based on current scientific evidence, life long (44).

(b) Needles and syringes used for routine immunization must be autoclaved for twenty minutes or boiled for 30 min.

(c) It is mandatory that all blood donors and blood products be screened for HBV and HCV infection and those found positive should be rejected. Voluntary blood donation should be encouraged because purchased blood has shown a higher risk of post-transfusion hepatitis.

(d) Carriers should be told

(i) Should not share razors or tooth brushes

(ii) Use barrier methods of contraception

(iii) Should not donate blood.

## Poliomyelitis

### Definition

Poliomyelitis (polio) is a highly infectious disease caused by a virus which invades the nervous system, and can cause total paralysis in a matter of hours. The disease is characterized by fever, fatigue, headache, vomiting, stiffness in the neck and pain in the limbs which may be followed by irreversible paralysis (usually in the legs) in one in 200 cases.

### Problem statement

In the pre-vaccination era, poliomyelitis was found in all countries of the world. In 1988, the forty-first World Health Assembly adopted a resolution for the worldwide eradication of polio. Four agencies i. e. World Health Organization, Rotary International, the United Nations Children's Fund (UNICEF) and the United States Centers for Disease Control and Prevention (CDC) formed the core of the "polio partnership" (45). Overall, in the 17 years since the Global Polio Eradication Initiative was launched, the number of cases has fallen by over 99%, from an estimated more than 350 000 cases in 1988 to 1951 reported cases in 2005. In 2006, only four countries in the world i. e. Nigeria, India, Pakistan and Afghanistan, remain polio-endemic, down from more than 125 in 1988. Despite these achievements, the Global Polio Eradication Initiative faces an increase in global cases in 2006, due to an ongoing outbreak in northern Nigeria, and a new outbreak in western Uttar Pradesh, India (46). Uttar Pradesh State in western India remains one of the world's hotbeds of poliomyelitis. Nearly all of the 297 reported cases in India during 2006 were in Uttar Pradesh (India had 66 cases in 2005) (47).

### Prevalence

In developing countries such as India where the polio endemicity is stable, virtually all cases of polio have an onset before the fifth year of life. The most accurate technique to measure the prevalence of polio in a community therefore is a house to house survey of lameness and muscle wasting due to polio in children aged 5-10 years. Alternatively, surveys of school children may be taken up, less accurate though they may be. It has been found that surveys based on identifying lameness of the leg as a sole criterion for diagnosis of paralytic polio will identify about 80 per cent of cases. The total prevalence of residual paralysis due to poliomyelitis could be estimated by multiplying the prevalence of lameness due to polio by 1.25 and reported as cases per 1,000, usually in children older than 5 years. This prevalence rate represents the sum of all cases, almost all of which occurred from 0-4 years of age.

### Incidence

The prevalence rate of residual paralysis can be used to estimate annual incidence of paralytic cases. For example, if a prevalence rate of 10 cases per 1,000 is found in a cohort of children 5-10 years of age, correction for those

cases not involving the lower extremities is done by multiplying the prevalence rate by 1.25 which gives a prevalence rate of 12.5 per 1,000. This can be translated into average annual incidence by dividing the prevalence rate (12. 5) by the number of years at risk (i. e. five), giving an average annual incidence of 2. 5 per 1, 000 in the age

| | | |
|---|---|---|
| Annual incidence per 1000 in total population | = | Annual incidence in the age group 0-4 years **X** Distribution of 0-4 year age group in general population |

group 0-4 years.

If the 0-4 year population is known (usually 20%) the annual incidence of polio for the whole population can be determined as follows :

Continuing the above example, if the 0-4 year-old population makes up 20 per cent of the population, the annual incidence is 2.5 x 0.2 = 0.5 per 1,000 population or 50 per 100,000 population. An estimate of all cases of paralytic poliomyelitis can be made by multiplying annual incidence by 1.33 to correct for those cases that completely recovered or died after onset of disease (48).

### Epidemiological determinants

Agent factors

**(a) Agent**

The causal organism is a filterable neurotropic virus with three immunological types - Polio virus types 1, 2 and 3. All types can cause paralysis but type 1 has been most commonly involved. Polio viruses are resistant to freezing and drying. They are easily killed by heat at 55ºC for 30 min, potassium permanganate, ultraviolet rays and chlorine. In a cold environment, it can live in water for 4 months and in faeces for 6 months. It is therefore well adapted for the faeco-oral route of transmission.

**(b) Reservoir**

Man is the only reservoir. Persons with inapparent infection, especially children constitute the main reservoir. It is estimated that for every clinical case there may be 1000 subclinical cases in children and 75 in adults.

**(c) Source of Infection**

Persons with inapparent infection, in early clinical period; generally prior to paralysis, serve to keep infection going in a community through their faeces or pharyngeal secretions. However the silver lining is that there are no chronic carriers.

Host factors

**(a) Age**

Poliomyelitis is essentially a disease of childhood. Adults are usually spared because of acquired immunity. In India 50% of polio cases occur during infancy. The most vulnerable age is 6 months to 3 years.

**(b) Sex**

Male sex stands at a disadvantage - being affected 3 times more often than females.

**(c) Risk factors**

Certain factors which precipitate attack of paralytic polio have been identified. These include fatigue, trauma, intramuscular injections and operative procedures such as tonsillectomy especially during a polio epidemic.

**(d) Immunity**

Immunity following infection is fairly solid. However re-infection can occur with a different serotype as infection with one serotype does not protect completely against the other two types of viruses.

### Environmental factors

Polio spreads particularly in large and densely packed populations with poor sanitation and less than optimum routine immunization. The disease is more likely to occur during rainy season. The environmental sources of infection include contaminated water, food and flies.

### Mode of Transmission

Poliomyelitis (polio) is a highly infectious viral disease, which mainly affects young children. The common mode of disease transmission is faeco - oral. The virus is transmitted through contaminated food and water, and multiplies in the intestine, from where it can invade the nervous system. Many infected people have no symptoms, but do excrete the virus in their faeces, hence transmitting infection to others. Mouth to mouth spread by droplets can also occur.

### Incubation period

Usually 7 to 14 days, though it can range from 3 days to 35 days.

### Clinical features

Clinical features of the disease varies from inapparant or sub-clinical infection to paralytic poliomyelitis. Initial symptoms are fever, fatigue, headache, vomiting, stiffness in the neck and pain in the limbs. One in 200 infections leads to irreversible paralysis (usually in the legs). Among those paralyzed, 5%-10% die when their breathing muscles become immobilized.

Affection of the central nervous system is more a rarity than a rule, but such cases are more obvious than the non-paralytic cases and also cause socio-economic hardships later. This makes the disease more recognizable by its nervous involvement. The anterior horns in the spinal cord and motor neurons of cranial nerves are affected in such cases, resulting in a lower motor neuron type of flaccid muscular paralysis mainly in the limbs and specially the lower limbs. The case fatality rate in paralytic cases is 2 to 3 per cent and in the bulbar type it is 5 to 6 per cent. The paralysis starts with varying degrees, initially more extensive but gradually reducing down to a lesser residual paralysis. Patients with paralysis represent a small minority of clinical cases.

### Prevention

(a) A high standard of hygiene and sanitation should be maintained with arrangements for proper disposal of faeces, safe water supply and proper food hygiene.

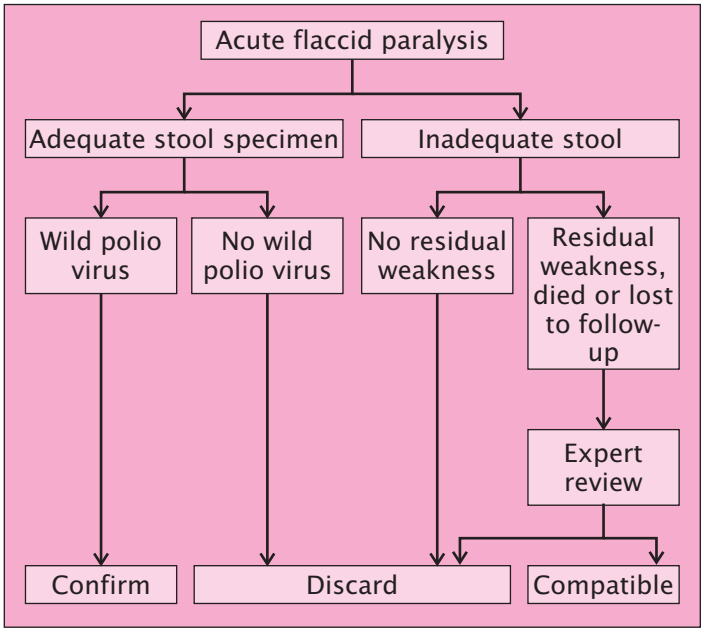
(b) Active immunization of all infants / children should be carried out with oral polio vaccine. The Armed Forces have joined the nation in the attempt to eradicate polio from the country. They are active participants of the Pulse Polio Immunization Programme.

**Acute Flaccid Paralysis (AFP) surveillance**

Polio confirmed and Polio compatible cases : Poliomyelitis cases are confirmed only when poliovirus is identified in the stools of a patient with acute flaccid paralysis (AFP). However, it is impossible to collect stool samples from all such patients, which satisfy the stringent conditions to be labelled as adequate. When an AFP patient without an adequate stool sample has residual paralysis beyond 60 days from the date of onset, detailed clinical, laboratory, and epidemiological investigations are done, and the evidence is submitted to the National Expert Review Committee. The committee sifts through the available evidence and diagnoses any poliomyelitis cases; these are classified as "polio-compatible" cases (49).

While dealing with polio eradication, we are interested in polio confirmed cases rather than polio compatible cases. Hence there is a need to reduce the number of compatible cases. Since AFP surveillance is an important strategy to eradicate polio, surveillance quality will affect the eradication process. India has made great progress towards polio eradication and the National Polio

Virological classification scheme Source : (50)



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Col MS Bishnoi

# Helminthiasis

## Definition

Traditionally helminthic infections include infections by diverse group of worms such as filarial worms. schistosomes, trematodes, in addition to cestodes and nematodes. This section deals with the later two, being important public health problems in our country. All over the globe, particularly in developing countries, Helminthic infections lead to considerable morbidity, suffering, reduction in work efficiency and economic loss.

The prevalence in the Armed Forces follows that in the civil population. Recruits hailing from high endemic areas may be about 80 to 100 per cent infested. As a result of treatment and comparative freedom from re-infection these rates naturally fall very considerably after enrolment. Some personnel are however re-infested when they spend their leave in their homes in rural areas. Helminthiasis in the past accounted for 4-6 per cent of total morbidity in the Armed Forces of which Round worm and Hook worm formed the major portion of helminthiasis about 80 per cent. However the overall incidence is far reduced now and is (per 1000 troops) 0. 03 for Army, 0. 02 for Navy and 0. 02 for Air Force in 2006.

## Classification

Helminths can be classified into Phylum Nemathelminthes, Class Nematoda or round worms and Platyhelminthes, Class Cestoda or tape worms and Class Trematoda or flukes. They can be grouped according to their mode of transmission such as soil (Geo), food and animal borne. In this chapter only those helminths which are of importance in the Armed Forces in India are described (Table - 1).

### Geo Helminths

These are intestinal nematodes, part of the development of which takes place outside the body – in the soil. These nematodes are usually found as multiple infections. Without soil life they cannot become infective. They may be divided into three types according to their life cycle.

#### Type 1 : Direct

Embryonated eggs are passed; they hatch and reinfect within 2-3 hours by being carried from the anal margin to the mouth and either do not reach the soil or, if they do, do not require a period of development there. This group includes *Enterobius vermicularis* (thread worm)and

Table - 1 : Classification of Helminths

| | Nematodes | Cestodes | Trematodes |
|---|---|---|---|
| Geo-helminths<br>(Soil trasmitted)<br>(a)Direct<br>(b)Modified direct<br>(c) Penetration of the skin | *Enterobius Vermicularis*<br>*Trichuris trichiura*<br>*Ascaris lumbricoides*<br>*Toxocara canis*<br>*Ancylostoma duodenale*<br>*Necator americanus*<br>*Strongyloides stercoralis* | | |
| Contagious (Faecal borne) | *Enterobius vermicularis* | *Taenia, Echinococcus*<br>*Hymenolepis nana* | |
| Arthropod transmitted | *W. bancrofti, B. malayi,*<br>*Onchocerca volvulus* | | |
| Snail & Cyclops transmitted | *Dracunculus medinensis* | | *Schistosoma haematobium*<br>*Schistosoma japonicum*<br>*Schistosoma mansoni*<br>*Fasciola hepatica*<br>*Fasciolopsis buski*<br>*Paragonimus westermani*<br>*Clonorchis sinensis* |
| Food & animal transmitted | *Trichinella spiralis* | *Taenia solium, Taenia saginata,*<br>*Diphyllobothrium latum* | |

*Trichuris trichiura.*

**Type 2 : Modified direct**

Eggs are passed out in the stool and undergo a period of development in the soil before being ingested, where they hatch, releasing larvae which penetrate the mucous membrane of the stomach and enter the circulation to reach the lungs, passing up the respiratory tract to enter the oesophagus, reaching the intestine where they become adult. These include *Ascaris lumbricoides* (roundworm) and *Toxocara canis.*

**Type 3 : Penetration of the skin**

In this group eggs are passed in the stools to the soil, where they hatch into larvae which undergo further development before they are ready to penetrate the skin and reach the circulation and lungs, which they penetrate to enter the respiratory tract; they move up to enter the oesophagus and reach the small intestine, where they become adult. *Ankylostoma* (hookworm) and *Strongyloides stercoralis* belong to this group. *Strongyloides*, however, differ in that larvae are passed in the stool and auto infection can occur at the anal margin, or independent development takes place in soil, where the can exist in the absence of any further cycle through man.

**TYPE 1 : Direct**

## Enterobiasis (Threadworm, Pinworm, Oxyuriasis)

Distribution : Worm is distributed worldwide.

### Aetiology

The adult worms are small and white with the skin transversely striated. The female (9-12mm) has a long, pointed tail and a slit like vulva in the anterior quarter of the body. The male which is much smaller (2. 5mm) has a posteriorly curved third and a blunt caudal extremity. The egg has a characteristic shape, flattened on one side. It is almost colourless, with a bean-shaped double contour shell containing a fully formed embryo.

### Life cycle

There is no multiplication inside the body of the human host. The mature female has a life duration of 35 to 90 days and when the ovary is full of eggs she migrates down to the anus, from which she emerges to lay the eggs on the peri-anal skin and on the perineum. The eggs, which are ingested in the faecal material lodged under the finger nails, hatch in the stomach and larvae emerge which rapidly pass along the intestine to caecum and appendix, where they mature. The whole cycle takes 2-4 weeks.

### Transmission

There are four possible methods of transmission. The most common is by direct transmission from peri-anal region to the mouth by contaminated finger nails or soiled night clothes. A second way is by exposure to viable eggs on objects in the environment. A third way is via the mouth or nose from contaminated dust. The fourth way is by retro-infection in which eggs hatch on the anal mucosa and larvae migrate up the bowel. Ectopic lesions have occasionally been found in the female genital organs, abdominal cavity and even ear & nose.

### Symptoms and Signs

Pruritis ani is the main symptom, varying from mild itch to severe pain, which mainly occurs at night. General symptoms are insomnia and restlessness, and a number of children have loss of appetite, weight-loss, irritability and enuresis. There is usually no eosinophilia or anemia.

### Diagnosis

The diagnosis is made by finding the characteristic eggs in the faeces (5% only), peri-anal scraping with Scotch tape or by finding the adult worms around the anus, usually at night.

### Prevention and Control

The whole must be treated to avoid re-infection. Chemotherapy must be combined with education, and personal hygiene aimed at preventing auto-infection. Although it is simple to effect a temporary cure, eradication may be difficult because of re-infection from the contaminated environment or from asymptomatic members of the household. During treatment the child must sleep in clean clothes and gloves. The finger nails must be cut short and scrubbed.

## Trichuriasis (Whipworm)

### Distribution

*Trichuris trichiura* occurs worldwide. The annual global mortality is estimated to be around 60 000.

### Aetiology

*Trichuris trichiura* is a greyish-white worm, often slightly pink, which lives in the caecum and the appendix. The male (30-45mm long) has an attenuated anterior portion which is half as long as the thicker posterior portion. The caudal extremity is curved through 360 degrees with a single spicule in the sheath which is studded with spines. The female (30-35 mm long) has the posterior half occupied by a stout uterus packed with eggs. The egg is brown with a characteristic barrel shape with a plug at each end; it contains a single embryo.

### Life cycle

The worms live in the caecum, embedded in the mucus between the intestinal villi. The egg is laid unsegmented, and embryonation takes at least 21 days. It can withstand low temperatures but not desiccation. Infection is direct from stale faeces. The egg hatches after being swallowed in the intestine, where the shell is digested by intestinal juices and the larva emerges in the small intestine. It penetrates the villi and develops for a week until it re-emerges and passes to the caecum and colo-rectum, where it attaches itself to the mucosa and becomes adult.

### Transmission

Transmission is direct from mature eggs to the mouth via fingers contaminated from infected soil.

### Symptoms and signs

The prepatent period from ingestion of eggs to appearance of eggs in the stool is 60 days. In light infections, there are no symptoms. Epigastric pain, vomiting, distension, flatulence, anorexia and weight loss may occur. Pain in epigastrium and iliac fossa is common. Co- infection with *E hystolitica, E coli* or *Shigella* causes

aggravated symptoms of dysentery. Anemia is seen when associated with amoebic infection. Eosinophilia, if present, denotes concurrent *Toxocara* infection. In severe infantile trichuriasis digital clubbing, hypo-protonaemia and growth retardation may be seen.

Diagnosis

The diagnosis is made by finding the characteristic eggs in the stool by direct smear or by concentration method. Proctoscopy in cases of dysentery will show numerous worms attached to the mucosa.

Prevention and control

Trichuris is common in areas of high rainfall, high humidity, dense shade and poor sanitation and contaminated soil. *T trichiura* is primary a human infection but *T suis* is indistinguishable and thus an increased incidence is seen in people handling pigs. The greatest prevalence is in children of primary school age who pollute the soil around the house and develop heavy worm burden. Avoidance of soil pollution is the key to control which can be combined with mass chemotherapy. Susceptibility to albendazole may vary in different regions and it is prudent to evaluate sensitivity when planning mass chemotherapy.

**Type 2 : Modified direct**

## Ascariasis (Roundworms)

Distribution

It is one of the most widespread human infections. Distribution is world wide. Infestation is most common in moist, hot tropical countries, where hygienic disposal of faeces is inadequate, and the soil is of clay type. The infestation is very heavy in rural India and in insanitary urbanised areas. Permanent habitat of the adult worm is the small intestine of man. No natural or induced immunity exists.

The high atmospheric and terrestrial moisture and temperature favour development of the infective stage of the eggs. Children are more frequently and more heavily infected than adults. This is more likely to occur in those localities where defaecation and faecal contamination occur indiscriminately near the dwellings.

Aetiology

Adult worms are 25-40 cm in length. When freshly passed they are light brown or pink in colour. They are cylindrical in shape tapering at both ends; the anterior end is thinner than the posterior. The sexes are separate. The male is smaller in size and coiled posteriorly. The life span of the adult worm in the human host is from 6 months to a year.

Life cycle (Fig - 1)

Permanent habitat of the adult worm is the small intestine of man. Fertilized egg is round or oval, mammillated, bile stained and brownish in colour, 60-75 microns in length by 40-50 microns in breadth. It contains a large conspicuous unsegmented ovum and floats in a saturated solution of common salt. The female is capable of liberating eggs even if not fertilized. Unfertilized egg is narrower and more elliptical in shape with thinner shell containing a small atrophied ovum and does not float in salt solution. Fertilisation takes place in small intestine and are passed out as immature ova. . Embryo develops in the damp soil in2-4 months (at the optimum of 25 degrees C in 3 weeks). It remains coiled up in the egg and undergoes one moult before being hatched as the infective second stage rhabditiform larva in the small intestine when the egg is swallowed. Here the rhabditiform larva penetrates the mucous membrane and enters the blood stream, reaching the lungs via the right heart. As it can not pass through the lung capillaries, it burrows through the alveolar wall to enter the respiratory tract. From here it is carried up the trachea to the larynx, where it moves over the epiglottis and enters the oesophagus, and is swallowed a second time to reach the small intestine. The whole process takes 10 – 14 days, during which time the larva again moults twice. In man the period from infection to the first passage of ova in the stool (prepatent period) is 60 – 70 days.

Transmission

Reservoir is an infested person discharging eggs in and about houses where facilities for proper faecal disposal are lacking. The adhesive nature of the egg probably results in gradual contamination of most of the objects in houses and public places as well as food, particularly vegetables grown in soil where faeces are used as manure.

Clinical Features

**(a) Larval Phase (Larval Ascariasis)**

Clinical manifestations may first appear in relation to pulmonary migration of the larvae. They range from a mild dry cough to severe dyspnoea, cyanosis, whooping type of cough and haemoptysis. There may be urticarial rashes, eosinophilia, asthmatic attacks and mottled lung infiltration noticed in chest radiograph. This syndrome is called Loeffler's syndrome which may turn out to be fatal. The nature and severity of symptoms depend upon the number of invading organisms and on the degree of the sensitivity of the host. Eosinophilia is quite a common feature at this stage and also later.

**(b) Adult stage (Intestinal Ascariasis)**

Presence of a large number of worms in the intestine increases the abdominal contour producing a protuberant abdomen and lumbar lordosis. They rob the host of his nutrition and give rise to colicky pain. They may produce appendicular, biliary and intestinal obstruction. They may migrate into the peritoneal cavity through a perforated intestinal ulcer.

Diagnosis

Stool examination for evidence of eggs is the commonest laboratory method. The presence of worms can be demonstrated by radiography with a barium meal, which on being ingested by the worm within 4-6 hours, casts an opaque shadow. The confirmation of diagnosis is by finding the adult worm in stool or vomit with or without an antihelminthic administration.

Prevention and Control

**(a) Primary Prevention**

Methods based on primary prevention are the most effective in interrupting transmission. Health education

on these aspects, taking into consideration the life cycle of the parasite and the peculiar ecological, social and cultural circumstances that prevail in a community are the ultimate keys to the control of ascariasis. These are :

(i) Sanitary disposal of human excreta to prevent or reduce faecal contamination of the soil. Mothers should be educated regarding dangers of indiscriminate defaecation by children. Open air defaecation in general, should be prohibited. On the other hand effective and acceptable sanitary facilities should be provided.

(ii) Safe drinking water from a safe source, after proper treatment including filtration should be provided. Water hygiene discipline in homes should be strictly followed where again, education of mothers is important.

(iii) Food hygiene by way of thorough washing of vegetables to be consumed should be insisted upon.

(iv) Personal hygiene- viz washing hands before taking any meal and after ablution should be practiced, biting of nails or sucking of thumb/fingers should not be practiced.

**(b) Secondary Prevention**

The safe and effective ascaricides such as mebendazole, pyrantel and Levamisole are available. Early diagnosis and treatment are important tools in prevention and control of transmission in low endemic areas. Even in hyper endemic areas they form a part of mass treatment and thereby a useful and important option. However mass treatment will not interrupt transmission of the disease but merely reduce the worm load.

### Toxocariasis (Dog roundworm)

#### Distribution

*Toxocara* canis infection in dogs is worldwide. Its manifestations in humans such as *Visceral* larva migrans and ocular toxocariasis also have been detected in Americas, Africa and Europe.

#### Aetiology

*T canis* has morphology like that of *A lumbricoides* though its eggs are larger with superficial pitting.

#### Life cycle

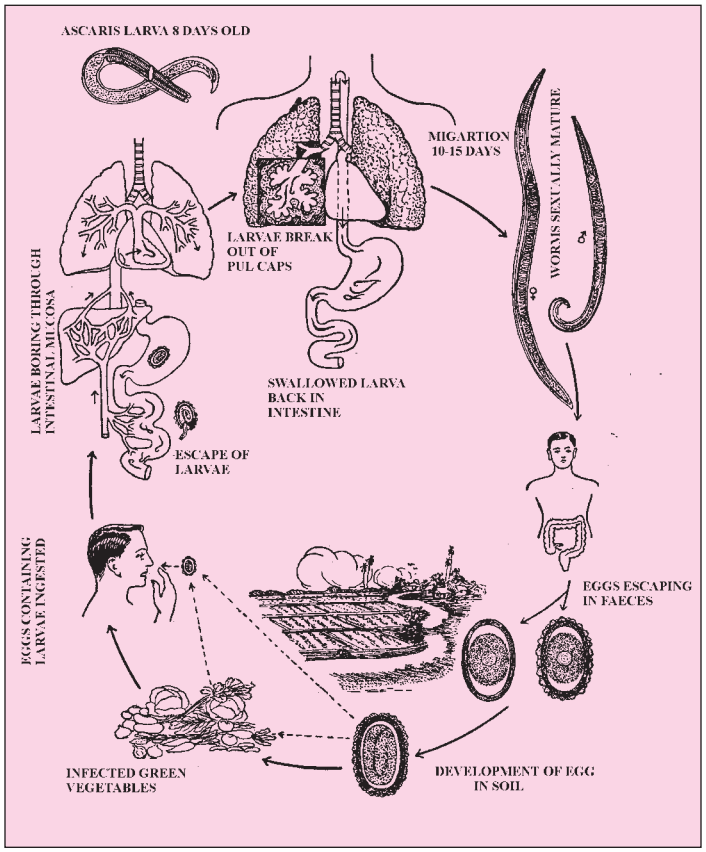
In the dog the life cycle is similar to of *Ascaris* in man except that transplacental infection of puppies takes place and the whole cycle may be maintained in a small flat without any access to the outside.

In man, who is not the normal host, the eggs hatch in the stomach and the second stage larvae penetrate the mucosa to enter mesenteric vessels, reaching viscera and liver where they are held up in the capillaries but may pass to lungs and brain through general circulation. There they are destroyed by granulomatous reaction. The larvae do not grow or moult in man but can remain alive for up to 10 years.

#### Transmission

The main source of infection is puppies, which excrete

Fig - 1 : Life cycle of ascaris lumbricoides.




large number of eggs. Infection is acquired from contaminated soil, Direct infection from handling puppies is not considered a risk because embryonation of excreted *Toxocara* ova requires a minimum of 2 weeks.

#### Clinical Features

Unless the infection is heavy and the VLM syndrome is produced, most cases remain asymptomatic. VLM can be self-limiting or cause death. Lesions in the eye can produce loss of vision where it may closely resemble retinoblastoma.

#### Diagnosis

Serology of IgG, IgH and anti-A isohaemagglutinin are consistent laboratory findings.

#### Prevention and control

Control rests upon control of infection in dogs. Regular treatment of dogs, bitches as well as puppies with anthelmintics is essential when there are children in house as the mean age of infection is 2 to 5 years. Dogs should be denied access to children's play areas.

**Type 3 : Penetration of the Skin**

### Ankylostomiasis (Hookworm disease)

#### Introduction

Hookworm is caused by two hookworms *Ankylostoma duodenale*, the old world hookworm and the very closely allied species *Necator americanus*, the new world hook worm. The intestinal infestation is commonly termed

'ankylostomiasis' and the clinical syndrome of anemia is usually called the 'hook worm disease'.

### Geographical Distribution

It is widely distributed in all the tropical and subtropical countries where hygienic disposal of faeces is inadequate, the soil is loamy and moisture retaining, high moisture and temperature favouring development of infective larvae. The geographical distribution lies in the tropical and subtropical zones between 45° N and 30° S (15). *Ancylostoma duodenale* is widespread throughout India, but the really heavy infestation is in the sub Himalayan division of Northern India from Uttar Pradesh to Assam (tea gardens), Prevalence is low in the drier parts of Rajasthan and Gujrat. In the southern and eastern parts of India, *Necator americanus* is predominant. In other parts a mixture of both exists.

### Endemicity Index

Morbidity & mortality due to this worm depends much on the worm load. Chandler's Index is still used in epidemiological studies to assess worm load and also the effect of mass treatment in different populations.

### Aetiology

The adult worm is cylindrical, greyish white and about one cm long. The anterior end of the worm is bent slightly to form a hook. In *A. duodenale* the buccal capsule is provided with six cutting teeth; four hook like triangular plates on the ventral surface and two knob-like on the dorsal surface. *Necator americanus* has got four chitinous plates instead of six cutting teeth, two on the ventral surface and two on the dorsal surface; hence they are less

Assessment of worm load

| Average number of eggs per gram of stools | |
|---|---|
| Below 200 | Hookworm is not of much significance |
| 200-250 | May be regarded as potential danger |
| 250. 300 | Minor public health problem |

invasive and less effective blood suckers. Sexes are separate. The male is smaller and its posterior end is expanded in an umbrella fashioned copulatory bursa, whereas in the female it is tapering. The eggs are colourless (not bile stained) with a thin egg-shell containing segmented ovum usually with four blastomeres and a clear space between the egg shell and the ovum.

### Life cycle (Fig - 2)

The eggs with fertilized ovum are passed in the faeces of the human host into the soil. From each egg a rhabditiform larva (250 microns) hatches out in the soil. It moults twice and develops into filariform larva (500 microns-600 microns) which is the infective stage of the parasite. The time taken for development from egg to filariform larva is on an average 8-10 days. The optimum temperature required for development is between 28ºC to 32ºC for *N. americans* and 5ºC to 8ºC lower than that for the A. *duodenale.* Direct dessication kills larva quickly; hence moisture, is essential for its survival. This is usually supplied to the soil by frequent light showers of rain. Sandy or loamy soil is most suitable for hookworm larvae but not clay. Under favourable condition these larvae can remain infective for two months. Gaining entrance into a new human host through the bare skin, the infective filariform larvae cast off their sheaths and penetrate the skin deeper. Farming practices in which raw manure infested with larvae is used and when hands have to be used for harrowing the earth as in potato farming carry the risk. The custom of walking barefoot in the polluted fields and in deep mining, where defaecation is indiscriminate also carries risk of infection. *Ancylostoma* may at times, utilize the oral source of entry. On reaching the subcutaneous tissue, the larvae enter the venous circulation and then via the right heart into the pulmonary capillaries, breaking through the capillary wall and entering into the alveolar spaces. They then migrate upto the bronchi, trachea, larynx and crawl over the epiglottis to the pharynx and they are ultimately swallowed. During migration a third moulting takes place and a buccal capsule is formed. It takes about 10 days for migration from skin to the small intestine. The growing larvae settle down in the small intestine, undergo a fourth moulting and develop into adolescent worms. In 3-4 weeks time they are sexually matured and the fertilized females begin to lay eggs. The adult worm anchors to the mucousa of the small intestine particularly the jejunum, less often of the duodenum, and sucks blood. Eggs are passed in the faeces. The cycle is then repeated. The interval between the time of skin penetration and the first appearance of eggs in the faeces is about six weeks.

### Transmission

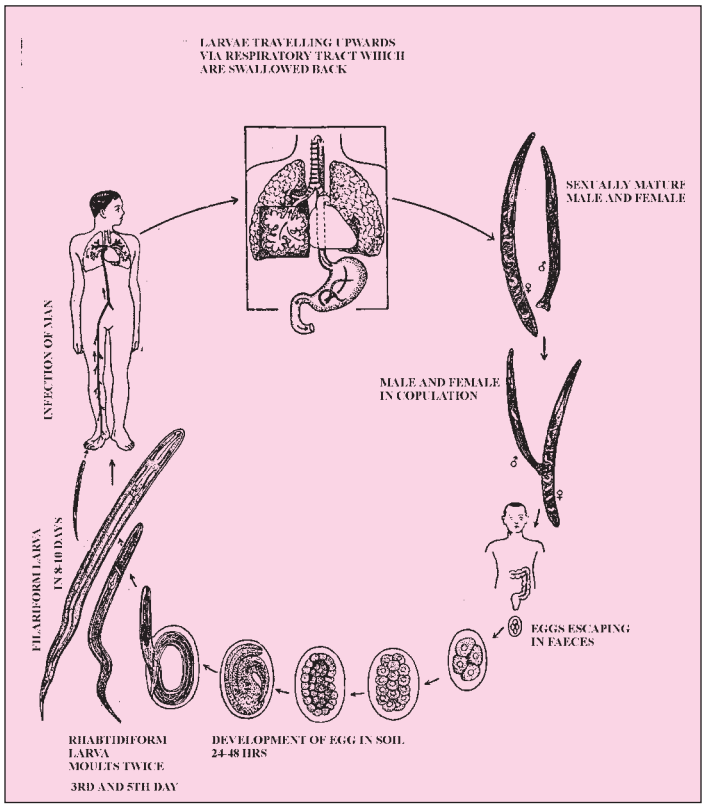
Infection is normally acquired via the skin from filariform larvae in the soil contaminated by human faeces; or orally via the ingestion of contaminated food.

### Clinical Features

The interval between the time of skin penetration and the first appearance of eggs in the faeces is about six weeks. At the site of entry of infective larvae there is a 'ground itch', which consists of an irritating vesicular rash on exposed portions of body like hands or feet. Symptoms may take a few weeks, months or even years to appear, depending upon the intensity of infection, state of nutrition and general condition of the host, or may not appear at all. However, they remain potential source of infection as long as they are infected and continue to pollute the soil. The average daily blood loss for *A duodenale* is about 0. 15 to 0. 2 ml while for *N americanus* it is 0. 03 ml per worm. With a worm load of 500-1000significant blood loss and anemia will result, even in the presence of adequate iron intake.

In some patients taste may be perverted with some of them exhibiting an unnatural craving for such things as mud or lime (pica or geophagy). In children features include *diarrhea*, melaena, vomiting and massive

Fig - 2 : Life cycle ***A duodenale***




haemorrhage. The mortality is up to 12%.

More frequently the disease is chronic, ebbing and flowing, slowly progressing over a number of years.

Diagnosis

Occult blood is always present in stools. Diagnosis of ancylostomiasis is made by stool examination for ova or adult forms. The 'hook worm disease' is assessed by taking a complete haemogram which shows anemia of iron deficiency. Intradermal test using antigen prepared from adult worms may sometimes be used for epidemiological surveys. In the laboratory the faeces is examined for the ova by the following methods :

**(a) Direct Method**

After making a saline suspension on a glass slide and covering the suspension with a cover slip.

**(b) Concentration Method**

A moderately dense suspension of faeces is made in a small bottle with a wide mouth, such as an empty penicillin vial, using saturated solution of common salt. The bottle is then filled to the brim with a salt solution. A microscope slide is put carefully on the top of the bottle, so that the fluid is in contact with the slide. It is left undisturbed for 20 min. Then the slide is removed vertically up and turned upside down, so that adherent fluid is upper most. A cover slip is put and examined.

Eggs float in saturated solution of common salt. It is oval or elliptical in shape, measuring 65 microns in length by 45 microns in breadth.

Reservoir and Source of Infection

Reservoir is an infested person discharging eggs in the faeces. The usual immediate source of infection is soil contaminated with infective larvae.

Prevention and control

The sheet anchor is to prevent contamination of soil. To prevent development of the infective stage of the parasite or exposure to it, the following measures should be adopted :

**(a) Sanitary Measures**

Provision of proper latrines, proper disposal of faeces and prohibition of indiscriminate defecation are the trio of first importance. Shallow trench latrines are dangerous; deep trench latrines and bore hole latrines are better; trenching of stool is inferior to composting; septic tank or sewage disposal plants are the best disposal systems.

**(b) Health Education**

It is very important because the provision of latrine is one thing and its use is another thing. Farmers should be educated not to walk bare footed and to wear sandals in the neighbourhood of latrines and not to use human manure before two months of its maturation.

**(c) Mass Deworming**

Several effective drugs viz Albendazole, Mebendazole, Levamisole & Pyrantel are available for treatment. Mass treatment should be carried out with caution as there are toxic side effects. Further, treatment of anaemia is important in individual cases of hookworm disease.

## Food and animal-transmitted Helminths

In these helminths the infective stage develops in animals whose flesh is an important item of food for man. They are the cestodes-- *Taenia saginata* (beef tape worm), *Taenia solium* (pork tapeworm), *Diphyllobothrium latum* (fish tapeworm); and a nematode -- *Trichinella spiralis*.

## Taenia saginata and Taenia solium (Taeniasis)

*T. solium* is the pork tape worm, the 'armed ' tape worm of man and *T. saginata* is the beef tape worm, the 'unarmed' tape worm of man. Adults of both tapeworms infest the small intestines of man and this infestation is commonly termed "Taeniasis". The larval stages infect the porcine and bovine muscles; the larva of *T. solium* (Cysticercus cellulosae) may infect man also.

Geographical Distribution

The infection is common in countries where sanitation is poor and where these animals are allowed to graze in the neighbourhood of human habitation. *T. Saginata* infestation is prevalent among the beef eating population and *T. Solium* is common among pork eaters.

Aetiology

Adult tape worms are white, semitransparent, 5-10 m in length and consists of head(scolex) neck and segments (proglottides). Scolex in *T. saginata* measures 1-2 mm in diameter, quadrate in outline and has four lateral circular suckers but no rostellum and hooklets. The neck is thin and tapering behind the scolex. Scolex in *T. solium* is 2-3 mm long and has a short rostellum and is provided with a double row of 20 to 50 hooklets. The number of segments

varies from 1000-2000 in T. saginata and 800-900 in *T. solium.* The segments near the scolex are immature, in the middle portion they are mature showing both the sex organs and at the tail-end are seen gravid segments. The uterus in the gravid segment consists of a central longitudinal stem with lateral dichotomous branches which are 5 to 10 in *T. solium* and 15 to 30 in *T. saginata*. Eggs are liberated by the rupture of gravid proglottides. The eggs are spherical and brown due to bile stain, 30-40 microns in diameter with thick radially striated wall containing hexacanth (3 pairs of hooklets) embryo. They do not float in saturated salt solution. They may remain viable for 8 weeks. Eggs of *T. saginata* are infective to cattle only and those of *T. solium* are infective to pigs and man.

Life Cycle (Fig - 3 & Fig - 4)

Man is the sole definitive host, the adult tapeworm inhabits man's intestinal canal. The gravid segments of the worm containing eggs are passed in faeces. The cow/pig acquires infection by eating grass or drinking water which has been contaminated by human faeces. Having reached the stomach of the cow/pig the eggs release the contained larvae which pierce the gut wall and are carried via the blood stream to the muscles and other organs where they encyst. This stage is known as Cysticercus bovis (measly beef in cattle) and Cysticercus cellulosae in pigs (measly pork) . The cysts resemble small mistletoe berries. For their further development the encysted larvae must be consumed by man while they are in a viable stage and this occurs when man eats underdone beef or pork. Encysted larvae are released in man's stomach, pass into the intestine and then develop into adult tapeworms. The important difference in infestation by these two tape worms is that while for *T. saginata* man never acts an intermediary host, he may do so for *T. solium* when he swallows eggs through contaminated water or food, or by regurgitation of a gravid segment from his intestine to his stomach. The cysticerci developing in the muscles or brain give rise to various syndromes. Man may thus harbour both adult *T. solium* and its larval form. After the larvae are ingested it takes 8 to 10 weeks for the worm to develop, become sexually mature and produce eggs.

Transmission

The life cycle of these is maintained between humans, who are the only definitive host for them, and pigs for *T solium* and cattle for *T saginata*. The humans are able to harbor both the types of adult worms without much ill effect and thus act as chronic carriers. Cattle and pigs become infected by eating grass or garbage and the hexacanth embryo is librated in their intestines. The embryo penetrates the mucosa and reaches brain, muscles and other tissues. At these sites, larvae loose their hookletes, enlarge and develop into fluid filled cysts. On consumption of inadequately cooked flesh with cysticerci by man, these are digested free of muscles and protoscolex attaches itself to the intestines of man to develop into adult worm. Occasionally, in case of *T solium*,

Fig - 3 : Life cycle of **Taenia saginata**

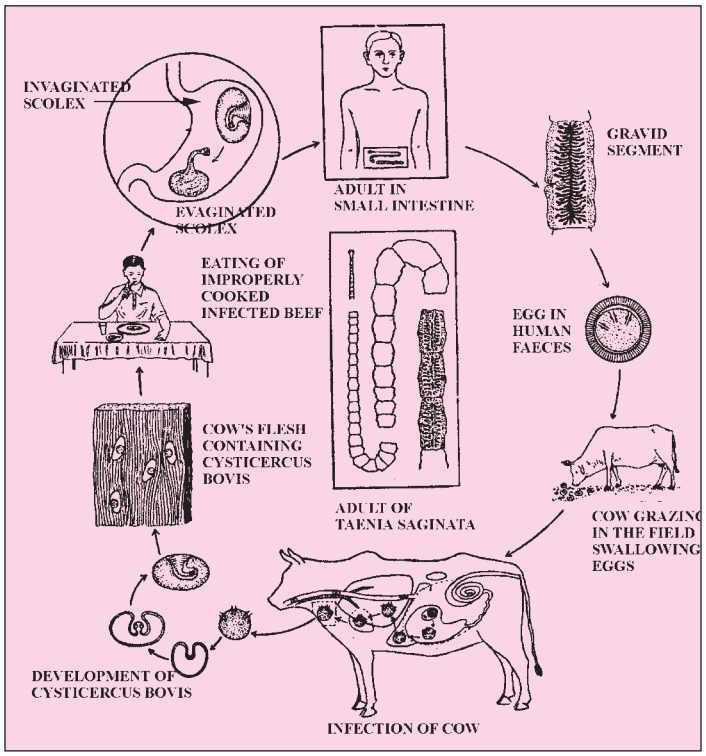
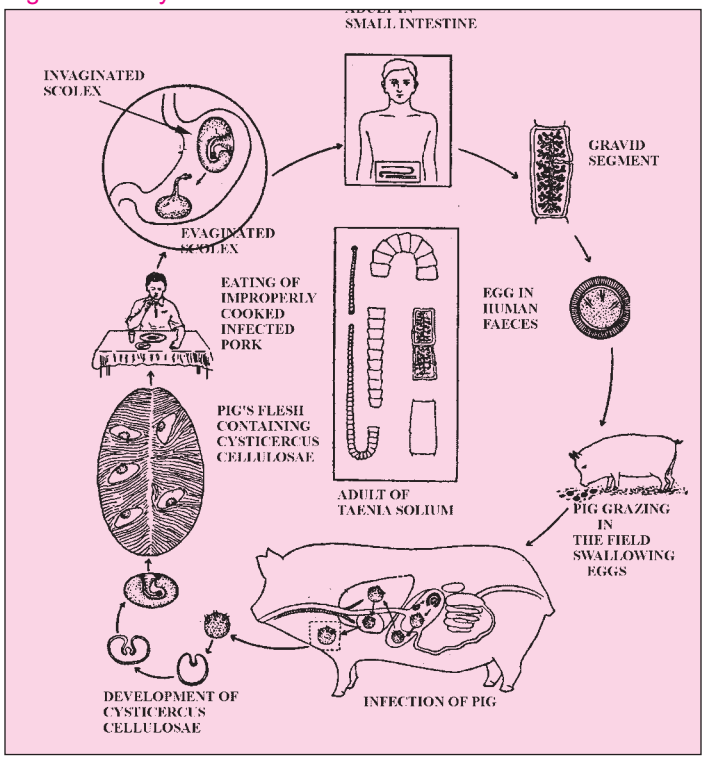



Fig - 4 : Life cycle of **Taenia solium**




man can get infected like the pig by consuming food or water contaminated with the eggs, leading to development of cystecercosis in man.

Diagnosis

Presence of gravid segments on naked eye examination of stools is an evidence of tape worm infestation. These should be collected for further microscopic examination for determining the type of worm and demonstration of eggs. The sample of faeces after antihelminthic treatment should be screened and examined for the presence of scolex to confirm cure. Cysticercus cellulosae can be diagnosed by biopsy examination and radiological examination revealing calcified cysts.

Reservoir

Reservoir is an infested person discharging eggs in faeces. Immediate source of infection is the flesh of the infested animal. Person harbouring *T. solium* can, however, become a source of infection to another person or to himself. Man remains a source of infection for 10 years or even 30 to 40 years. Susceptibility is universal and there is no acquired immunity.

Pathogenicity and Clinical Features

Adult worm living in the intestine usually does not give rise to any symptoms. It may sometimes give rise to vague abdominal discomfort, chronic indigestion, diarrhoea alternating with constipation, anaemia, anorexia, loss of weight, nervousness and insomnia. Cysticercus cellulosae may give rise to symptoms referable to the particular organ affected; thus it may produce epilepsy if the brain is the seat. While *adult T solium* infection is acquired by man by eating under-cooked pork containing cysticerci, however, human cysticercosis is a *faceo*-oral *infecton* acquired by ingestimg eggs excreted in the faeces of a human infested with adult tape worm. Individuals harbouring an adult *T solium* are at a higher risk of suffering from cysticercosis, probably through *faceo*-oral auto-infection. It has long been hypothesized that internal auto-infection might also occur as a result of reverse peristalsis, thereby allowing *Tinea solium* eggs to travel from small bowel to the stomach and these become activated and invasive; little evidence, however, has emerged to support this view.

Prevention and Control

(a) Proper animal husbandry and hygienic feeding of cattle and pigs and avoidance of eating underdone beef or pork are the most important measures for prevention and control. Adequate meat inspection and health education of the consumer supplement these measures.

(b) Proper sewage disposal, prohibition of indiscriminate defaecation, health education of the people are the long term control measures.

(c) Treatment of all cases with effective drugs like praziquantel & niclosamide, reduces the infective quantum. Praziquantel is given in the dose 10-20 mg/kg as single dose. Adult dose of niclosamide is 2 gm. Personal hygiene and hygiene of all the food handlers is important to prevent likelihood of ingestion of eggs of T. solium through auto infection and infection from others.

(d) Those harbouring the adult worms infect the cows and pigs and hence should be treated until the scolex is excreted. The patient of T. solium infestation should be isolated and treated with the same precautions as a case of enteric fever. He should be warned of the danger of auto-infestation and hence must practice scrupulous personal hygiene. Stools should preferably be destroyed by burning.

## Echinococcus granulosus

(Cystic echinococcosis, Hydatid disease)

Introduction

This is an infestation of the small intestine of a dog with a tape worm, *Echinococcus granulosus*. It constitutes a zoonosis as the larval form of the worm produces the hydatid disease in human beings as well as in sheep and cattle.

Distribution

Although the hydatid disease is world wide in distribution, it is most commonly found in those countries where sheep and cattle raising is an important industry resulting in close association between man, sheep and dog. The disease is more prevalent in the subtropics and in temperate climate than in the tropics.

Aetiology

Adult worm is 3 to 6 mm long. It has a scolex, neck and strobila consisting of 3 to 4 segments. The first segment is immature, the second one is mature and the next are gravid. The head bears four suckers and a rostellum with two circular rows of hooks. The neck is short and thick. Eggs resemble those of other taenia.

Life Cycle (Fig - 5)

In the duodenum the hexacanth embroys hatch out and they bore their way though the intestinal wall and are carried though radicals of the portal vein to the liver which acts as a first filter. Some of the embryos may pass through the hepatic capillaries, enter the pulmonary circulation and filter out in the lungs. A few of the embryos may pass the pulmonary capillaries, enter the general blood stream and invade any other organ. However, they are most commonly found in the liver and lungs. Wherever the embryo settles, it forms the hydatid cyst. From the inner layer of the cyst, 'brood capsule' with a number of scolices develops. A fully developed scolex is the sign of complete biological development of the hydatid cyst. When ingested by the definitive host, the scolices are capable of developing into adult worms in about 6 to 7 weeks time. Thus the cycle is repeated usually between dog and sheep. As the dogs have no access to the hydatid cysts developed in the viscera of man, the human infestation is a blind alley. Life span of the adult worm is a few months in contrast to the life span of the larval from which may continue to develop for many years.

Hydatid Cyst

The larval form causes hydatid cyst in man. The cyst wall consist of the ectocyst which is the outer chitinous laminated hyaline membrane about 1 mm. thick and the endocyst which is the inner germinal layer. This is a cellular vital layer of the cyst giving rise to brood capsule

with scolices and the hydatid fluid. The host reacts by forming a fibrous layer known as pericyst around the growing embryo. The parasite derives its nourishment through it. When an old cyst becomes sclerosed or calcified, the parasite within it dies due to lack of nutrition. Hydatid fluid is antigenic and highly toxic. If it is allowed to stand, the granular deposit which settles at the bottom consists of liberated brood capsule, free scolices and loose hooklets.

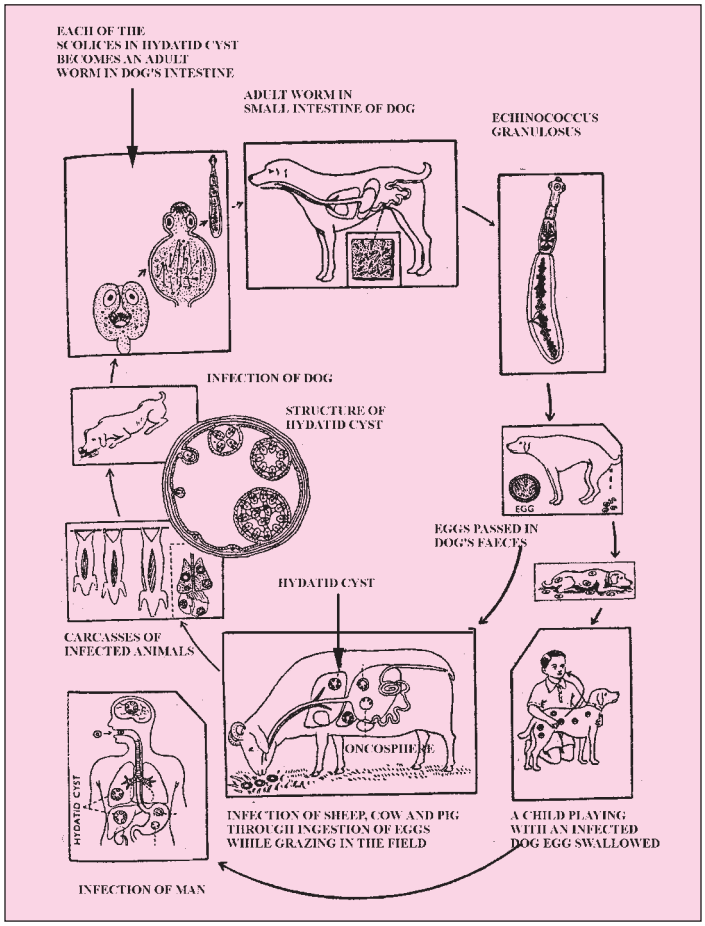
### Transmission, Reservoir and Source

The reservoirs are the carnivorous animals like dogs, wolves, jackals and foxes who are the definitive hosts harbouring the adult worm. Out of these animals, dog is the most important animal as far as the hydatid disease in man is concerned. The sheep is the most suitable intermediate host but cattle can also act as such. The eggs discharged in the faeces of these definitive hosts are swallowed by the intermediate hosts, while grazing in the field. Man gets the infestation by handling and fondling of the dogs.

### Clinical features

The condition remains asymptomatic throughout the life in majority of cases. In symptomatic cases, the clinical manifestations are highly variable and depend on the following :

Fig - 5 : Life cycle of **Echinococcus granulosus, E. multilocularis**




(a) Organ involved

(b) Size of the cyst

(c) Interaction between the expanding cyst and surrounding organ

(d) Complications caused by the rupture of cysts.

The cysts located in vital organs interfere with the functions of the organ and may cause fatality in certain cases.

Occasionally, due to trauma or surgery, the cysts may rupture. A ruptured cyst presents two risks;

(a) Hydatid fluid when absorbed into circulation produces fatal anaphylactic shock

(b) Secondly, it may lead to formation of secondary echinococcois in other parts of the body due to spread of scolices in circulation.

### Diagnosis

Diagnosis is made by precipitin, complement fixation and haemagglutination test and intradermal Casoni's test. Microscopic examination for hooklets, scolices and cyst membrane in sputum, vomitus, urine or faeces after rupture of cysts or in discharge from a sinus also aids in diagnosis. Confirmation is by examination of tissues obtained surgically or at autopsy. Eosinophilia is present. Radiological examination for hydatid is often helpful. Detection of antigen excreted in urine by CIEP or Co-A is the most recent approach which may also be used to evaluate success of treatment.

### Prevention and Control

(a) Prevention of infection in dogs by rigid control of slaughter-houses so that dogs do not have access to them.

(b) Deworming of infested dogs with specific antihelminthics.

(c) Health education of people for understanding the nature of the disease, precautions to be taken, need for personal prophylaxis (cleaning of hand before eating) and controlled slaughtering of animals, should be emphasized. General household hygiene must be improved.

(d) There is no specific treatment excepting surgical removal of cysts which is not without considerable risk in as much as the accidental penetration of one of the cysts can lead to anaphylactic shock which may prove fatal. Mebendazole has been tried and may well become drug of choice.

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# Bio-Medical Sciences

## Air-borne (Respiratory) Diseases


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## Mechanism of Air-borne Infections

The central aspect of the spread of infectious disease is the transmission of infection, or the various mechanisms by which disease agents reach and infect the human host. This involves escape of the agent from the source, conveyance to the susceptible host , and entry into that host. Transmission may be direct or indirect, the classification is as follows

Classification of the mechanism of transmission is as follows

| Direct transmission | Indirect transmission |
|---|---|
| Direct contact | Airborne |
| Droplet infection | Vehicleborne |
| | Vectorborne |

Since the Stone Age and before, man and his ancestors have sought refuge from the elements by taking shelter within caves, tents and wooden structures. Little aware that the common protection they obtained also fostered the exchange and proliferation of airborne pathogens, which would in the coming years form of one of the most dreaded group of organism.

Airborne infection is defined as "A mechanism of transmission of an infectious agent by particles, dust, or droplet nuclei suspended in the air."

Two types of particles are implicated in the airborne kind of spread

(a) Droplet nuclei

(b) Dust

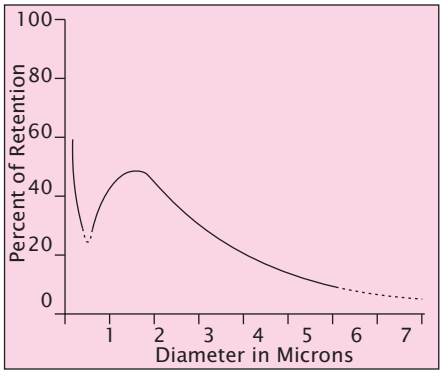
**Dust**

Dust are particles of varying size that result from resuspension of particles that have settled on floors or bedding. A variety of infectious agents ( bacterias, viruses and fungal spores) have been found in the dust of hospital wards and living rooms, these agents survive for varying periods as per optimum condition of temperature and humidity. These particles become airborne due to the act of sweeping, dusting or bed-making or from the soil by the wind.

**Droplet nuclei**

Droplet nuclei are tiny particles (1-10 microns) that represents the dried residue of droplets. Smaller particles that are less than 3 to 5 microns in diameter may contain one or two micro-organism fail to settle out of gravity & remain suspended in the atmosphere for long periods of time. These infectious aero-sols are small enough to bypass host defenses in the upper respiratory tract and airways. More particles are deposited in small bronchioles and alveoli as particle size decreases below 5 micron . One such inhaled particle may be sufficient to reach the alveolus and initiate infection. Typical pulmonary infections acquired due inhalation of infectious aerosols include Tuberculosis, Influenza, Legionellosis, Histoplasmosis, Q fever etc. Fig - 1 Shows the relationship between particle size and retention in the alveoli.

Fig - 1




These droplet nuclei may be formed in several ways which are

(a) Evaporation of droplets that have been coughed or sneezed into the air.

(b) Aeroliztion of infective material in the course of laboratory procedures

(c) Processes for rendering animals in slaughter houses.

**General Prevention and Control measures**

Ventilation

Since organisms transmissible through the air can be widely dispersed, specific air ventilation is required to manage their dispersion thus control outbreaks of airborne infections. If resources are available then (especially in healthcare facility) techniques such as the use of monitored negative airflow ventilation with at least six air changes per hour and filtration of direct exhaust to the outside should be used. In routine areas of work and stay adequacy of ventilation at all times is ensured by provision of at least 2 windows/ room with an area of about 10 percent of the floor space and arranged so as to provide cross ventilation.

Respiratory protection devices

Surgical masks that cover the mouth and nose should be worn by healthcare staff in hospitals and by the patient themselves also. (CDC-recommends N95 respirator / surgical mask made by 3M.)

Overcrowding

Other important measure, for preventing airborne infections is prevention of overcrowding. The minimum floor area should be 6 $m^2$ per person. Beds must be spaced with an interval of at least 2 m between the centres of the two adjacent beds, the greater the interval, the better it is.

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# Small Pox : A Historical Introspection

## Introduction

Smallpox (variola) represents both the zenith and nadir of human achievement. It is the only disease that has been eradicated through a concerted and extensive effort that transcended political and ideological boundaries. Because of these efforts, not one documented naturally occurring case of this infection, which once caused high mortality rates, has occurred since October 26, 1977. (The last naturally occurring case involved an unvaccinated hospital cook in Somalia. ) Smallpox officially was declared eradicated by the World Health Organization (WHO) in 1980. Later two accidental laboratory infections were reported in Birmingham, England in 1978 (1, 2). Smallpox also represents one of the most devastating potential biological weapons ever conceived (3). In 1976, there were 76 laboratories through out the world that officially kept stocks of Smallpox virus. By 1980, the number was reduced to six laboratories. In 1983, the number was down to two; the US Laboratory in Atlanta, Georgia, and the Research Centre of Virology, Koltsovo, Russia, both WHO collaborating centers(4).

## Eradication of the disease

Small Pox eradication has been possible due to the following reasons (5) :

(a) No known animal reservoir.

(b) No long-term carrier of the virus.

(c) Life long immunity, after recovery from the disease.

(d) The detection of cases is comparatively simple because the rash was so characteristic and occurred in visible parts of the body.

(e) Persons with sub clinical infection did not transmit the disease.

(f) Presence of a highly effective vaccine which was easily administered, stable and conferred long term protection.

(g) International Co-operation.

## The looming threat of smallpox

Smallpox is classified as a Category A agent by the Centers for Disease Control and Prevention. Category A agents are believed to pose the greatest potential threat for adverse public health impact and have a moderate to high potential for large-scale dissemination. Other Category A agents are anthrax, plague, botulism, tularemia, and viral hemorrhagic fevers. Smallpox might find mankind across the whole world a fertile medium to spread, given that most of us have no immunity against it. The WHO has at its disposal some 200 million doses of the smallpox vaccine, but most of them are old and have been kept frozen for many years, and hence their effectiveness on human beings remains untested(6).

## Vaccine current status

Stockpiled vaccine has been used only for laboratory researchers working on orthopoxviruses. In the event of a known bioterrorist release of smallpox virus, vaccine would be administered to exposed individuals. If vaccine is given within 3 to 4 days of exposure, immunity can develop before the disease occurs, and this would be expected to prevent or ameliorate the severity of disease. Post exposure immunization is recommended for persons who have had face-to-face, household contact with or have been in proximity to a person who has active smallpox skin lesions, persons who have been involved in the care of such an individual, and persons exposed in any way to laboratory specimens or bedding from an infected patient. The rationale for a policy based on the so-called RING VACCINATION strategy recommended by the Centers for Disease Control and Prevention, in which cases of smallpox are rapidly identified, infected individuals are isolated, and contacts of the infected individuals as well as their contacts are immunized immediately(7). The ring strategy is based on the knowledge that vaccination can prevent or ameliorate disease severity if given within 3 to 4 days of initial exposure and can decrease symptoms if given within the first week of exposure.

New Vaccine

On September 01, 2007, the U. S. Food and Drug Administration (FDA) licensed a new vaccine ACAM2000 against smallpox which can be produced quickly upon need. Centers for Disease Control and Prevention has stockpiled 192. 5 million doses of the new vaccine (derived from the old Dryvax, and made using a pox virus vaccinia).

## Antiviral Drugs

Cidofovir (Vistide)

In vitro studies demonstrated cidofovir to inhibit poxvirus replication and cell lysis. This drug must be used under an FDA Investigational New Drug (IND) protocol because it is not licensed for use as a treatment for smallpox. Cidofovir is a nucleoside analog DNA polymerase inhibitor; if administered within 48 h of exposure may attenuate or avoid infection; adefovir, cidofovir, and ribavirin are under investigation for use in smallpox. Ribavirin as an aerosol treatment for paediatric respiratory syncytial virus is under investigation. **Adult Dose** of cidfovir is 5 mg/kg IV over 1h.

## Monkey pox

Isolated cases of a vesiculopustular disease resembling smallpox have occurred in West Africa and Zaire after smallpox transmission has been interrupted in the area. The virus isolated is identical with monkey pox, a member of the variola vaccinia group of viruses. Serological surveys of wild monkeys have shown that monkey pox is an uncommon infection in the wild non-human primates (8).

## Small Pox

- Caused by variola virus
- Only disease that has been eradicated in medical history in recent times
- Last indigenous case in India occurred in 17 May 1975 in Bihar
- The world's last case occurred in Somalia on 26 Oct 1977
- On 08 May 1980 WHO declared eradication of Small Pox
- Strategy for eradication : Surveillance and containment
- Classified as Category A agent by CDC as a bioweapon
- Recommended strategy for control:

## Rash in small pox

**Distribution**

- palms and soles frequently involved
- axilla usually free
- rash predominant on extensor surface and bony prominences

**Characterstics of rash**

- deep seated
- vesicles multilocular and umblicated
- only one stage of rash may be seen at one time
- No area of inflammation is seen around vesicles

**Evolution**

- Evolution of rash is slow, deliberate and majestic passing through definite, stages of macule, papule, vesicle and pustule
- Scab begins to form 10-14 days after the rash appears
- Fever subsides with the appearance of rash

## Small Pox Vaccine

| | |
|---|---|
| **Vaccine Name** | Vaccinia virus vaccine (Dryvax) -- Vaccine contains live vaccinia virus but does not contain variola virus, which causes smallpox. Following inoculation, vaccine induces an immune reaction that serves to protect against smallpox. |
| **Adult Dose** | Using biohazard precautions, pick up a droplet of vaccine using bifurcated (eg, two-pronged) needle (supplied with vaccine) and deposit on skin on upper arm; with same needle, prick skin percutaneously over droplet site 2-3 punctures for primary vaccination (15 punctures for revaccination) within a few seconds to allow vaccine to penetrate; wipe off any remaining vaccine from skin with sterile gauze and dispose in biohazard waste container; administration will create a sore and cause 1-2 droplets of blood to form |
| **Pediatric Dose** | Administer as in adults |
| **Contraindications** | Documented hypersensitivity; eczema or atopic dermatitis and other acute, chronic, or exfoliative skin conditions; diseases, drugs, or conditions that cause immunodeficiency or immunosuppression; pregnancy and household contacts of pregnant women; infants <1 y; Note: No contraindications exist if patient was exposed to smallpox; contraindications exist only when vaccinating those without exposure |
| **Interactions** | None reported |
| **Pregnancy** | Usually safe but benefits must outweigh the risks. |
| **Precautions** | Do not administer IM, IV, or SC; may cause rash (rare), fever, myalgias, or headache; soreness may occur at injection site; rare severe reactions include eczema vaccinatum, progressive vaccinia, or postvaccinal encephalitis; based on past experience, deaths due to severe reactions are estimated to occur in 1 person per million following primary vaccination and 1 person per 4 million for revaccination; vaccinia immune globulin IV is available from the CDC to treat extensive lesions following implantation, vaccinia necrosum, ocular exposure, eczema vaccinatum, and generalized vaccinia |

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Maj (Mrs) Puja Dudeja

# Measles

## Introduction

An acute highly infectious disease of childhood caused by a specific virus of the group myxoviruses. It is associated with high mortality and morbidity in developing countries (1).

### History

The first scientific description of the disease and its distinction from smallpox is attributed to the Persian physician Ibn Razi (Rhazes) 860-932 who published a book entitled "Smallpox and Measles". In 1954, the virus causing the disease was isolated from an 11-year old boy from the US, David Edmonston, and adapted and propagated on chick embryo tissue culture(2). To date, 21 strains of the Measles virus have been identified (3). Licensed vaccines to prevent the disease became available in 1963.

## Burden of the disease

### World

While Measles is now rare in many industrialized countries, it remains a common illness in many developing countries. More than 20 million people are affected each year by Measles. In 2005, it was estimated that there were 345 000 Measles deaths globally : this translates to about 945 deaths every day; 39 people die every hour from Measles. The primary reason for continuing high childhood Measles morbidity and mortality is the failure to deliver at least one dose of Measles vaccine to all infants. According to the World Health Organization (WHO), Measles is a leading cause of vaccine preventable childhood mortality. It is virtually endemic in all parts of the world. Before the vaccine became available in the 1960s, Measles killed between 7-8 million children in a year and caused an estimated 135 million cases (4). Today it still kills about 1million children of the estimated 30 million who get Measles. Africa and Southeast Asia continue to experience endemic transmission and high mortality rates, despite a global mortality reduction of 39% between 1999 and 2003(5).

### India

Table - 1 : Estimated Measles deaths by World Health Organization (WHO) region, 2005

| WHO Region | Cases |
|---|---|
| Africa | 126000 |
| Americas | <1000 |
| Eastern Mediterranean | 39000 |
| European | <1000 |
| South East Asia | 174000 |
| Western Pacific | 5000 |
| **Total** | **345000** |

In India Measles is a major cause of morbidity and a significant contributor to childhood mortality. However with the increase in immunization coverage levels, the intervals between cyclical peaks have increased and the intensity of peaks minimized. After the implementation of UIP, the numbers of cases have come down from 2. 47 lakhs to 51700 during the year 2001(6). Out of the 51546 cases reported of Measles in 2004, 140 had died in the country.

## Armed Forces

Hospital admission due to Measles as a percentage of total admission (less members of MNS) in 2005 and 2006 was 0. 09% and 0. 06 % respectively (7).

There has been an overall decrease in hospital admission due to Measles (Rate per 1000) in combined cadets and recruits.

## Epidemiology

Measles is one of the most contagious infectious diseases. The epidemiology of Measles is markedly affected by population size, density, movement and social behaviour. In the absence of vaccination the disease infects essentially everyone at some time during life except in some isolated populations (8). Mathematical models suggest that in a totally susceptible population the average case of Measles may result in transmission of Measles to 12-18 persons (9). Thus it is estimated that the immunity level needed to interrupt transmission is on the order of 94 percent or higher.

### Agent

Measles virus (MV) is an enveloped, nonsegmented negative-stranded RNA virus of the Paramyxoviridae family (10). It is very sensitive to acid conditions, drying and light but can survive well in aerosolised droplets. Three membrane proteins appear to play a critical role in the pathogenesis. The hemaagglutinin protein (H), which projects from the virion, attaches to cell surfaces. The fusion (F) protein allows cell to cell spread. Finally the Matrix M protein, associated with inner surface of viral envelope, appears to be important for successful generation of viral particles. Abnormalities in the synthesis of these proteins have been postulated to play an important role in the pathogenesis of SSPE (11).

Source of infection is a case and a subclinical case (1). Period of communicability is appoximately 4 days before and 5 days after the appearance of rash.

### Host

Children in the age group 6 months to 3 years of age in developing countries and over five years in developed countries are commonly affected. One attack of Measles confers life long immunity. A review of the community based studies of published Measles outbreak investigations found a median case-fatality ratio of 3. 7% (range 0 to 23. 9%). (12).

### Envionmental Factors

Although the reasons for the severity of infection in the developing world are still debated, two possible reasons stand out (13) :

**Overcrowding**

Measles is very contagious; up to 90% of non immune people who come in contact with a case will be infected. Transmission rates are therefore high in areas of overcrowding. Secondary cases resulting from household contact are also more severe- in one epidemic, case fatality was 23% for secondary cases Vs 1% for the first household case; 85 % of the deaths were due to secondary household infections.

**Malnutrition**

Cellular immunity is very important for the host's response to the Measles virus. Since this is impaired in the severly malnourished child, poverty and malnutrition predispose to severe and persistent infections.

**Transmission**

The Measles virus is a highly contagious airborne pathogen which spreads primarily via the respiratory system. The virus is transmitted in respiratory secretions, and can be passed from person to person via aerosol droplets containing virus particles, such as those produced by a coughing patient. Once transmission occurs, the virus infects the epithelial cells of its new host, and may also replicate in the urinary tract, lymphatic system, conjunctivae, blood vessels, and central nervous system (14).

**Pathogenesis**

The virus infects and lyses epithelial cells of the respiratory and GI tracts, leading to secondary bacterial pneumonia and enteropathy that further produces malnutrition. It also attacks and depreses the immune system encouraging the secondary infections and reactivation of dormant pathogens. Death occurs from chest and CNS complications.

**Clinical features**

Incubation period is commonly 10 days from exposure to onset of fever, and 14 days to onset of rash. The classical symptoms of Measles include a fever for at least three days, and the three Cs-Cough, coryza (runny nose) and conjunctivitis (red eyes). The fever may reach up to 104˚ Fahrenheit/ 40˚ Celsius. Koplik's spots seen inside the mouth are pathognomonic (diagnostic) for Measles but are not often seen, even in real cases of Measles, because they are transient and may disappear within a day of arising. **Koplik's spots** are small, irregular, red spots with a minute bluish white speck in the center of each seen on the buccal mucosa and lingual mucosa (mucous membrane of the inside of the cheek and tongue) and are pathognomonic of early stage Measles. They are named after Henry Koplik (1858-1927), an American pediatrician who first described them in 1896. The characteristic Measles rash is classically described as a generalized, maculopapular, erythematous rash. It starts on the head before spreading to cover most of the body, often causing itching. The rash is said to "stain", changing colour from red to dark brown, before disappearing. Measles infection during pregnancy is asssociated with spontaneous abortion and with delivery of low birth weight infants(14). Time course of Measles infection is described as under(13) :

**Complications**

(a) Pneumonia most common cause of death. Caused by Measles virus or secondary bacterial infections (16).
(b) Otitis media
(c) Laryngitis both secondary bacterial and viral
(d) Sore mouth- decreases feeding in infant
(e) Corneal ulceration and Keratomalacia (secondary HS infection) leading to blindness (exacerbated by Vitamin A deficiency)
(f) Diarrhea(+/- tenesmus, blood) leading to dehydration and malnutrition
(g) Hemorrhagic Measles with purpuric rash and mucosal hemorrhage (rare but fatal)

CNS Complications

Febrile convulsions are the most common. Encephalitis occurs in three forms :

(a) Acute post infectious Measles encephalitis
(b) Acute progressive encephalitis
(c) Subacute Sclerosing panencephalitis is a rare complication. Slow progressive disease over months with subtle changes in personality and intellect due to continuing infection; later myoclonic jerks, chorioathetosis, ataxia, coma, focal retinitis. There is no specific treatment.

**Diagnosis**

Clinical diagnosis of Measles requires a history of fever of at least three days together with at least one of the three Cs. Observation of Koplik's spots is also diagnostic of Measles. Alternatively, laboratory diagnosis of Measles can be done with confirmation of positive Measles IgM antibodies or isolation of Measles virus RNA from respiratory specimens. In cases of Measles infection following secondary vaccine failure IgM antibody may not be present. In these cases serological confirmation may be made by showing IgG antibody rises by Enzyme immunoassay or complement fixation. Positive contact with other patients known to have Measles adds strong epidemiological evidence to the diagnosis. Histologically, a unique cell can be found in the paracortical region of hyperplastic lymph nodes in patients affected with this condition. This cell, known as the Warthin - Finkeldey cell, is a multinucleated giant with eosinophilic cytoplasmic and nuclear inclusions.

**Management**

(a) Give Vit A 200, 000IU immediately and repeat on next day. There is evidence that vitamin A supplementation in children is associated with a reduction of 23% to 30% in mortality risk and

attenuation in the severity of Measles and diarrhoea (17).

(b) Give topical antibiotics

(c) Chloramphenicol eye drops 6 hourly

(d) Symptomatic hydration and nutrition

(e) Secondary infections can be prevented by antibiotics. It decreases mortality in an epidemic

**Hospital admission**

| | Degree of severity of infection | | | |
|---|---|---|---|---|
| | Severe | Mod/Sev | Moderate | Mild |
| **Oral lesions** | | | | |
| Buccal mucosa | + | + | + | + |
| Gingiva | + | + | +/- | - |
| Tongue/palate | + | + | - | - |
| Haemorrhagic | + | - | - | - |
| **Rash** | | | | |
| Haemorrhagic | + | - | - | - |
| Confluent | + | + | - | - |
| Desqumating | + | +/- | - | - |
| Widespread | - | - | + | - |
| Scattered | - | - | - | + |
| **Systemic upset** | | | | |
| Bronchopneumonia | + | + | - | - |
| Cough | + | + | + | - |
| Coryza | + | + | + | + |
| Diarrhoea | + | + | + | - |
| Bloody diarrhoea | + | - | - | - |
| | | | | |

During an epidemic, decide which clinical signs should determine whether a patient is ill enough to warrant admitting to hospital. The following criteria were used by Lamb in a Gambian epidemic to grade severity of illness (18).

Other signs that may warrant admission include :

(a) Severe mouth or skin ulceration

(b) Corneal ulceration

(c) Convulsions/LOC

(d) Laryngeal obstruction

(e) Marked dehydration

If the child is malnourished or underweight, these signs should be considered with greater seriousness.

**Prevention**

Measles vaccination

A number of live, attenuated Measles vaccines are available, either as single-antigen vaccines or in combination with either rubella or mumps and rubella vaccines. When the combined MR or MMR vaccines are used, the protective immune response to each of the components remains unchanged. A killed Measles vaccine was licensed in 1963, but was withdrawn after a few years because of frequent association with high fever and severe atypical pneumonia following subsequent exposure to Measles virus (19).

**Measles vaccine strains**

Most of the live, attenuated Measles vaccines used now originate from the Edmonston strain of Measles virus isolated by Enders and Peebles in 1954.

**Age at immunization**

The recommended age for Measles vaccination depends on the local Measles epidemiology as well as on programmatic considerations. In most developing countries, high attack rates and serious disease among infants necessitate early vaccination, usually at 9 months of age, despite the relatively low (80 - 85%) seroconversion rates following vaccination in this age group. HIV-infected infants should receive Measles vaccine at 6 months of age, followed by an additional dose at 9 months. Asymptomatic HIV infection is an indication, not a contraindication, for Measles vaccination. In most industrialized countries, Measles vaccination may be deferred until a child is 12-15 months old, when seroconversion rates in excess of 90% may be expected. To ensure optimum population immunity, all children should be given a second opportunity for Measles immunization. Although generally administered at school entry (age 4-6 years), the second dose may be given as early as one month following the first dose, depending on the local programmatic and epidemiological situation.

In countries with Measles elimination goals, a one-time only Measles Supplemental Immunization Activities (SIA) (20, 21, 22, 23) should be considered, targeting all children aged 9 months to 14 years, regardless of disease history or previous vaccination status. Efforts are also needed to target specific groups of young adults who may be at increased risk for Measles infection, including military recruits, university students, health care workers, refugees and international travellers to Measles endemic areas. Efforts to eliminate Measles require careful surveillance, including the capacity for laboratory confirmation of suspected Measles cases.

**Vaccine characteristics**

The vaccine is very sensitive to sunlight, hence the need to keep it in coloured glass vials; following reconstitution, the vaccine must be stored in the dark at 2-8°C and used within 6 hours. Measles vaccine is generally injected subcutaneously but is also effective when administered intramuscularly. Each dose of 0. 5 ml contains at least 1000 infective units of the vaccine virus; this is also true when it is combined with mumps and/or rubella vaccines.

**Immunity**

The vaccine induces both humoral and cellular immune responses comparable to those following natural infection, although the serological titres are usually lower. IgM, IgG and IgA antibodies may be detected in both serum and nasal secretions, and IgG persists for many years. The concentration and persistence of maternal antibodies differ in infants of women vaccinated against Measles versus infants of naturally immune women (24).

**Adverse reactions**

Slight pain and tenderness at the site of injection may occur within 24 hours, sometimes followed by mild fever and local lymphadenopathy. About 7-12 days after vaccination, up to 5% of Measles vaccine recipients may experience fever of at least 39. 4 ˚C for 12 days. Thrombocytopenia purpura occurs in approximately 1 in 30 000 vaccinated individuals. Toxic shock syndrome (TSS) occurs when Measles vaccine is contaminated or the same vial is used for more than one session on the same day or next day.

**Combined vaccine**

Measles vaccine can be combined with other live attenuated vaccines such as mumps, and rubella vaccines (MMR vaccine) and such combinations are also highly effective.

Immunoglobulin

Measles may be prevented by administration of immunoglobulin (human) early in the incubation period. The dose recommended by WHO is 0. 25 ml per kg of body weight. It should be given within 3-4 days of exposure. The person passively immunized should be given live Measles vaccine 8-12 weeks later. The need for immunoglobulin is now much reduced because of the availability of an effective live attenuated vaccine.

**Public Health aspects**

Measles, in spite of available vaccination, remains a heavy public health burden worldwide especially in developing countries. Of the deaths attributable to Measles, 98 per cent occur in developing countries (25). The recent Measles outbreak in UK (London)(26), Australia (Victoria)(27), Japan (Tsu)(28), India (Orissa, Chandigarh) (29) and other places highlights the worldwide rise in Measles infection and the challenge to meet the goal of Atlanta Declaration for reducing the disease and disease associated mortality by half by the year 2005. To achieve the goal of Measles elimination vaccination coverage must be increased (30, 31). Availability of health workers can be a major constraining factor on vaccination coverage in developing countries (32). However, great progress in Measles control has been made in resource-poor countries through accelerated vaccination (33). Interepidemic period, which corresponds to the interval between major epidemics of Measles, increases as the vaccination ratio increases(34). The global elimination of Measles has been debated since Measles vaccines were first licensed in the 1960's, and this debate is likely to be renewed if polio virus is eradicated (35).

**Current status of implementation of Measles control strategies in India**

Under the Universal Immunization Programme started in 1985, all States in the country give a dose of Measles containing vaccine to children aged 9-12 months. The coverage is variable between states and within the states even in the good performing states there are districts which have medium to low coverage. The absolute number of children dropping out between BCG and Measles is 6. 26 million (12).

Plan of action 2005-2010

The Multi year strategic plan of the government of India addresses the issue of reducing the Measles mortality by two-thirds by 2010, compared to 2000 estimates. The plan emphasizes on achieving at least 90% coverage in 80% of the districts of the country by 2009 and collection and use of good quality epidemiological data from active surveillance and outbreak investigation to guide further action.

Key Strategies

(a) Achieving high routine Measles vaccination coverage of infants at 9-12 months of age; provide Measles vaccine to the children over 1 year if not vaccinated earlier at the earliest contact.

(b) Effective Measles surveillance that provides information at a minimum; about number of cases and deaths by month. This is supported by good quality outbreak investigation confirmed through laboratory investigations & which capture parameters like age and vaccination status of cases and deaths.

(c) Improving management of Measles cases, including vitamin A supplementation and adequate treatment of cases.

(d) Based on evaluated Measles immunization coverage and surveillance data, providing a second opportunity for Measles immunization to appropriate age groups of children through either a second routine dose of Measles vaccine or through supplemental immunization activities.

**Vaccination strategy in developed nations**

In developed countries, most children are immunized against Measles at the age of 18 months, generally as part of a three-part MMR vaccine (Measles, mumps, and rubella). The vaccination is generally not given earlier than this because children younger than 18 months usually retain anti-Measles immunoglobulins (antibodies) transmitted from the mother during pregnancy. A "booster" vaccine is then given between the ages of four and five. Vaccination rates have been high enough to make Measles relatively uncommon.

**Measles and Millennium Development Goals**

Combining Measles immunization with other health interventions is a contribution to the achievement of Millennium Development Goal Number 4 : a two-thirds reduction in child deaths between 1990 and 2015.

**Action during disasters**

During disaster management disturbed social conditions are present and a large number of children with low

nutritional status who were either partially immunized or not immunised lived together in close contact at the camp setting (36). In a high-risk situation prevailing at the camp site with children residing in close contact to each other, immunization of children even between 6 and 9 months of age is also recommended (37). The general principle for managing outbreak of respiratory group of diseases is to isolate the cases and keep the contacts under surveillance till the longest incubation period of the disease.

**Exanthema**

- Measles (1st disease)
- Scarlet fever (2nd disease)
- Rubella (3rd disease)
- Duke's disease (4th disease)
- Slap cheek (5th disease)

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# Rubella

## Introduction

Rubella, commonly known as German measles, is a contagious infectious disease caused by an RNA togavirus of the genus Rubivirus (1). It is usually a mild and self limiting illness which has assumed importance because of its ability to induce congenital defects in infants of women who acquire rubella during pregnancy.

### History

All the physicians (Friedrich Hoffmann, de Bergen, Orlow, George de Maton, who carried out initial work on rubella were German, and the disease was known medically as Rötheln (from the German name Röteln), hence the common name of German measles was given(2, 3). Norman McAllister Gregg found 78 cases of congenital cataracts in infants and 68 of them were born to mothers who had caught rubella in early pregnancy(4, 5).

### Occurrence

In temperate climates, rubella is endemic year-round, with a regular seasonal peak during springtime. In tropical areas, rubella is widespread. Before the advent of rubella vaccination, major epidemics of rubella tended to occur at 6 to 9 year intervals (6). Despite the marked drop in incidence, it is estimated that upto 15 percent of adolescents and young adults remain susceptible. Transmission of rubella has continued to occur in the postpubertal population, with more than half of all cases occurring among persons 20 years of age or older in recent years.

## Transmission

Humans are the only known reservoir. Rubella is highly communicable but less so than measles or varicella. Virus is transmitted by the respiratory route, and infection usually occurs as a result of contact with nasopharyngeal secretions of infected persons by droplet spread. Primary rubella infection induces lifelong immunity.

## Clinical Characteristics (7)

### Postnatal Infection

Rubella is an acute, mild disease in children and young adults. The first symptoms occur after an incubation period ranging from 14 to 21 days. Communicability begins about 7 days before the onset of rash and persists at least 4 days after rash onset. Infectivity is greatest when the rash is erupting (8). The cardinal manifestations of the disease are a nonspecific maculopapular rash lasting 3 days or less (hence the term "3 day measles") and generalized lymphadenopathy, particularly of the postauricular, suboccipital, and posterior cervical lymph nodes. However, asymtomatic infections are common : upto 50 percent of infections occur without rash (6), and cases without enlargement of lymph nodes have been documented (9). Rash which is often the first sign of illness, appears first on the face and then spreads downward rapidly to the neck, arms, trunk and extremities; pruritus is not unusual. In adolescents or adults, the rash may be preceded by a 1 to 5 day prodrome of low-grade fever, headache, malaise, anorexia, mild conjunctivitis, coryza, sore throat, and lymphadenopathy. The manifestations rapidly subside after the first day of the rash. Exanthems comparable to that observed with rubella infection have been described in infections with echovirus and coxsackie virus, fifth disease (parvovirus), other enteroviral infections, and mild measles; these infections, however, are not commonly associated with postauricular or suboccipital adenopathy.

### Prenatal Infection

The major disease burden of rubella virus is congenital infection. Primary rubella infection during pregnancy, whether clinical or subclinical, carries a significant risk of fetal infection. Congenital rubella syndrome is often associated with a disseminated and chronic infection that may persist throughout fetal life and for many months after birth. Spontaneous abortion, stillbirth, or CRS can result from chronic infection and inhibition of cell multiplication in the developing fetus. Delayed and deranged organogenesis and hypoplastic organ development lead to the characteristic structural defects. Transplacental infection is not always reflected by immediately apparent disease; upto 50 to 70 percent of infants with congenital rubella infection may appear normal at birth. Deafness is commonly diagnosed later when it is the sole manifestation.

Congenital infection is not inevitable, however, and the fetal response to infection is not uniform; the **gestational age** of the conceptus at the time of primary maternal infection is the principal factor influencing the outcome of pregnancy. The risk of CRS as a consequence of maternal infection in the first trimester may be as high as 85 percent(7) but the risk decreases sharply after the eighth week and is absent after the twentieth week of gestation.

## Complications

Although rubella is a mild disease in children, it may be more significant with complications in adults. Arthralgia and arthritis may occur in adults, particulary women, at a reported rate as high as 70 percent. Joint involvement usually occurs after the rash fades and typically lasts 5 to 10 days. Rare complications include optic neuritis, thrombocytopenic purpura, and myocarditis. Postinfectious encephalitis of short duration may occur 1 to 6 days after the appearance of rash; its incidence rate is estimated at 1 in 5, 000 to 16, 000 cases.

## Diagnosis

Clinical diagnosis is often unreliable, because symptoms (including rash) are absent in up to one-half of persons infected with rubella. A history of exposure to rubella may be helpful in the absence of the full complement of clinical signs and symptoms. Culture of virus is difficult and not widely available. Serologic confirmation remains the definitive means of diagnosing rubella. Antibodies to the virus (initially, both IgM and IgG) appear after the onset of illness. IgM antibodies generally do not persist more than 4 to 5 weeks after the onset of illness, whereas IgG

antibodies usually persist for the lifetime of the patient. Many rubella antibody assay methods are available, such as enzyme-linked immunosorbent assay (EIA), latex agglutination (LA), and fluorescent immunoassay (FIA). Approximately 90 percent of all neonates with congenital rubella infection have virus in most of their accessible extravascular fluids (e. g, cerebrospinal fluid, tears, urine) and in the posterior portion of the oropharynx. Because IgM antibody normally does not cross the placenta, the presence of rubella-specific IgM antibody in cord blood is evidence of congenital infection. The presence and persistence of rubella-specific IgG postpartum at higher levels than expected (the half-life of maternal antibodies is one month) are also suggestive of intrauterine infection.

**Congenital rubella Syndrome (CRS)**

Congenital rubella infection and CRS are caused by infection in early pregnancy. From just before conception and during the first 8-10 weeks of gestation, rubella infection may result in multiple fetal defects in up to 90% of cases, and often results in miscarriage or stillbirth. The risk subsequently declines. Fetal defects are rarely associated with maternal rubella after the 16th week of pregnancy, although sensorineural hearing deficit may occasionally occur up to 20 weeks. Studies indicate that in India 40% of the women of child bearing age are susceptible to rubella (10).

**Manifestations of congenital rubella infection**

(a) Spontaneous abortions
(b) Stillbirths
(c) Bone lesions
(d) Cardiac defects
  (i) Patent ductus arteriosus
  (ii) Pulmonary stenosis and coarctation
  (iii) Myocardial necrosis
(e) CNS defects
  (i) Encephalitis
  (ii) Mental retardation
  (iii) Microcephaly
  (iv) Progressive panencephalitis
  (v) Psychomotor retardation
  (vi) Spastic quadriparesis
(f) Hearing impairment (deafness)
(g) Endocrinopathies
  (i) Adrenal disorders
  (ii) Diabetes mellitus
  (iii) Precocious puberty
  (iv) Growth retardation
  (v) Growth hormone deficiency
(h) Eye defects
  (i) Cataracts
  (ii) Glaucoma
  (iii) Microphthalmos
  (iv) Retinopathy
(j) Genitourinary defects
(k) Hematologic disorders
  (i) Anaemia
  (ii) Thrombocytopenia
  (iii) Immunodeficiencies
(l) Hepatitis
(m) Interstitial pneumonitis
(n) Psychiatric disorders

**Prevention**

The primary purpose of rubella vaccination is to prevent the occurrence of congenital rubella infection including CRS. Two approaches are recommended (11) :

(a) Prevention of CRS only, through immunization of adolescent girls and/or women of childbearing age; or
(b) elimination of rubella as well as CRS through universal vaccination of infants and young children (with/ without mass campaigns), surveillance, and assuring immunity in women of childbearing age. The currently licensed rubella vaccines in wide international use are based on the live attenuated RA 27/3 strain of the virus. The 27/3 vaccines are propagated in human diploid cells and have proven to be safe and efficacious. Rubella vaccines are commercially available in a monovalent form, a bivalent combination with measles vaccine or mumps vaccine, or as trivalent measles-mumps-rubella vaccine (MMR).

When immunization is targeted at adolescent girls or women of childbearing age, the epidemiology of rubella is largely unaffected since most infections occur before the age at immunization. With such an approach, the incidence of CRS declines linearly with the level of coverage. However, elimination of CRS cannot be achieved with this strategy, in part because it would require every susceptible woman to be effectively immunized.

Childhood immunization of both sexes reduces the number of infections and extends the interepidemic interval by reducing the circulation of rubella virus in the community. Hence, one consequence of a childhood-only immunization programme may be an increase in the proportion of susceptibles in the adult population. The higher the vaccination coverage, the more apparent this effect will be. This shift in the proportion of susceptibles in older age groups can result in more cases of CRS than in the prevaccination period.

Countries undertaking measles elimination should consider taking the opportunity to eliminate rubella as well, through use of MR or MMR vaccine in their childhood immunization programmes, and also in measles campaigns. All countries undertaking rubella elimination should ensure that women of childbearing age are immune and that routine coverage in children is sustained >80%.

If the health care system cannot reach a substantial

proportion of women of child bearing age, initial emphasis might be placed on interrupting transmission while attempting to reach as many of the risk population as possible (12).

MMR Vaccine

It's a live attenuated vaccine

**Contents :** each 0. 5 ml contains Measles (100 TCID) 50, Schwartz strain) Mumps (5000 TCID 50, Urabe AM-9), Rubella (1000 TCID 50, Winsrar RA/3M) cultured on human diploid cells.

**Dose and route :** 0. 5ml S/C single dose, upper arm or thigh.

**Age :** 15-18 months. If not given at this age, all girls should be immunized at any age.

**Storage :** 2-8 $^{0}$C.

**Adverse effects :**

(a) Mild fever in 5-15%

(b) Rash 5% (5-7 days after vaccination)

(c) Lymphadenopathy.

(d) Arthralgia/arthritis-10-21 days after vaccination. Occurs uncommonly in children but more frequently in post-pubertal females with a frequency of 25% and 10% respectively.

(e) Transient peripheral paresthesia and pain in the arms and legs-rarely.

**Complications** due to measles are very rare; SSPE, toxic shock syndrome and convulsions.

Efficacy induces Ab in 99% of recipients and has protective efficacy in 90%

**Contraindictions :**

(a) Pregnancy (women vaccinated with MMR should avoid pregnancy for 3 months)

(b) Allergy to a vaccine component

(c) Immunodeficiency

(d) Moderate or severe acute illness with or without fever

(e) Recent immune globulin administration

### Rubella

- Rubella is an infection caused by a virus.
- Rubella is normally a mild childhood disease, but women who get rubella early in pregnancy can pass the virus on to their fetuses. This is called congenital rubella syndrome (CRS).
- A rash is the most prominent symptom of rubella, especially in children. Complications from rubella are rare. But complications from CRS are more serious and include deafness, cataracts, and mental retardation. Rubella vaccines are safe and effective. But because conditions vary greatly from country to country, there is no universal recommendation on the use of vaccines.
- If countries immunize against rubella, they generally use a combination vaccine that also guards against measles (MR) or measles and mumps (MMR).
- It is important to ensure that coverage in infants is sustained at over 80% to avoid the shifting of rubella

### Rubella Vaccine

- Type of vaccine - Live attenuated viral
- Number of doses - One dose
- Schedule - Generally 12-15 months
- Booster - A second opportunity for immunization is recommended ( routine or campaign )
- Contraindications - Severe reaction to previous dose; pregnancy; congenital or acquired immune disorders (not HIV infection). Although it is not recommended to administer the vaccine during pregnancy, there has never been any evidence of damage to the fetus from vaccinating the mother during pregnancy
- Adverse reactions - Same as measles vaccine, plus cases of arthritis in adolescent females for rubella-containing vaccine and parotitis; rarely aseptic meningitis with mumps- containing vaccines may occur
- Special precautions - None
- Dosage - 0.5ml
- Injection site - Outer mid-thigh/upper arm depending on the age
- Injection type - Subcutaneous

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Maj (Mrs) Puja Dudeja

# Diphtheria

## Introduction (1)

Diphtheria is an acute infectious disease caused by toxigenic strains of Cornybacterium diphtheria. The bacilli multiply locally and elaborate a powerful exotoxin which is responsible for

(a) Formation of a grayish yellow membrane ("false membrane") commonly over tonsils, pharynx or larynx (or at the site of implantation) with well defined edges and the membrane cannot be wiped away.

(b) Marked congestion, edema and local tissue destruction.

(c) Enlargement of lymph nodes.

(d) Signs and symptoms of toxemia.

The infection is typically that of upper respiratory tract; the sites most commonly affected are fauces, nasal mucosa, pharynx and larynx; but it may occur in any tissue. The second important though less common site is the skin (2).

| Causes of Sore Throat (3) |
|---|
| Streptococcus pyogens (rheumatic heart disease and glomerulonephritis) |
| Mild viral infections |
| Corynebacterium diptheriae |
| Epstein Barr virus |
| Neisseria gonorrhoeae |
| Secondary syphilis |

### History

The word diphtheria means pair of leather scrolls , Aretaeus, the Cappodocian in second century, described the Egyptian or Syriac ulcer, which most medical historians agree can be identified as diphtheria (4). The disease was first recognized as a clinical entity by Bretonneau who called it 'diphtherite'. The name is derived from the tough, leathery pseudomembrane formed in the disease (diphtheros, meaning leather). It is also known by the name of strangling angel of children (5). The diphtheria bacillus was first discovered by Klebs(1883), but was cultivated by Loeffler(1884)(6,7). It is hence known as Klebs- Loefler bacillus.

### Geographical Distribution

Diphtheria occurs in all parts of the world, but it is mainly a disease of temperate climate (8). Diphtheria is endemic in many parts of the world, including countries of the Caribbean and Latin America. During the last 10 years, large epidemics of diphtheria have occurred in the former Soviet Union, where formerly, diphtheria had been well controlled. The largest outbreak of diphtheria in the developed world occurred from 1990-1995 throughout the states of the former Soviet Union. Since 1994, with the initiation of aggressive immunization efforts, the number of reported cases has decreased. A feature of these epidemics concerns the age group; most cases have occurred among adolescents and adults, rather than children.

| 2005 Global figures |
|---|
| 8,229 reported cases |
| 5000 estimated deaths |
| 78% estimated DPT3 coverage |
| 29% of countries reached >=80% DPT3 coverage in all |

### India

The reported incidence of diphtheria in the country during 1987 was about 12,952 whereas during the year 1999, there were only 2,725 cases showing a decline of about 79 %( 9). It is still endemic in our country (1). The last decade has seen resurgence of diphtheria in both developed and developing countries where it was previously well controlled (10). Low or declining routine immunization coverage, as well as naturally waning of immunity against diphtheria are major factors for endemicity or even resurgence of diphtheria. This is a matter of concerned for all public health professionals. It occurs more in cities than in the rural areas, and more in dry areas than wet. Several studies carried out over last 30 years at different places in this country also reported that diphtheria occur more frequently during the month of August to November (11-14).

### Armed Forces

Diphtheria is not an important cause of sick wastage in the Armed Forces and the incidence is low.

### Epidemiology

The causative organism, Corynebacterium diphtheria, is a gram positive, non-motile organism. Three types of diphtheria bacilli are differentiated-gravis, mitis and intermedius. There are both virulent & avirulent strains of diphtheria bacilli. The avirulent strains do not produce exotoxin. The toxin, which is a protein, has been isolated in crystalline form. The virulence of C. diphtheria is conditioned by the presence of one or more bacteriophages(15). Man is the only reservoir of infection (1).

### Carrier State

Diphtheria carriers are the usual cause of clinical cases. They may be temporary or chronic carriers; nasal or throat carriers. The nasal carriers are particularly dangerous as source of infection since they shed more organisms into the environment than do throat carriers. The temporary carrier state may last for about a month, but the chronic carrier state may persist for a year or so.

### Source

A case of clinical diphtheria is highly infectious, but being usually isolated in hospital (or at home) becomes a less important means of spreading the disease. Sub-clinical cases, which are frequently missed, are an important source of infection. The healthy 'carrier' is, however, a particularly important cause of outbreaks in close communities such as the Armed Forces units, schools and other residential institutions. In schools a 'carrier epidemic' often precedes the clinical epidemic.

### Mode of Transmission

The mode of transmission may be droplets, direct contact or indirect contact. The droplet route is the most important mode of spread of diphtheria in the Armed Forces. The greater the overcrowding in barracks the higher is the probability for infection of a susceptible individual. Among children direct contact as in kissing or close fondling is an important route of transmission of infection from adult carriers. Quite commonly older children bring the infection home from their schools and transmit it to younger ones. Indirect transmission, especially by putting in their mouths, toys or pencils which may have been sucked by a 'carrier' child, also plays an important part. Outbreaks have also been recorded from milk infected by a 'carrier' or a mild case.

### Host

Diphtheria is primarily a disease of children. Infants born of immune mothers derive maternal antibodies which protect them during the first few months of life against diphtheria. Recovery from clinical attack is not always followed by lasting immunity. Immunity is often acquired through an in apparent infection. Schick test surveys in India have revealed that 70 per cent of children over the age of 3 years, and 99 percent over the age of 5 years are already immune to diphtheria.

#### Incubation Period

The incubation period is usually 2 to 6 days, occasionally may be longer.

#### Communicability Period

The period of communicability is variable. It is usually two weeks or less but seldom more than 4 weeks; carriers may remain infective much longer.

### Clinical features

#### Tonsils and pharynx

Tonsillar and pharyngeal diphtheria are most common; symptoms begin with a sore throat, usually in the absence of systemic complaints. Fever, if it occurs, is usually lower than 102°F, and malaise, dysphagia, and headache are not prominent features.

(a) In individuals with diphtheria infection who are not immune, membrane formation begins after the 2-5 day incubation period and grows to involve the pharyngeal walls, tonsils, uvula, and soft palate. The membrane may extend to the larynx and trachea, causing airway obstruction and eventual suffocation.

(b) Underlying tissue of the throat and neck becomes edematous, and lymphadenopathy develops. Marked edema of the neck may lead to a bull-neck appearance with a distinct collar of swelling; the patient throws the head back to relieve pressure on the throat and larynx. Erasure edema associated with pharyngeal diphtheria obliterates the angle of the jaw, the borders of the sternocleidomastoid muscle, and the medial border of the clavicles. Swallowing may be made difficult by unilateral or bilateral paralysis of the muscles of the palate.

(c) If toxin production is unopposed by antitoxin and severe disease occurs, early localized signs and symptoms give way to circulatory collapse, respiratory failure, stupor, coma, and death.

(d) **Larynx:** In a minority of patients, the larynx is the initial site of infection, with initial presenting symptoms similar to laryngotracheobronchitis from other causes. Initial hoarseness may progress to loss of voice and severe respiratory tract obstruction. Initially, nasal diphtheria may present as a common viral upper respiratory tract infection. A foul odor may develop. This form of diphtheria is most common in infants.

(e) **Skin:** Cutaneous diphtheria may occur at one or more sites, usually localized to areas of previous mild trauma or bruising. It is more common in tropical climates, but outbreaks have occurred in the United States. Pain, tenderness, and erythema at the site of infection progress to ulceration with sharply defined borders and formation of a brownish gray membrane. Local disease may persist for weeks to months.

(f) **Other sites:** Additional sites of infection have included the external ear, the eye (usually the palpebral conjunctivae), and the genital mucosa. Rare sporadic cases of endocarditis have been reported, usually due to nontoxigenic strains. Septicemia caused by C diphtheriae is rare but universally fatal.

### Complications

Respiratory tract obstruction occurs due to swelling and sloughing of pseudomembrane. Myocarditis (dysrhythmias, conduction disturbances and cardiomyopathy) is seen in almost one quarter of hospitalized patients; those who die usually do so within 4 or 5 days. Polyneuropathy occurs 3-5 weeks after diphtheria and follows an indolent course. Pneumonia develops in more than half of patients who succumb to diphtheria (16).

### Diagnosis

An appropriate microbiological diagnosis is crucial and is always regarded as being complementary to clinical diagnosis (17). Diagnostic tests used to confirm infection combine isolation of C diphtheriae on cultures with toxigenicity testing. Bacteriologic culturing is essential to confirm the diagnosis of diphtheria.

#### Schick test

The intracutaneous skin test introduced by Schick in 1913 that enables us to distinguish between individuals who are susceptible and those who are resistant (i.e., immune) to diphtheria toxin and to test for sensitivity to toxoid details in Table - 1. The test is based on the following empirical findings:

(a) Intracutaneous injection of 1/50 MLD (minimal lethal dose) (for a guinea pig) of diphtheria toxin produces a strong, but tolerable, reaction in individuals having no antitoxin.

(b) Individuals having 1/30 unit or more of antitoxin per ml of blood neutralize this test dose and show no reaction. Such individuals are also usually resistant to diphtheria.

The Schick test is a simple screening device helpful in the assessment of immunocompetence (18).

**Treatment**

The CDC recommends either:

(a) Erythromycin (orally or by injection) for 14 days (40 mg/kg per day with a maximum of 2 g/d), or

(b) Procaine penicillin G given intramuscularly for 14 days (300,000 U/d for patients weighing <10 kg and 600,000 U/d for those weighing >10 kg). Patients with allergies to penicillin G or erythromycin can use rifampicin or clindamycin.

**Preventive Measures**

The control of diphtheria is based on the following three measures.

(a) Primary prevention of disease by ensuring high population immunity through immunization.

(b) Secondary prevention of spread by the rapid investigation of close contacts, to ensure their proper treatment.

(c) Tertiary prevention of complications and deaths by early diagnosis and proper management.

Avoidance of overcrowding, spacing of beds, adequate ventilation in all barracks, rooms, huts and tents and protection from cold should be ensured. Issue of charpoy and use of mosquito net augments these measures. A routine adult immunisation is not considered necessary in the Armed Forces. The most important single primary prophylactic measure in children of Armed Forces personnel is their routine immunisation by administration of triple antigen (DPT) in infancy, besides health education of families to ensure ventilation and adequate spacing in bed rooms.

Table - 1 : Reactions to schick test

| Skin response | Toxin | | Toxoid | | Interpretation |
|---|---|---|---|---|---|
| | 36 h | 120 h | 36 h | 120 h | |
| Positive reaction | - | + | - | - | Nonimmune, nonsensitive |
| Negative reaction | - | - | - | - | Immune, nonsensitive |
| Pseudo reaction | + | - | + | - | Immune, sensitive |

**WHO-recommended surveillance standard of diphtheria**

Rationale for surveillance

Diphtheria is a widespread severe infectious disease that has the potential for epidemics. Surveillance data can be used to monitor levels of coverage (target > 90%) and disease as a measure of the impact of control programmes. Recent epidemics have highlighted the need for adequate surveillance and epidemic preparedness

Recommended case definition

An illness characterised by laryngitis **or** pharyngitis **or** tonsillitis, **and** an adherent membrane of the tonsils, pharynx and/or nose

Recommended types of surveillance

(a) Routine monthly reporting of aggregated data of probable or confirmed cases is recommended from peripheral level to intermediate and central levels

(b) Designated reporting sites at all levels should report at a specified frequency (e.g. weekly or monthly) even if there are zero cases (often referred to as "zero reporting")

(c) All outbreaks should be investigated immediately and case-based data collected

(d) In countries achieving low incidence (usually where coverage is > 85-90%) immediate reporting of case-based data of probable or confirmed cases is recommended from peripheral level to intermediate and central levels

**Control action on occurrence of a case**

(a) Isolation

It should be continued until 2 cultures, taken not less than 24 hours apart (after cessation of antimicrobial therapy) from throat and nose, fail to show diphtheria bacilli; where culture is impractical, isolation may be ended after 14 days with fair degree of safety.

(b) Concurrent Disinfection

It should be carried out for naso-pharyngeal discharges, linen and cutlery used by patient and local terminal disinfection as described in Chapter 82.

(c) Notification

It should be carried out immediately including to the local heath authorities.

(d) Attendants

They should be proved Schick test negative otherwise active immunisation should be carried out.

(e) Surveillance of Contacts

(i) All intimate contacts should be segregated until nose or throat cultures are negative. All carriers should be treated with antibiotics.

(ii) Contacts who are intimately exposed and

not previously immunised with toxoid should be given first dose of toxoid and 1000-2000 units of diphtheria antitoxin as well as an appropriate antibiotic (Penicillin or erythromycin) if culture is positive. Persons previously immunised should have a booster dose of toxoid.

(iii) The contacts should be thoroughly investigated by repeated swabbing to detect any atypical cases among intimate contacts. They should be isolated and treated.

(f) Epidemic Measures

Immediate action should be taken to immunise the population group involved with emphasis on protection of infants and pre-school children. If cases continue to occur in the unit, Schick test and examination of throat swab should be carried out. The results of the throat swab and Schick test should be analysed and action as under should be taken.

(g) High incidence among school children

When incidence among children in a locality is high, all children below the age of 10 years should be immunised without any preliminary Schick test, children upto 5 years of age with triple vaccine and children over 5 years of age, with the combined diphtheria-tetanus vaccine. However, PTAP or PTAH alone can also be used if immunisation against tetanus is not required. A preliminary Schick test should be carried out when dealing with children above the age of 10 years and adults. TAF is a safer agent than PTAP or PTAH among adults.

(h) Contacts among school children

In case of contacts among school children, specially in residential schools, the following procedures are adopted :-

(i) Throat swabs of all contacts are taken and all are given 5000 units of antitoxin in one arm after sensitivity test has been carried out; the first dose of PTAP is given in the other arm.

(ii) Those showing positive swabs are segregated until virulence test shows them non-virulent. Then they are returned to the hostel / school and given the rest of the active immunisation.

(iii) Those with virulent bacilli are treated with topical and systemic antibiotics. They are returned to the hostel/ school when three consecutive swabs with interval of 3 days between each show negative result or after 14 days of the 2nd doses of antigen is given to the rest of the community, whichever is earlier. Alternatively the procedure in subpara (f) is carried out.

DPT Vaccine

- **Type of vaccine:** Diphtheria and Tetanus as toxoids. Pertussis as killed whole-cell bacterium
- **Number of doses:** At least three primary doses
- **Schedule:** 6, 10, 14 weeks of age
- **Booster:** 18 months
- **Contraindications:** Anaphylactic reaction to previous dose or to any constituent
- **Adverse reactions:** Mild local or systemic reactions are common
- **Special precautions:** DPT not usually given over 6 years of age
- **Dosage:** 0.5ml
- **Injection site:** Outer mid-thigh in infants/outer upper arm if older
- **Injection type:** Intramuscular
- **Storage:** Store between 2˚C - 8˚C. DPT vaccine should never be frozen

**DTP vaccine**

Diphtheria-tetanus-pertussis vaccine is made from diphtheria toxoid, tetanus toxoid, and pertussis vaccine. It is a liquid vaccine. If a vial of DTP vaccine stands for a long time, fine particles may separate from the liquid. They look like fine sand at the bottom of the vial. Before giving the vaccine shake the vial to mix the vaccine and liquid. DTP vaccine should never be frozen. The "Shake test" will determine if the vaccine has been damaged by freezing. If the vaccine fails the shake test you must discard it.

Usually, reactions to DTP vaccine are mild. The side-effects include:

Fever

Up to half of the children who receive DTP vaccine may have a fever in the evening after receiving the injection. The fever should disappear within a day. Note that a fever that begins more than 24 hours after a DTP injection is not likely to be a reaction to the vaccine. Administering paracetamol or any appropriate antipyretic at the time and at four and eight hours after immunization decreases the subsequent incidence of febrile and local reactions.

Diphtheria

- Diphtheria is spread from person to person in airborne droplets.
- Symptoms of the disease include sore throat, loss of appetite, and a slight fever.
- Patients with the disease can experience complications such as abnormal heartbeats and inflammation of the heart muscle and valves.
- Children with diphtheria should be treated with diphtheria antitoxin and antibiotics.

### Soreness

Up to half of the children may have pain, redness, or swelling at the injection site.

### Crying

Crying for more than three hours, mostly because of pain, can be observed in up to 1% of infants.

More severe reactions reported include convulsions (usually related to fever, one case in 12 500 doses administered) and hypotonichypo responsive episodes (one case in 1750 doses administered). Anaphylactic reactions are extremely rare. There is no evidence that the vaccine causes any serious neurological disorder such as encephalopathy.

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Maj (Mrs) Puja Dudeja

# Varicella

## Introduction

Varicella (Chicken pox) and Herpes Zoster (shingles) are two distinct diseases caused by Varicella Zoster Virus (VZV). Varicella is the clinical manifestation of the primary infection caused by VZV, which like other herpes viruses is capable of maintaining latency in the human body and reactivating to result in secondary or latent infection known as herpes zoster (1) It is world wide in distribution and occurs both in epidemic and endemic forms (2).

### Armed Forces

Chicken pox is the 10th leading cause of hospital admission in Armed forces. It forms 2. 26 percent of the total hospital admissions. Chicken pox has overall showed a decline in incidence in 2006 as compared to 2005 (3).

### History

There are many explanations offered for the origin of the name chickenpox :

(a) Samuel Johnson suggested that the disease was "no very great danger", thus a "chicken" version of the pox

(b) The specks that appear looked as though the skin was pecked by chickens

(c) The disease was named after chick peas, from a supposed similarity to size of the seed with the lesions

(d) The term reflects a corruption of the Old English word “giccin”, which meant itching.

As "pox" also means curse, in medieval times some believed it was a plague brought on to curse children by the use of black magic.

## Etiology

VZV is a DNA virus also known as human herpes virus 3 (HHV-3), one of the eight herpes viruses known to affect humans and is member of the herpes virus group (4).

## Pathogenesis

VZV enters through the respiratory tract and conjunctiva. The virus is believed to replicate at the site of entry in the nasopharynx and in regional lymph nodes. A primary viremia occurs 46 days after infection and disseminates the virus to other organs, such as the liver, spleen, and sensory ganglia. Further replication occurs in the viscera, followed by a secondary viremia, with viral infection of the skin.

## Transmission

Chickenpox is a highly contagious disease that spreads from person to person by direct contact or through the air from an infected person's coughing or sneezing. Touching the fluid from a chickenpox blister can also spread the disease. It takes from 7-21 days after contact with an infected person for someone to develop chickenpox (5). The incubation period may be prolonged in immunocompromised patients and those who have received post exposure treatment with a varicella antibody containing product.

## Clinical Features

A mild prodrome may precede the onset of a rash. Adults may have 1 to 2 days of fever and malaise prior to rash onset, but in children the rash is often the first sign of disease. The rash is generalized and pruritic and progresses rapidly from macules to papules to vesicular lesions before crusting. Rash evolves into noninfectious dried crusts over a 5 to 6 days period (6). A thin-walled, clear vesicle (dew drop) develops on top of the area of redness. This "dew drop on a rose petal" lesion is very characteristic for chickenpox. The rash usually appears first on the head, then on the trunk, and then the extremities; the highest concentration of lesions is on the trunk **(centripetal distribution).** Lesions also can occur on mucous membranes of the oropharynx, respiratory tract, vagina, conjunctiva, and the cornea. Lesions are usually 14 mm in diameter. The vesicles are superficial and delicate and contain clear fluid on an erythematous base. Successive crops appear over several days, with lesions present in several stages of development. The clinical course in healthy children is generally mild, with malaise, pruritis, and temperature up to 102˚F for 23 days. Adults may have more severe disease and have a higher incidence of complications. Respiratory and gastrointestinal symptoms are absent. Children infected with human immunodeficiency virus also may have severe, prolonged illness. Although immunity following varicella infection is considered to be long lasting, second cases of varicella do occur rarely among immunologically normal persons (7).

### Complications

Varicella severity and complications are increased among immunocompromised persons, neonates, children less than 1 year of age, and adults(8, 9). However, healthy children and adults may also develop serious complications and even die from varicella (9, 10, 11, 12). Secondary bacterial infections of skin lesions with Staphylococcus or Streptococcus are the most common cause of hospitalization and outpatient medical visits. Central nervous system manifestations of varicella range from aseptic meningitis to encephalitis. Involvement of the cerebellum, with resulting cerebellar ataxia which is the most common complication. **Reye's syndrome** is an unusual complication of varicella and occurs almost exclusively in children who take aspirin during the acute illness. The etiology of Reye's syndrome is unknown.

## Communicability

The period of communicability extends from 1 to 2 days before the onset of rash through the first 4 to 5 days, or until lesions have formed crusts. Immunocompromised patients with varicella are probably contagious during the entire period when new lesions are appearing. The virus has not been isolated from crusted lesions. It is less contagious than measles, but more so than mumps and rubella. Secondary attack rates among susceptible household contacts of persons with varicella are as high as 90% (i.e. 9 of 10 susceptible household contacts of

persons with varicella will become infected).

### Congenital VZV Infection

Primary maternal varicella infection in the first 20 weeks of gestation is occasionally associated with a variety of abnormalities in the newborn, including low birth weight, hypoplasia of an extremity, skin scarring, localized muscular atrophy, encephalitis, cortical atrophy, chorioretinitis, and microcephaly. This constellation of abnormalities, collectively known as **congenital varicella syndrome**, was first recognized in 1947.

### Laboratory diagnosis

The clinical features of the disease are generally clearcut and laboratory diagnosis is not required. However the laboratory criteria for diagnosis is

(a) Positive serologic test for varicella - zoster immunoglobulin M (IgM) antibody.

(b) Isolation of varicella-zoster virus (VZV), demonstration of VZV antigen by direct fluorescent antibody (DFA) or by polymerase chain reaction (PCR) tests from a clinical specimen

(c) Significant rise in serum varicella immunoglobulin G (IgG) antibody level by any standard serological assay

However examination of vesicle fluid under direct microscope will show multinucleated giant cells, covered by Giemsa stain. The direct fluorescent antibody (DFA) test is the method of choice for rapid clinical diagnosis.

## Recurrent Disease (Herpes Zoster)

Herpes zoster, or shingles, occurs when latent VZV reactivates and causes recurrent disease. The immunologic mechanism that controls latency of VZV is not well understood. However, factors associated with recurrent disease include aging, immunosuppression, intrauterine exposure to VZV, and having had varicella at a young age (younger than 18 months). The vesicular eruption of zoster generally occurs unilaterally in the distribution of a sensory nerve. Most often, this involves the trunk or the fifth cranial nerve. Two to four days prior to the eruption, there may be pain and paresthesia in the involved area. There are few systemic symptoms (13).

## Vaccination

Vaccine effectiveness has been found most commonly in the range of 70%-86% for prevention of all disease with several lower estimates (40%-59%) and > 95% for severe disease (15). Varicella vaccine may be used either at an individual level to protect susceptible adolescents and adults, or at a population level, to cover all children as part of a national immunization programme. Vaccination of adolescents and adults will protect at-risk individuals, but will not have a significant impact on the epidemiology of the disease on a population basis. On the other hand, extensive use as a routine vaccine in children will have a significant impact on the epidemiology of the disease. If sustained high coverage can be achieved, the disease may virtually disappear. If only partial coverage can be obtained, the epidemiology may shift, leading to an increase in the number of cases in older children and adults.

The recommendations by WHO for varicella vaccine are :

(a) Most developing countries have other vaccine-preventable diseases that cause significantly greater morbidity and mortality, and varicella vaccine is not a high priority for routine introduction into their national immunization programmes.

(b) Routine childhood immunization against varicella may be considered in countries where this disease is a relatively important public health and socioeconomic problem, where the vaccine is affordable, and where high (85% - 90%) and sustained vaccine coverage can be achieved. (Childhood immunization with lower coverage could theoretically shift the epidemiology of the disease and increase the number of severe cases in older children and adults. )

(c) Additionally, the vaccine may be offered in any country to individual adolescents and adults without a history of varicella, in particular to those at increased risk of contracting or spreading the infection. This use in adolescents and adults entails no risk of an epidemiological shift, as childhood exposure to VZV remains unaffected.

Varicella vaccine (14)

| Type of vaccine | Live attenuated virus, Oka strain |
|---|---|
| **Number of doses** | One dose for persons aged under 13 years; two doses in adolescents and adults four to eight weeks apart, |
| **Schedule** | subcutaneous 1224 months of age for early childhood immunization |
| **Contraindications** | Pregnancy; reaction to previous dose (including reaction to a component such as gelatin); any advanced immune disorder or cellular immune deficiency; symptomatic HIV |

### MMRV Vaccine

MMRV vaccine is indicated for vaccination against measles, mumps, rubella and varicella in children 12 months to 12yrs of age. Persons 13 yrs of age and older should not receive MMRV. MMRV may be used for both the first and second doses of MMR and varicella in children younger than 13 years. The minimum interval between doses of MMRV is 3 months.

### Herpes Zoster Vaccine

Zoster vaccine is approved by FDA for persons 60 years and older. A single dose of zoster vaccine is recommended for adults 60 years of age and older whether or not they report a prior episode of herpes

zoster. Persons with a chronic medical condition may be vaccinated unless a contraindication or precaution exists for the condition.

**Post exposure Prophylaxis**

It is recommended to use varicella vaccine for susceptible persons following exposure to varicella and for outbreak control. If administered within 72 hours and possibly up to 120 hours following varicella exposure, varicella vaccine may prevent or significantly modify disease (16, 17, 18).

**Varicella Zoster Immune Globulin**

Varicella Zoster Immune Globulin (VZIG) is recommended for post-exposure prophylaxis of susceptible persons who are at high risk for developing severe disease and when varicella vaccine is contraindicated (12). VZIG is most effective in preventing varicella infection when given within 96 hours of varicella exposure.

## Steps for investigation and control of varicella outbreaks

**(a) Confirm outbreak, investigate all persons exposed in the outbreak, and determine varicella susceptibility.**

(i) Define cases and confirm outbreak.

(ii) Screen outbreak cohort for susceptibility to varicella.

- Use history of disease and vaccination
- Use serologic testing.

(iii) Investigate cases to characterize illness including onset, severity, duration, pre-existing medical conditions and medications, and complications.

**(b) Initiate outbreak control & treat cases (if appropriate)**

(i) Isolate or cohort infective cases.

(ii) Exclude non-vaccinated persons without history of disease.

(iii) Recommend treatment of active cases with antiviral therapy (adolescents and adults only).

(iv) Offer vaccine to susceptible persons.

(v) Offer VZIG to exposed, susceptible persons at high risk of severe disease.

**(c) Establish surveillance for :**

(i) Additional varicella cases

(ii) Vaccine-associated adverse events.

**(d) Analyze collected data.**

(i) Describe cases and transmission (date of rash onset, age, sex, severity, etc. ).

(ii) Describe serological status (if serology testing performed).

(iii) Evaluate outbreak control efforts.

### Chicken Pox (Varicella)

- Caused by varicella Zoster virus
- Transmitted from person to person by droplet infection and droplet nuclei
- Incubation period 7-21 days
- Latent infection produces Herpes zoster
- Action in an outbreak; Cases isolate, contacts surveillance and vaccination
- Complications vary by age
- During the disease aspirin should be avoided for fear

### Differential Diagnosis of Fever with Rash (19)

- Centrally distributed maculopapular eruptions (e.g. Measles & Rubella)
- Peripheral eruptions (e.g, Rocky Mountain spotted fever, secondary syphilis)
- Confluent desquamative erythemas (e.g Toxic shock syndrome)
- Vesiculobullous eruptions (e.g Varicella, Smallpox, Rickettsialpox)
- Urticarial eruptions : Hypersensitivity reactions are usually not associated with fever. The presence of fever suggests serum sickness, connective-tissue disease or infection (Hepatitis B, Enteroviral or Parasitic infection)
- Nodular eruptions (e.g disseminated candidiasis, Cryptococcosis, Erythema Nodosum, Sweet's Syndrome)
- Purpuric eruptions (e.g, Acute Meningococcemia,

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# Mumps

## Introduction

The name comes from the British word "to mump", that is grimace or grin. This results from the appearance of the patient as a result of parotid gland swelling. Mumps is a viral infection primarily affecting the salivary glands. In most instances mumps is a mild childhood disease. However, the mumps virus may also affect adults, among whom complications such as meningitis and orchitis are relatively common. Encephalitis and permanent neurological sequelae are rare complications of mumps. In most parts of the world, the annual incidence of mumps is in the range of 100 to1 000 per 100 000 population, with epidemic peaks every two to five years. Peak incidence is found among children five to nine years of age. (1)

## Epidemiology

The mumps virus belongs to the genus rubulavirus and is a part of the paramyxoviridae family. It is an enveloped, non-segmented, negative-sense RNA virus with helical symmetry. It has two major surface glycoproteins : the hemagglutinin-neuraminidase and the fusion protein. Mumps virus is sensitive to heat and ultraviolet light. Only one serotype is known. (2)

Mumps is endemic worldwide. In areas without childhood vaccination against mumps, epidemics occur every two to five years. (3). Before the 1960s, mumps was a common infectious disease in all parts of the world, with annual incidences usually ranging from approximately 0. 1% to1%, and up to 6% in certain populations. In hot climates the disease is endemic throughout the year, whereas in temperate climates incidence peaks in winter and spring. (1)

## Transmission

Humans are the only known natural host for mumps virus. The virus is spread via direct contact or by airborne droplets from the upper respiratory tract and requires more intimate contact for transmission than measles or chicken pox. Rarely, transmission can be fomite borne through articles freshly contaminated with saliva. Overcrowding resulting in close contact such as school classrooms, cinema halls, army barracks facilitates transmission. Persons with mumps are infective from about 2 days before the onset of swelling of the salivary glands up to 9 days after the onset of swelling.

## Pathogenesis

The primary site of viral replication is the upper respiratory tract or the gastrointestinal tract. The virus spreads rapidly to the local lymphoid tissue and a primary viraemia ensues following which the virus spreads to distant sites in the body. The parotid gland is most commonly involved. However the testis, epididymis, pancreas, ovary and CNS may also be involved. A few days after the onset of illness, virus can again be isolated from the blood, indicating that virus multiplication in target organs leads to a secondary viraemia. The virus is excreted in the urine in infectious form during the two weeks following the onset of clinical illness. Natural infection usually results in life long immunity.

## Clinical Features

The incubation time averages 16 to18 days with a range of 2 to 4 weeks. (1) With an overall mortality of only 1 per 10 000 cases, mumps is generally a mild, self limiting disease. (1). A prodromal illness of headache, malaise, myalgia and low grade fever occurs for one or two days before the onset of parotid enlargement. Cases of classic mumps develop enlargement of one parotid gland, followed a few days later by enlargement of the contralateral gland. The patient complains of pain and tenderness in the area of the gland. The sub-mandibular and sublingual glands may occasionally be involved. Parotid swelling develops in 95% of those with clinical illness. Up to 30% of patients may have no or very mild symptoms (sub-clinical cases). Most infections in children below two years of age are subclinical. In a small proportion of patients, the symptoms may resemble mild URTI. The parotid swelling starts to subside after 4 to 7 days and complete recovery usually takes another three days.

## Complications

Although the disease is usually mild, up to 10% of patients can develop aseptic meningitis. Encephalitis which can result in death or disability is a less common complication. Permanent deafness, orchitis, and pancreatitis are other untoward effects of mumps.

### Epididymo-orchitis

Epididymo-orchitis occurs in about 25% of postpubertal men who contract mumps. (4) Testicular atrophy occurs in about one-third of patients with mumps orchitis, but sterility is rare. Mumps orchitis appears to be a risk factor for testicular cancer, though not a major one (5). Oophoritis can occur in postpubertal; one study found mastitis in 31% of women over 14 years of age (6). Among women who acquire mumps during the first 12 weeks of pregnancy, more than a quarter suffer spontaneous abortion (7). Maternal mumps is not associated with congenital anomalies. (8, 9).

### Aseptic meningitis

Aseptic meningitis occurs in 10% of patients with mumps but as many as 50% show abnormalities in the CSF. (10, 11). The symptoms are similar to other types of aseptic meningitis and can start one week before parotid swelling to 3 weeks after it. The virus can be isolated from the CSF during the first 2 to 3 days after onset. Later, specific antibodies can be demonstrated in the CSF. Symptoms of meningitis subside three to 10 days after onset and recovery is usually complete. Encephalitis is a rare complication of mumps. The incidence of encephalitis is

around 1 in 6000 cases of mumps. (12, 13). Clinical features suggesting encephalitis are convulsions, focal neurological signs, movement disorder and changes in sensory perception.

Deafness

Deafness is a well-recognized complication of mumps. (14, 15). Before vaccinations, mumps used to be one of the leading causes of hearing loss in children and young adults. In most cases, the hearing loss is transient but permanent dysfunction may occur. Hearing problems did not correlate with meningitis and appears to be due to direct damage to the cochlea. The incidence of hearing loss is estimated to be in the region of 1 per 15, 000 cases.

Pancreatitis

The exact incidence of pancreatitis is hard to determine but is thought to be as high as 4%. 16). There is evidence suggesting that mumps virus can infect human pancreatic beta cells, and may trigger the onset of insulin-dependent diabetes mellitus in some individuals (17).

Arthralgia

Arthralgia affecting a large joint may develop 2 weeks after parotitis. They are more frequent in young male adults. Myocarditis can usually only be found on ECG examination in 10 - 15% of patients. Rarely, congestive heart failure and deaths have been reported. Transient renal dysfunction is a frequent complication of clinical mumps. Cases of symptomatic nephritis following mumps are unusual.

**Diagnosis**

Cases are commonly diagnosed based on history and clinical presentation and laboratory tests are unnecessary. For specific diagnosis, it is possible to isolate the virus from throat swabs, saliva, urine, and CSF. An assay for the detection of mumps-specific immunoglobulin M antibodies in serum and oral fluid specimens is commercially available. Diagnosis can also be made by significant rise between acute and convalescent phase titers in serum mumps IgG antibody level using any standard serologic assay or positive serologic test for mumps IgM antibody. Interpretation of titer rise may have limitations because of mumps cross-reaction with parainfluenza viruses. (1, 2). Mumps virus replicates in a variety of cell cultures as well as in embryonated hens eggs. For primary isolation in routine diagnostic virology, monkey kidney, human embryonic kidney or HeLa cell cultures are used. The presence of mumps virus in a cell culture may be detected by the hemadsorption inhibition (HAI) test. (1).

**Management**

Mumps is a mild, self limited disease. No specific anti – viral therapy is indicated. Treatment is conservative. Analgesics may be given for severe headaches or discomfort due to parotitis. In orchitis, stronger analgesics may be needed. Bed rest is recommended for a faster recovery.

**Prevention**

Deaths due to mumps are rare. However, the fact that in unvaccinated communities almost every person may get infected and infections are associated with a number of complications imposes a substantial economic burden on society (1). Effective vaccines against mumps and high vaccination coverage reduce the incidence of mumps to insignificant levels.

The first vaccine developed against mumps was a killed vaccine which was used in the United States between 1950 and 1978. This vaccine offered low efficacy and short term effectiveness. Since then, live attenuated mumps virus vaccines have been developed based on several different strains. The common ones are the Jeryl-Lynn strains, RIT 4385 strains, Leningrad-3 strains, L-Zagreb strains, Urabe strains & the Rubini strains. (1).

The recommended use is the form of a single dose schedule, given at age 12-18 months. This is because persistent maternal antibody to mumps virus from previous infection or vaccination interferes with the response to mumps vaccines in young infants. Mumps vaccines are available as monovalent, bivalent measles-mumps (MM) and trivalent measles-mumps-rubella (MMR) vaccines. Most of these vaccines contain more than 1 000 cell-CCID50 of attenuated mumps virus per dose. The trivalent MMR vaccine is given as 0. 5 ml subcutaneously in the outer aspect of upper arm between 12 to 15 months of age. In India the MMR vaccine is manufactured by the Serum Institute of India. The strains used are L Zagreb for mumps, Edmonston Zagreb for measlesa and Plotkins RA 27/3 for rubella. Being live vaccines, these have exacting storage requirements. They should be protected from heat and light both before and after reconstitution. Reconstituted vaccine must be discarded if not used within 6 hours.

There are very few contraindications to mumps vaccination. Like all other live vaccines the mumps vaccine should not be administered to immunocompromised individuals. MMR vaccine can be given to individuals infected with human immunodeficiency virus (HIV) and who are not severely immunocompromised (35). Though the vaccine has no known teratogenic effects, the mumps vaccine should not be administered to pregnant women and pregnancy should be avoided for three months after vaccination (18).

The mumps vaccine has proven to be extremely safe, adverse effects are rare and mild. The most common adverse reactions following mumps vaccination are parotitis and low-grade fever. Aseptic meningitis following vaccination has been reported at widely varying frequencies. Vaccine-associated meningitis usually resolves spontaneously in less than a week without any sequelae. Orchitis and sensory-neural deafness have been reported following mumps vaccination.

Immunoglobulin has not been demonstrated to be of established value in post exposure prophylaxis and is not recommended.

**Control**

The World Health Organization (WHO) believes that

mumps can be controlled through high routine coverage with mumps vaccine administered at age 12-18 months. Coverage rates below 70%-80% may result in an epidemiological shift, as reduced (but not interrupted) circulation of mumps virus in the community may result in an increased number of cases in adults without immunity from natural infection. It considers the addition of mumps vaccine to the measles and rubella vaccination programmes using the MMR combined vaccine as logistically sound, encourages the use of MMR

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Wg Cdr Rajesh Vaidya

# Meningococcal Meningitis

## Introduction

Meningitis, or inflammation of the meninges, can be caused by several different bacterial pathogens. By far, the most important of these pathogens is *Neisseria meningitidis* because of its potential to cause epidemics (1). Meningococcal meningitis occurs worldwide in both endemic and epidemic forms. It is estimated to be responsible for over 500, 000 cases and about 135, 000 deaths annually (2). First isolated in 1887, *Neisseria meningitidis*, is an exclusive human pathogen with the mucosal surfaces of the human nasopharynx being its natural habitat and reservoir (3). In most cases colonization of the human nasopharynx is asymptomatic. However, blood stream invasion by *Neisseria meningitidis* can lead to meningitis and septicaemia with serious consequences. Even with adequate chemotherapy, meningococcal meningitis has a fatality rate of about 10% and about 15% of the survivors have residual central nervous system (CNS) damage (4). The disease has special significance for the Armed Forces since outbreaks frequently occur among persons living in close proximity such as military barracks.

## Agent

*Neisseria meningitidis* are bean shaped, gram negative, aerobic diplococci. The bacteria are surrounded by an outer membrane of lipids, membrane proteins and lipopolysaccharides. Pathogenic meningococci are enveloped by a polysaccharide capsule (5). The capsular polysaccharide provides the basis for their classification into serogroups (6). They differ in their agglutination reactions to sera directed against polysaccharide antigens. At least 13 serogroups have been described : A, B, C, D, E, H, I, K, L, W-135, X, Y and Z. Almost all meningococcal infections are caused by five serogroups A, B, C, 29E or W-135 (7).

## Host Factors

Maternal antibodies offer protection against invasive disease till the age of six months. Susceptibility peaks at age 6-12 months and decreases again after colonization of closely related nonpathogenic bacteria. Subsequent colonization with *Neisseria meningitidis* induces antibodies to the infecting strain, thus reinforcing natural immunity. Invasive disease occurs if no protective bactericidal antibodies are mounted against the infecting strain (7). Those infected with the human immunodeficiency virus are probably also at increased risk for sporadic meningococcal disease (8).

Incidence rates are highest between the age of six months and two years (8). The disease is rarely reported in individuals over 50 years of age. There appears to be no gender predilection, though males account for slightly more than half the reported cases (7). Smoking, both active and passive, antecedent upper respiratory tract infection, underlying chronic illnesses are all associated with increased risk of meningococcal disease (8). Low socioeconomic status with its attendant attributes of poor housing, overcrowding, and inadequate ventilation have been consistently found to be associated with higher risk for meningococcal disease (9, 10).

## Environmental Factors

Individuals acquire the infection if they are exposed to virulent bacteria and have no protective bactericidal antibodies. Smoking and concurrent viral infection of the upper respiratory tract diminish the integrity of the respiratory mucosa and increase the likelihood of invasive disease. Crowded living conditions also facilitate disease spread, since individuals from different areas have different strains of meningococci. The risk of invasive disease is higher in the first few days after exposure to a new strain.

## Epidemiology

Worldwide serogroups A, B and C account for most cases of meningococcal disease The predominant serogroups in Asia and Africa are A and C while serogroups B and C are responsible for the majority of cases in Europe and the Americas (8, 11-13). Recent outbreaks among Haj pilgrims have been attributed to serogroup W135 (8). Epidemic rates of meningococcal disease varies from <1-3/100,000 in many developed nations to 10-25/100,000 in some developing countries.

The highest level of meningococcal disease occurs in the 'African meningitis belt', which stretches across sub-Saharan Africa from Senegal in the west, to Ethiopia in the east. During epidemics this region has a disease incidence rate of >1,000 cases per 10,000 population (14). The largest recorded outbreak of meningococcal disease in history occurred in Africa in 1996 where 250,000 cases including 25,000 deaths were reported to the WHO.

Major epidemics of menincococcal meningitis have been reported from Asia over the past 35 years. China, Vietnam, Mongolia, Bhutan, and Nepal have all reported large outbreaks with Serogroup B being implicated most often (8).

Isolated cases of meningococcal meningitis have been reported from many Indian states including Haryana, Uttar Pradesh, Rajasthan, Sikkim, Gujarat, Jammu & Kashmir, West Bengal, Chandigarh, Kerala and Orissa (8). Serogroup A has been associated with all the repeated outbreaks of meningitis, although serogroup B and C have been detected in a few sporadic cases (15, 16). Several outbreaks of meningococcal meningitis have been reported from Delhi in 1966, 1985 and 2005 (8).

## Transmission

The main modes of transmission are direct contact and respiratory droplets. Respiratory droplets produced by coughing and sneezing can be transmitted to non immune hosts within a distance of one meter. Close contact like kissing, living in close quarters (like military dormitories) and sharing of utensils enhance the risk of transmission

(1).

The average incubation period is 3 – 4 days with a range of 2 to 10 days (1). This is also the period of communicability. The bacteria are rapidly eliminated from the nasopharynx after starting antibiotics, usually within 24 hours. Humans are the only reservoir. Both cases and carriers serve as the source of infection. 5 – 10% adults are asymptomatic nasopharyngeal carriers during inter-epidemic periods. This figure can, however, rise to 60 – 80% in closed populations like military recruits in camps (7).

### Pathophysiology

For invasive disease to occur, a susceptible host must be exposed to a pathogenic strain, be colonized by the pathogenic strain on the naso-oropharyngeal mucosa followed by invasion by the bacteria. Invasion can be subdivided into mucosal penetration followed by invasion of blood stream and finally, invasion of meninges (8). Meningococci overcome host defenses and attach to the microvillous surface of nonciliated columnar mucosal cells of the nasopharynx, where they multiply. Binding stimulates engulfment of the meningococci by epithelial cells, which may then traverse the mucosal epithelium. In most persons coloniozation of the nasopharynx is an immunizing process, resulting in a systemic protective antibody response. In a small proportion of those infected, *N. meningitidis* penetrates the mucosa and gains access to the bloodstream, causing systemic disease (6). Systemic disease appears with the development of meningococcemia and usually precedes meningitis by 24 to 48 hours. This can lead to systemic infection in the form of bacteremia, involvement of the meninges or severe systemic infection with circulatory collapse and disseminated intravascular coagulation. Meningococcemia leads to diffuse vascular injury (7).

### Clinical Features

The most common symptoms are acute onset of intense headache, high fever, nausea, vomiting, sensitivity to light (photophobia), and stiff neck. These symptoms can develop over several hours, or they may take 1-2 days. Most adult patients have an altered mental state with clinical signs of nuchal rigidity. Less commonly reported symptoms include stupor or coma, which carries a poorer prognosis. A more severe form of meningococcal disease is meningococcal septicaemia which is characterized by a haemorrhagic rash which usually indicates disease progression and rapid circulatory collapse.

In Infants and young children bacterial meningitis usually presents as a subacute infection that progresses over several days. There is a slower onset of signs and symptoms with nonspecific symptoms and neck stiffness may be absent. Irritability and projectile vomiting may be the presenting features in this age group. Seizures occur in 40% of children with meningitis. The Waterhouse-Friderichsen syndrome may develop in 10-20% of children with meningococcal infection. This syndrome is characterized by large petechial hemorrhages in the skin & mucous membranes, fever, septic shock & DIC (7).

Even when the disease is diagnosed early and adequate therapy instituted, 5% to 10% of patients die, typically within 24-48 hours of onset of symptoms. Bacterial meningitis may result in brain damage, hearing loss, or learning disability in 10 to 20% of survivors (1)

### Diagnosis

The diagnosis of meningococcal meningitis is suspected by the clinical presentation and a lumbar puncture showing a purulent spinal fluid. Typical CSF abnormalities in meningitis include the increased pressure (>180 mm water), WBC counts between 10 and 10, 000 cells/μL, (predominantly neutrophils), decreased glucose concentration (<45 mg/dL), and increased protein concentration (>45 mg/dL) (7).

Bacteriological diagnosis in patients with meningococcal disease can be done by Gram staining, direct antigen detection using latex agglutination, or culture. Blood cultures may not be always revealing and only CSF samples are generally positive. Molecular diagnosis using polymerase chain reaction (PCR) has also been used. As soon as the CSF has been collected, it should be transported to the microbiology laboratory, where it should be examined within one hour from the time of collection. In case, delay of several hours is anticipated, the sample may be incubated at 35°C in a 5% $CO_2$ atmosphere.

Gram staining of cerebrospinal fluid is still considered an important method for rapid detection of *N meningitides*. However, definitive diagnosis of meningococcal disease has relied on bacteriologic culture. Gram stain is positive in 70-90% of untreated cases, and culture results are positive in as many as 80% of cases (7). However, the sensitivity of culture may be low, especially when performed after the initiation of antibiotic treatment. However culture from skin biopsy specimens or antigen detection or PCR in blood or CSF are not affected by prior antibiotic administration (8, 17-20).

Commercially available kits to detect polysaccharide antigen in cerebrospinal fluid, have been used to enhance the laboratory diagnosis. These methods are rapid and specific and can provide a serogroup-specific diagnosis, but false negative results are common (20). Polymerase-chain-reaction (PCR) analysis offers the advantages of detecting serogroup-specific *N meningitidis* DNA and of not requiring live organisms for a positive result.

### Management

Meningococcal disease is potentially fatal and should always be viewed as a medical emergency. Management of meningococcal disease requires early recognition of the disease, prompt initial parentral antibiotic therapy and close monitoring with frequent repeated prognostic evaluations. Admission to a hospital centre is essential. Isolation of the patient is not necessary. Antimicrobial therapy must be commenced as soon as possible after the lumbar puncture has been carried out. Several antibiotics can be used for treatment including penicillin, ampicillin, chloramphenicol, and ceftriaxone (1). A single intramuscular dose of an oily suspension of

chloramphenicol has been shown to be as effective as a five-day course of crystalline penicillin in the treatment of meningococcal meningitis. During epidemics, this may offer a practical alternative to penicellin or ceftriaxone which require multiple injections (21).

Because of the risks of severe illness and death effective antibiotics should be promptly administered in patients suspected of having meningococcal disease. Standard empirical therapy varies according to age. In infants younger than 4 weeks, it consists of ampicillin plus cefotaxime or an aminoglycoside. Infants aged 4 to12 weeks should be treated with ampicillin plus a third-generation cephalosporin. In children aged 12 weeks to 18 years, a third-generation cephalosporin or ampicillin plus chloramphenicol is an appropriate combination. Adults should be treated with a third-generation cephalosporin, while individuals older than 50 years should be treated with ampicillin plus a third-generation cephalosporin. Once the accurate diagnosis of meningococcal meningitis is established, appropriate changes can be made. Currently, penicillin is the drug of choice for the treatment of meningococcal meningitis and septicemia (7).

The adult dose of penicillin is 4 million units IV four times a day. The paediatric dose is 250,000 Units/kg/day given intravenously in divided doses. For Ceftriaxone the adult dose is four gram IV per day divided into two doses. Paediatric dose is 50 mg/kg IV divided into two doses (not to exceed 4 g/d).

The use of corticosteroids has not been shown to be effective for meningococcal meningitis and its use remains controversial.

### Prevention and Control

#### Chemoprophylaxis

Chemoprophylaxis is the preferred means of prevention of disease among close contacts of sporadic cases. Household contacts, contacts at day care centers and anyone else directly exposed to an infected patient's oral secretions should be administered chemoprophylaxis as soon as possible (ideally within 24 hours). Chemoprophylaxis has probably limited or no benefit if given more than 14 days after the onset of disease. Antibiotics that can be used for chemoprophylaxis are rifampin, ciprofloxacin, ceftriaxone, minocycline, ofloxacin, and spiramycin. Ciprofloxacin single oral dose of 500 mg, rifampicin 600 mg 12 hourly for two days, or ceftriaxone 250 mg IM single dose are the options for adults. Rifampicin should be avoided during pregnancy. The choices for children include rifampicin 10 mg/Kg 12 hourly for two days (5mg/Kg for infants), or injection ceftriaxone 125 mg IM single dose (22, 23).

Chemoprophylaxis is not recommended during epidemics because of multiple sources of exposure and prolonged risk of exposure. Logistic problems and high cost also make this an impractical alternative for mass use. It is not an effective means of interrupting transmission during an epidemic.

Chemoprophylaxis may prevent secondary cases among close contacts but, since secondary cases comprise less than 2% of all meningococcal disease, chemoprophylaxis is of little value for the control of most endemic and epidemic disease. As almost 15% of children and young adults carry meningococci in the nasopharynx, control of meningococcal disease based on chemotherapeutic elimination of nasopharyngeal carriage is practically impossible except in small communities. Immunization using safe and effective vaccines is the only rational approach to the control of meningococcal disease (24).

### Meningococcal Vaccines

Invasive disease occurs only in patients without specific bactericidal or opsonizing antibodies and therefore, can be prevented by inducing these antibodies. Of the five common serotypes responsible for more than 90% of meningococcal disease, vaccines are available for group A, C, Y and W-135. At present two types of meningococcal vaccines are licensed; meningococcal polysaccharide vaccines (bivalent and quadrivalent) and meningococcal conjugated polysaccharide vaccine.

#### Polysaccharide Vaccines

Bilvalent polysaccharide vaccines provide protection against serogroups A and C, while the quadrivalent polysaccharide vaccines provide protection against serogroups A, C, Y and W-135. The vaccines are purified, heat-stable, lyophilized capsular polysaccharides from meningococci of the respective serogroups. The recommended single dose of the reconstituted vaccine contains 50 µg of each of the individual polysaccharides. The dose for primary vaccination for both adults and children older than two years is a single 0. 5-mL subcutaneous injection. The vaccine can be administered at the same time as other vaccines but should be given at a different anatomic site. The antibody responses to each of the four polysaccharides in the quadrivalent vaccine are serogroup-specific and independent. Protective levels of antibody are usually achieved within 7-10 days of vaccination. These unconjugated polysaccharide vaccines confer protection in complement deficient persons also. The serogroup A and C vaccines have good immunogenicity, with clinical efficacy rates of 85% to 100% among children five years of age or older and adults. Serogroup Y and W-135 polysaccharides are safe and immunogenic in older children and adults. Vaccination does not reduce the transfer of bacteria to non-vaccinated persons and carrier status is unaffected. Vaccination has been highly effective in the control of community outbreaks and epidemics in military centers (8, 23, 24).

The vaccine is extremely safe. Adverse effects are mild, the most frequent reaction being pain and redness at the site of injection, lasting for a couple of days. Severe reactions to polysaccharide meningococcal vaccine are uncommon. The major drawback of the presently available vaccines is the absence of activity against group B meningococci (8, 23, 24).

#### Conjugated polysaccharide vaccine

A quadrivalent A, C, Y and W-135 conjugate vaccine has been licensed since January 2005. This vaccine contains 4 µg each of A, C, Y and W-135 polysaccharide conjugated to

48 µg of diphtheria toxoid. The meningococcal conjugate vaccines induce a T-cell-dependent response, resulting in an improved immune response in infants, priming immunologic memory and leading to a booster response to subsequent doses. These vaccines provide long-lasting immunity even when given as a series in infancy and thus induce herd immunity through protection from nasopharyngeal carriage. Nasopharnygeal carriage rates may also be decreased by use of the conjugate vaccine, reducing bacterial transmission. The conjugated polysaccharide vaccine is contraindicated in patients with a known hypersensitivity to any component of the vaccine, including diphtheria toxoid and in patients with a history of a severe reaction to any other vaccine containing similar components (23, 24)

Recommendations for use of meningococcal vaccine

Routine childhood vaccination with the meningococcal polysaccharide vaccine is not recommended because of its relative ineffectiveness in young children below two years of age. Large scale coverage with current vaccines does not provide sufficient "herd immunity". Consequently, WHO does not currently recommend meningococcal polysaccharide vaccine as part or routine infant immunization (24).

Routine vaccination with the vaccine is recommended for certain high-risk groups, including persons who have terminal complement component deficiencies and those who have anatomic or functional asplenia. Laboratory personnel and healthcare workers who are exposed routinely to *Neisseria meningitidis* in solutions that may be aerosolized should also be considered for vaccination (23).

Vaccination with a single dose of polysaccharide vaccine is recommended for travelers above 18 months of age going to an area experiencing an epidemic of meningococcal disease or to areas with a high rate of endemic meningococcal disease. Since the epidemic of meningococcal disease that occurred in 1987 during the Hajj in Mecca, proof of vaccination against meningococcus has been required for the pilgrims to the Hajj or Umra, at their entry in Saudi Arabia. More information concerning geographic areas for which vaccination is recommended can be obtained from internet (http : //www. cdc. gov/travel/).

Revaccination may be indicated for persons at high risk for infection (living in endemic areas) particularly for children who were first vaccinated when they were less than four years of age; such children should be considered for revaccination after 2-3 years if they remain at high risk

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# Tuberculosis

## Introduction

Tuberculosis (TB) is one the biggest public health challenges facing the world today. It is one of the oldest diseases known to mankind. Its causative organism *Mycobacterium tuberculosis* was one of the first bacterial pathogens to be identified. The etiopathogenesis of the disease is clearly understood. A vaccine against tuberculosis has been available for close a century. Effective treatment against the disease has been available for over sixty years. Yet the disease is close to its highest levels ever and the World Health Organization declared TB as a global public health emergency in 1993. It remains a potentially fatal disease which is transmitted by droplet nuclei after close contact with a person who has infectious disease. Treatment requires prolonged multidrug therapy which increases the potential risk of nonadherence by patients. Tuberculosis is a true indicator for social development. An overwhelming majority of cases and practically all deaths due to tuberculosis take place in developing countries (1 - 4).

Tuberculosis is currently second only to AIDS as an infectious cause of death worldwide. The World Health Organization estimates that the disease killed 1.7 million people in 2006 (1). The silver lining is that the number of new cases per capita appears to have been falling globally since 2003 (1).

The organism can infect practically any organ of the body. However, pulmonary tuberculosis accounts for over eighty per cent of the total cases suffering from tuberculosis. The other common forms of tuberculosis are meningeal, bone and joint, renal, genital, abdominal or mesenteric and tubercular lymphaedenopathy (1, 2). Tuberculosis is the commonest opportunistic infection in patients suffering from AIDS in large parts of the world. The association with HIV infection has refocused global attention on tuberculosis.

## History

Tuberculosis has been known by a number of names through history. The ancient Greeks called it phthisis (to waste). The swollen glands of the neck due to tuberculosis were called scrofula. TB of the skin was known as lupus vulgaris. TB of the bone is known as Pott's disease with characteristic vertebral fusion and deformity of the spine. The most familiar term for TB was consumption, which means to consume or wear away. Among all these names, perhaps the most fitting is 'Captain of the Men of Death'.

*Mycobacterium tuberculosis* has been present in the human population since antiquity. There is evidence of the disease in fragments of the spinal column from Egyptian mummies from 2400 B.C. which show definite pathological signs of tubercular decay (5). Around 460 B.C. , Hippocrates identified phthisis as the most widespread disease of the times, and noted that it was almost always fatal. Sylvius was the first to identify actual tubercles in the lungs and other areas of consumptive patients in 1679. He also described their progression to abscesses and cavities. In 1882, Robert Koch discovered a staining technique that enabled him to see *Mycobacterium tuberculosis* (6).

## Epidemiology

### World

Tuberculosis has been controlled almost completely in the developed world. Almost all the case and practically all deaths due to tuberculosis take place in developing countries. Though the absolute numbers of cases and deaths are the largest in Asia, the rates of disease and deaths are the highest in Africa.

The latest WHO report on Tuberculosis states that the disease is a major cause of illness and death worldwide, especially in Asia and Africa. A total of 9.2 million new cases (139 per 1,00,000 population) and 1.7 million deaths from TB occurred in 2006, of which 0.7 million cases and 0.2 million deaths were in HIV - positive people. 44% of the new cases were smear positive (1). The increase in the number of cases as compared to the previous year (2005) is attributed to population growth. India, China, Indonesia, South Africa and Nigeria rank first to fifth respectively in terms of absolute numbers of cases. The African Region has the highest incidence rate per capita (363 per 1,00,000 population).

The 2007 estimate is that 8.8 million new TB cases occurred of which 7.4 million occurred in Asia and Sub-Saharan Africa with 1.6 million deaths (7). In 1993, tuberculosis was declared a global public health emergency (2, 8). In Aug 2005 the WHO declared a tuberculosis emergency in Africa (9). One - third of the world's population is already infected with TB. Over the centuries, TB has taken over 1 billion lives. Deaths due to tuberculosis comprise 25% of all avoidable deaths in developing countries. 95% of TB cases and 98% of TB deaths are in developing countries. 75% of TB cases in developing countries are in the economically productive age group of 15 - 50 years (1).

The largest number of cases occur in South East Asia which accounts for 34% of incident cases globally. In 2007 there were an estimated 5.7 million cases in the region. Every year, 3 million people develop active TB in the region and more than 50,000 die. 80% of the patients are in the age group 15 - 54 years. Bangladesh, India, Indonesia, Myanmar and Thailand account for 95% cases (7). However, the estimated incidence per capita in Sub - Saharan Africa is nearly twice that of South East Asia at 350 cases per 1,00,000 population (2). As with cases of disease, the highest number of estimated deaths due to tuberculosis is in the South - East Asia Region, but the highest mortality per capita is in the Africa Region, where

HIV has led to rapid increases in the incidence of TB and increases the likelihood of dying from TB (1, 2, 7).

Despite these high numbers of cases and deaths the WHO believes that the global incidence of TB per capita peaked around 2003 and appears to have stabilized or begun to decline. Incidence per 1,00,000 population is falling in almost all parts of the world except Eastern Europe where it is stable. The downward trend is most pronounced in Latin America and the Caribbean ( 3.4% per year, 2001 - 2006). However, the slow decline in incidence is more than offset by the global population growth. This resulted in an increase in the number of new cases from 9.1 million in 2005 to 9.2 million in 2006. While there has been a tremendous decrease in tuberculosis cases in developed countries in the last forty years, there has been an increase in the absolute number of tuberculosis cases in developing countries (1).

It is estimated that between 2002 and 2020, approximately 1 billion people will be newly infected, over 150 million will get sick, and 36 million will die of TB, if control is not further strengthened (2).

India

Tuberculosis is the biggest public health problem in the country. With 1.8 million cases occurring annually, India accounts for a fifth of the world's new TB cases and 2/3rd of the cases in South - East Asia. This makes India the highest TB burden country in the world. It has been estimated that for the year 2000 there were about 3.8 million bacteriologically positive TB cases in the country (10). Overall prevalence of infection in India is estimated to be 30% while the annual incidence of infection is estimated to be 1 - 2 %. The prevalence of disease is thought to be 4 per 1000 and the incidence of disease 1.5 per 1000. The prevalence of infection has been found to be increasing with age. The peak age for males is 45 - 54 years and that for females is 35 years. No rural - urban differences in rate have been found.

TB kills more adults than any other infectious disease in India. Because it affects adults, tuberculosis causes enormous social and economic disruption. Prior to 2000, the annual number of deaths due to tuberculosis was estimated to be 5,00,000. This has been revised downwards to 3,70,000 as per WHO estimates in 2004 (mortality rate 30 per 1,00,000 persons). More than 80% of the burden of tuberculosis is due to premature death, as measured in terms of disability adjusted life years (DALYs) lost. In India, over 70% of the cases occur in the economically productive age group (15 - 54 years). TB causes huge economic loss with about 17 crore workdays lost due to the disease. The annual economic cost of tuberculosis to the Indian economy is at least US$ 3 billion (more than Rs 13,000 crore) (10). The burden of TB is enormous but is hidden by stigma. TB kills more women in India than any other infectious disease. Women with tuberculosis are often severely stigmatized.

**Armed Forces**

In the Armed Forces the prevalence has been much lower owing to the initial selective recruitment, much better living standards, better general nutrition, and comparative seclusion from the general population. The prevalence fluctuates between 1 and 3 per 1000 population (11, 12).

**Agent**

Human tuberculosis is caused by *Mycobacterium tuberculosis* which belongs to the genus *Mycobacterium*, family *Mycobacteriaceae* and Order *Actinomycetales*. *Mycobacterium tuberculosis* is Gram positive, non - motile, non - sporing, pleomorphic rod. The bacilli are obligate aerobes growing most successfully in tissues having the highest partial pressure of oxygen, such as lung apices. They are facultative intracellular pathogens, slow - growing with a generation time of 12 to 18 hours. Hence, lesions typically evolve in a sub - acute to chronic course. They are classified as acid - fast bacilli (AFB) because they retain the carbol - fuchsin red dye after washing with acid, alcohol, or both (3, 4).

*Mycobacterium bovis* is the etiologic agent of TB in cows and rarely in humans. Both cows and humans can serve as reservoirs. Humans can also be infected by the consumption of unpasteurized milk. *Mycobacteriun africanum* can be a rare cause of tuberculosis. Other human pathogens belonging to the *Mycobacterium* genus include *Mycobacterium avium* which causes a TB - like disease especially prevalent in AIDS patients, and *Mycobacterium leprae*, the causative agent of leprosy.

**Host**

Tuberculosis can occur at any age. In India disease prevalence is more in the older age groups. It occurs in both the sexes and it is not a hereditary disease. Man has no inherited immunity against tuberculosis. It is now known that both delayed hypersensitivity and acquired resistance to tuberculosis are cell mediated immune responses. Persons who are undernourished and suffering from silicosis, diabetes, myxoedema, HIV infection or under immuno - suppressive drugs are more susceptible (3, 4). Tuberculosis has often been described as a barometer of social welfare. It strikes poor people and those who do not have access to health care. The highest burden of tuberculosis is in the most impoverished countries. Poor housing and overcrowding are closely associated with transmission of infection.

**Mode of Transmission**

The source of infection is an open case (sputum positive) of pulmonary tuberculosis. *Mycobacterium tuberculosis* is spread by airborne particles, known as droplet nuclei that can be generated when persons with pulmonary or laryngeal TB sneeze, cough, speak, or sing. It has been estimated that a cough can generate 3000 droplet nuclei. The same number is generated by a person talking for five minutes (13). Persons who share the same airspace with persons with infectious TB disease are at greatest risk for infection. Infection occurs when a susceptible person inhales droplet nuclei containing tubercle bacilli and these bacilli become established in the alveoli of the lungs and

spread throughout the body. Prolonged household contact with an open case may lead to infection. Fomites do not play any role in transmission of the disease. Ingestion of unpasteurized milk or dairy products may lead to infection by *M bovis*. Direct inoculation though the skin can also lead to infection. However both these modes of transmission probably cause a very small number of cases (3, 7).

### Pathogenesis of TB

Primary infection occurs on first exposure to tubercle bacilli. Inhaled droplet nuclei are so small that they avoid the muco - ciliary defenses of the bronchi and lodge in the terminal alveoli of the lungs. Infection begins with multiplication of tubercle bacilli in the lungs. This is the Ghon focus. Lymphatics drain the bacilli to the hilar lymph nodes. The Ghon focus and related hilar lymphadenopathy form the primary complex. Bacilli may spread in the blood from the primary complex throughout the body. The immune response (delayed hypersensitivity and cellular immunity) develops about 4 - 6 weeks after the primary infection. The size of the infecting dose of bacilli and the strength of the immune response determine the course following primary infection. In most cases, the immune response stops the multiplication of bacilli. However, a few dormant bacilli may persist. A positive tuberculin skin test would be the only evidence of infection. The immune response in a few cases is not strong enough to prevent multiplication of bacilli and disease occurs within a few months (14).

#### Post - primary TB

Post - primary TB occurs after a latent period of months or years after primary infection. It may occur either by reactivation or by reinfection. Reactivation means that dormant bacilli persisting in tissues for months or years after primary infection start to multiply. This may be in response to a trigger, such as weakening of the immune system by HIV infection. Reinfection means a repeat infection in a person who has already previously had a primary infection. Post - primary TB usually affects the lungs but can involve any part of the body. The characteristic features of post - primary PTB are extensive lung destruction with cavitation, positive sputum smear, upper lobe involvement with usually no intrathoracic lymphadenopathy (14). Extra - pulmonary TB can affect the lymph nodes, pleura, bones and joints, the genito - urinary tract, the nervous system (meningitis), intestines etc. If untreated, TB leads to death within 2 - 3 years in at least half the patients (15).

### Management

Diagnosis and treatment of cases of tuberculosis is carried out in accordance with the guidelines issued by the Revised National Tuberculosis Control Programme. The following have been extracted from the Technical and Operational Guidelines for Tuberculosis Control issued by Central TB Division, Directorate General of Health Services, Ministry of Health and Family Welfare, Nirman Bhavan, New Delhi in October 2005 (15).

### Diagnosis

#### Identification of tuberculosis suspects

Most patients with TB visit health facilities promptly after symptoms occur. Hence, every adult patient with respiratory symptoms attending the health facility must be asked about symptoms suggestive of tuberculosis. The most common symptom of pulmonary TB is a persistent cough for 3 weeks or more, usually with expectoration. It may be accompanied by one or more of the following symptoms such as weight loss, chest pain, tiredness, shortness of breath, fever, particularly with rise of temperature in the evening. In some cases there will be blood in the sputum, loss of appetite and night sweats. About 2 - 3% of new adult outpatients in a general health facility are expected to have cough for 3 weeks or more and on an average 10% of the suspects are expected to have sputum positive pulmonary TB.

#### Case finding tools

The main tools for diagnosing pulmonary TB are sputum smear microscopy, chest X-ray, and culture of *Mycobacterium tuberculosis* bacilli.

#### Sputum smear microscopy

This is the primary tool for diagnosing TB as it is easy to perform at the peripheral laboratories, not expensive and specific with low inter and intra reader variation. It is simple and requires minimum training and can be used for diagnosis, monitoring and defining cure. Therefore, this is the key diagnostic tool used for case detection in RNTCP. If good diagnostic practices are followed, it is expected that at least 50% of the new pulmonary TB patients diagnosed will be smear - positive.

#### Chest X - ray

X - ray as a diagnostic tool is sensitive but less specific with large inter and intra reader variations. No shadow is typical of TB. 10 - 15% culture - positive cases remain undiagnosed and 40% patients diagnosed as having TB by X - ray alone may not have active TB disease. It is supportive to microscopy.

#### Culture

Culture of *Mycobacterium tuberculosis* bacilli is very sensitive and specific but is expensive as it requires a specialized laboratory set - up and results are available only after several weeks. If available, culture of tubercle bacilli may be helpful, although in sputum - negative cases a clinical decision to treat for TB based on X - ray findings and lack of response to broad - spectrum antibiotics would be more practical and also ensure prompt treatment. Culture and sensitivity testing is valuable for diagnosis and management of drug resistant tuberculosis, besides epidemiological surveillance and planning.

#### Tuberculin test

Tuberculin test may be useful as an additional tool for diagnosing pediatric TB, in whom a positive test is more likely to reflect recent infection with TB and indicates a much higher risk of developing disease. However, the tuberculin test has no role in diagnosing adult pulmonary TB disease in India.

### Diagnosis by Sputum Microscopy

Microscopic examination of sputum is, as a rule, the only way by which the diagnosis of pulmonary TB can be confirmed. Whenever TB is suspected, at least 3 specimens of sputum should be collected over 2 consecutive days and examined by microscopy. Only one laboratory form needs to be filled for all the three specimens of the patient. The smears are fixed by drying or heating and stained with the Ziehl - Neelsen (ZN) stain & examined under the oil immersion lens of a microscope. The interpretation of the slides is as given in Table - 1.

Table - 1: Reporting of Smears

| Examination finding | Result Recorded | Grading | No. of fields examined |
|---|---|---|---|
| > 10 AFB per oil immersion field | Positive | 3+ | 20 |
| 1 - 10 AFB per oil immersion field | Positive | 2+ | 50 |
| 10 - 99 AFB per 100 oil immersion fields | Positive | 1+ | 100 |
| 1 - 9 AFB per 100 oil immersion fields | Positive | Scanty | 100 |
| No AFB in 100 oil immersion fields | Negative | Negative | 100 |

### Classification of tuberculosis cases

The treatment of tuberculosis under the RNTCP is standardized into different categories. It is important to classify a patient into the correct category so that he may receive the correct combination of drugs and duration of treatment. Classification of pulmonary cases should be based on at least 3 sputum smear examinations. Sputum should also be examined for cases of suspected extra - pulmonary TB if pulmonary symptoms are present.

Pulmonary tuberculosis

#### Smear - positive patient

A patient with at least 2 initial sputum smear examinations (direct smear microscopy) positive for acid - fast bacilli (AFB) OR A patient with one sputum examination positive for AFB and radiographic abnormalities consistent with active pulmonary TB as determined by the treating Medical Officer (MO) OR A patient with one sputum specimen positive for AFB and culture positive for *M. tuberculosis.*

#### Smear - negative patient

A patient having symptoms suggestive of TB with at least 3 sputum examinations negative for AFB, and radiographic abnormalities consistent with active pulmonary TB as determined by the treating MO, followed by a decision to treat the patient with a full course of anti - TB therapy OR A patient whose diagnosis is based on culture positive for *M. tuberculosis* but sputum smear examinations negative for AFB.

#### Extra - pulmonary tuberculosis

Extra - pulmonary tuberculosis (EPTB) is tuberculosis of organs other than the lungs, such as the pleura (pleurisy), lymph nodes, intestines, genito - urinary tract, skin, joints and bones, and meninges of the brain. Diagnosis should be based on one culture - positive specimen from an extra - pulmonary site, or histological or radiological, or strong clinical evidence consistent with active extra - pulmonary TB followed by the treating MO's decision to treat with a full course of anti - TB therapy. Pleurisy is classified as extra - pulmonary TB. A patient diagnosed with both sputum smear positive pulmonary TB and extrapulmonary TB should be classified as a case of pulmonary TB.

Diagnostic algorithm of RNTCP

Patients with at least two positive smear results are diagnosed by the physician as a case of smear positive TB. They are further classified as new or old cases based on their treatment history, and appropriate therapy is prescribed.

For patients with only one sputum positive result on smear examination, chest X - ray is taken. If findings of the X - ray are consistent with pulmonary tuberculosis patient is diagnosed by the physician as a case of sputum positive pulmonary TB.

Patients in whom all 3 samples are negative on sputum smear examination are prescribed symptomatic treatment and broad spectrum antibiotics (such as cotrimoxazole, doxycycline, amoxycillin) for 10 - 14 days. In such cases antibiotics such as fluoroquinolones (ciprofloxacin, ofloxacin, etc.), rifampicin or streptomycin, which are active against tuberculosis, are not to be used. Most patients are likely to improve with antibiotics if they are not suffering from TB. If the symptoms persist after a course of broad spectrum antibiotics, repeat sputum smear examination (3 samples) must be done for such patients.

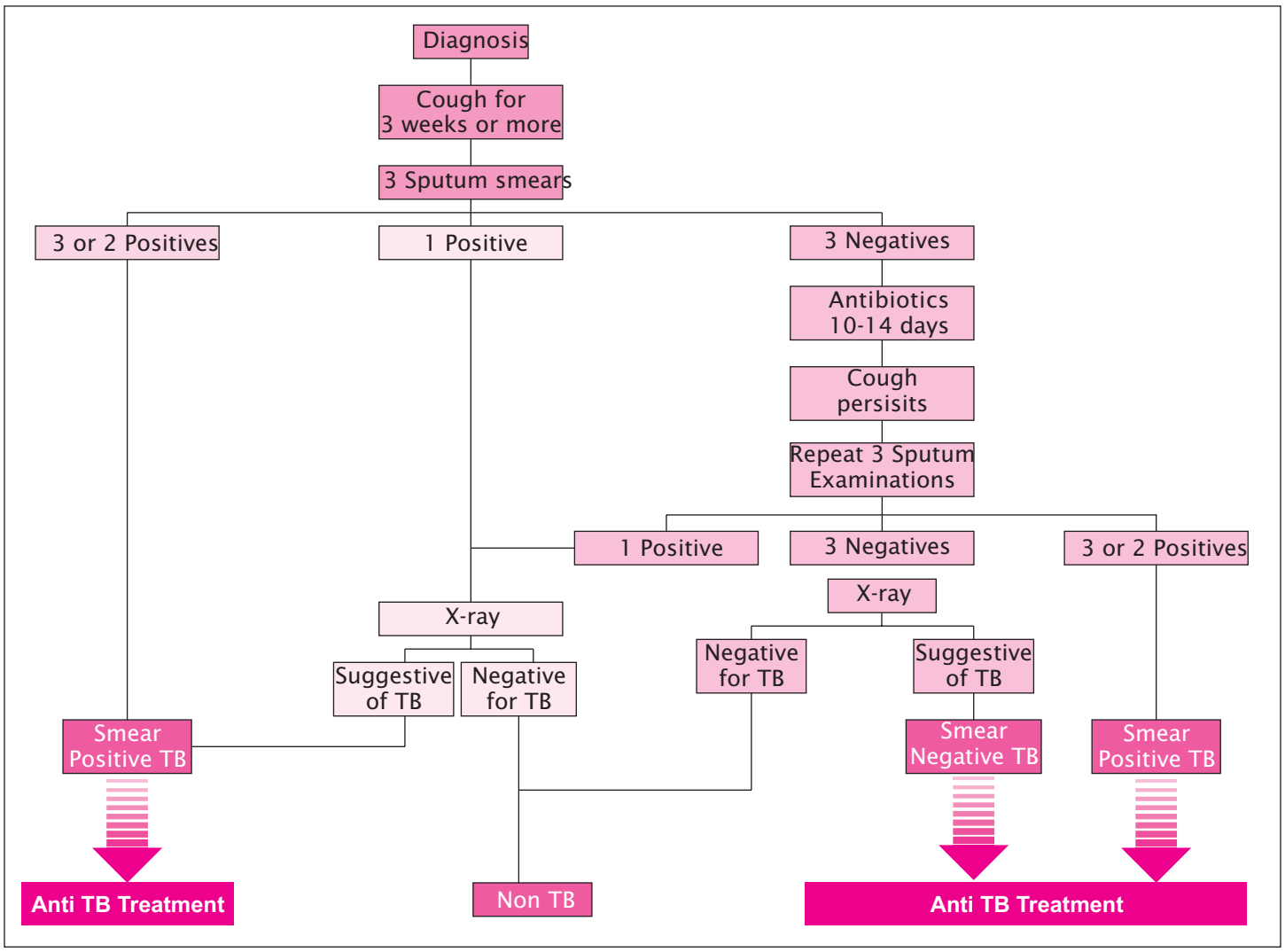
If two or more smears are positive, the patient is diagnosed as having smear positive pulmonary TB. If only one sputum sample is positive, chest X - ray is taken. If findings of the X - ray are consistent with pulmonary tuberculosis, patient is diagnosed by the physician as a case of sputum positive pulmonary TB. If the results for all the three sputum samples of repeat examination are found negative then a chest X - Ray is taken. If findings of the X - ray are consistent with pulmonary tuberculosis, patient is diagnosed by the physician as a case of sputum negative pulmonary TB. The Diagnostic Algorithm is given in Fig - 1.

Patients with EPTB who also have cough of any duration, should have 3 sputum samples examined. If the smear result is positive, the patient is classified as pulmonary TB and his/her treatment regimen will be that of a case of smear positive pulmonary TB.

### Treatment

Under the RNTCP, the objectives of tuberculosis treatment are to decrease mortality and morbidity by ensuring cure, minimizing relapses and preventing development of drug

Fig 1 : Diagnostic algorithm




resistance; to decrease infections and break the chain of transmission of infection; and to achieve the above whilst minimizing side effects due to drugs. These objectives are achieved in RNTCP through intermittent (thrice weekly) treatment regimens given under direct observation for both pulmonary and extra - pulmonary tuberculosis patients. Treatment regimens for tuberculosis have emerged as a result of controlled clinical trials in India and other parts of the world. It has been proven that thrice-a-week (intermittent) treatment is as effective as daily treatment and produces lesser side effects.

RNTCP provides standardized anti - TB treatment in three categories. Once the patient has been diagnosed as having TB, may be pulmonary or extra - pulmonary, his treatment regimen is decide based on the results of sputum Smear examination, history of previous anti - TB treatment, disease classification (pulmonary/ extra - pulmonary), and severity of illness.

Definition of types of cases

**New :** A TB patient who has never had treatment for tuberculosis or has taken antituberculosis drugs for less than one month.

**Relapse** : A TB patient who was declared cured or treatment completed by a physician, but who reports back to the health service and is now found to be sputum smear - positive.

**Transferred in** : A TB patient who has been received for treatment in a Tuberculosis Unit, after starting treatment in another unit where she/he has been registered.

**Treatment after default** : A TB patient who received anti - tuberculosis treatment for one month or more from any source and returns to treatment after having defaulted, i.e., not taken anti - TB drugs consecutively for two months or more, and is found to be sputum smear - positive.

**Failure** : Any TB patient who is smear - positive at 5 months or more after starting treatment. Failure also includes a patient who was treated with Category III regimen but who becomes smear - positive during treatment.

**Chronic** : A TB patient who remains smear - positive after completing a re - treatment regimen.

**Others** : TB patients who do not fit into the above

mentioned types. Reasons for putting a patient in this type must be specified.

Treatment regimens

Standardized treatment is given to patients based on their treatment category. The details of treatment are given in Table - 2. The most important drugs used in the treatment of TB are isoniazid (H), rifampicin (R), pyrazinamide (Z), streptomycin (S) and ethambutol (E). The dosage of the drugs is shown in Table - 3. Drugs are supplied in patient - wise boxes (PWB) containing the full course of treatment, and packaged in blister packs. The PWB have a color code indicating the category (Red for CAT I, Blue for CAT II and Green for CAT III). In each PWB, there are two pouches one for intensive phase (A) and one for continuation phase (B). For the intensive phase, each blister pack contains medicines for one dose. For the continuation phase, each blister pack contains one week's supply of medication. The drugs for extension of the intensive phase (prolongation pouches) are supplied separately. For adults, drugs will be given in the recommended number of pills/capsules irrespective of body weight. However, for patients weighing more than 60 kilograms an additional capsule of rifampicin 150 mg will be added to the treatment regimen. Patients who are more than 50 years old receive streptomycin 500mg and patients who weigh less than 30 Kg receive drugs as per body weight. For children, the drugs will be given according to body weight. Patient wise boxes for children is being developed, however until these are available the drugs are given to children as per body weight.

Table - 2 : Treatment

| Category of Treatment | Type of Patient | Regimen* |
|---|---|---|
| Category I | New sputum smear-positive<br>Seriously ill** new sputum smear-negative<br>Seriously ill** new extra-pulmonary | 2 $H_3R_3Z_3E_3$ / 4 $H_3R_3$ |
| Category II | Sputum smear-positive Relapse<br>Sputum smear-positive Failure<br>Sputum smear-positive | 2 $H_3R_3Z_3E_3S_3$ / 1 $H_3R_3Z_3E_3$ / 5 $H_3R_3E_3$ |
| Category III | New Sputum smear-negative, not seriously ill<br>New Extra-pulmonary, not seriously ill | 2 $H_3R_3Z_3$ / 4 $H_3R_3$ |

* The number before the letters refers to the number of months of treatment. The subscript after the letters refers to the number of doses per week. The dosage strengths are as follows: H: Isoniazid (600 mg), R: Rifampicin (450 mg), Z: Pyrazinamide (1500 mg), E: Ethambutol (1200 mg), S: Streptomycin (750 mg). Patients who weigh 60 kg or more receive additional rifampicin 150 mg. Patients who are more than 50 years old receive streptomycin 500 mg. Patients who weigh less than 30 kg, receive drugs as per body weight. Patients in Categories I & II who have a positive sputum smear at the end of the initial intensive phase receive an additional month of intensive phase treatment.

Table - 3 : Dosage of Drugs

| Medication | Dose (thrice a week) |
|---|---|
| Isoniazid | 600 mg |
| Rifampicin | 450 mg |
| Pyrazinamide | 1500 mg |
| Ethambutol | 1200 mg |
| Streptomycin | 0.75 g |

** Seriously ill also includes, any patient, pulmonary or extra-pulmonary who is HIV positive & declares his serostatus to the categorizing/treating medical officer. For the purpose of categorization, HIV testing should not be done

*** In rare & exceptional cases, patients who are sputum smear - negative or who have extra-pulmonary disease can have Relapse or Failure. This diagnosis in all such cases should always be made by an MO & should be supported by culture or histological evidence of current, active TB. In these cases, patient should be categorized as 'Others' & given Category II treatment.

**Monitoring of patients**

Sputum smear microscopy is much more informative than radiology in monitoring the progress of chemotherapy. Hence, the patient should be referred for follow - up sputum examinations at the prescribed intervals. Other investigations like ESR, antibody detection etc. are unreliable and have no role in diagnosing and / or evaluating the progress or results of treatment.

Follow up Smear examination

**New smear - positive patients**

Two smears are examined each time during follow - up. The first follow - up sputum examination is done at the end of 2 months of intensive phase. On the 22nd dose in intensive phase, the patient is given a sputum container and instructed to bring the early morning sample. The patient brings the sputum sample when he comes for the 23rd dose in the intensive phase when a spot sample is also collected. The results of both the smear examinations will be available at the next visit of the patient. If both smears are negative, the patient will be put on the continuation phase. If either of the smears is positive, the intensive phase will be extended by one more month, and sputum examination will be repeated at the end of the third month. Thereafter, the patient is put on the continuation phase regardless of his/her sputum status at the end of the extended intensive phase. Subsequent follow - up smear examinations are done after 2 months into continuation phase and if found positive the patient is declared as a treatment failure, re - registered and started on the re - treatment regimen afresh. If the follow - up sputum is negative, the continuation phase is completed and smear examination repeated at the end of treatment. The sputum should generally be collected at the time of collection of the 16th blister so that the results are available at the time of supply of the last week's blister pack. Results of end of treatment sputum should be available not later than one week of completion of treatment.

**Re - treatment patients**

The first sputum smear examination is done at 3 months after beginning of the intensive phase. On the 34th dose of the intensive phase the patient is given a sputum container and instructed to bring the early morning sample. The patient brings the sputum sample when he comes for 35th dose in the intensive phase when a spot sample is also collected. The results of both the smear examinations will be available at the next visit of the patient. If both smears are negative, the patient will be put on the continuation phase. If either of the samples is positive, the intensive phase of treatment will be extended by one more month, and another smear examination will be done at the end of the fourth month of treatment. Thereafter, the patient is put on the continuation phase regardless of his sputum status at the end of 4 months of the intensive phase. Subsequent follow - up sputum examinations are done after 2 months into continuation phase. Irrespective of the results of the follow - up smear examinations, the patient continues and completes the treatment when a final follow - up sputum smear is done. The sputum should generally be collected at the time of collection of the 20th blister so that the results are available at the time of supply of the last week's blister pack.

**Smear - negative patients**

Two smears are examined during the follow - up visit at the end of 2 months of the intensive phase and again at the end of treatment. If the patient becomes sputum smear - positive at the end of IP or at the end of treatment, his outcome is 'failure' and is started on re - treatment Cat II regimen after registration.

### Management of Pediatric Tuberculosis under RNTCP

Childhood TB is a reflection of the prevalence of sputum smear - positive pulmonary tuberculosis (PTB) and the extent of transmission of TB infection in the community. Children are likely to suffer from more serious forms of TB and are more likely to die if not treated properly. Reliable data on disease incidence and prevalence is however not available due to the difficulties in diagnosis of pediatric TB under field conditions.

TB should be suspected among children presenting with fever and / or cough for more than 3 weeks, with or without weight loss or no weight gain; and history of contact with a suspected or diagnosed case of active TB disease within the last 2 years. Diagnosis should be based on a combination of clinical presentation, sputum examination wherever possible, Chest X ray (PA view), Mantoux test (1 TU PPD RT23 with Tween 80, positive if induration >10mm after 48 - 72 hours) and history of contact. Diagnosis should be made by a Medical Officer and the existing RNTCP case definitions be used for all cases diagnosed. Children showing neurological symptoms like irritability, refusal to feed, headache, vomiting or altered sensorium may be suspected to have TB meningitis. Use of currently available scoring systems is not recommended for the diagnosis of TB among children. Where diagnostic difficulties are faced, the child should be referred to a pediatrician for further management. DOTS is the recommended strategy for treatment of TB and all pediatric TB patients should be registered under RNTCP. Intermittent short course chemotherapy given under direct observation should be used in children, as in adults.

Recent infection with tubercle bacilli is one of the risk factors for disease development. The younger the child, the higher is the risk of breakdown of infection into disease. Therefore, household contacts of smear - positive TB cases, especially those below 6 years of age, must be screened for symptoms of tuberculosis. In case of symptoms being present, the diagnostic algorithm for pediatric TB should be followed and the child should be given a full course of anti TB treatment if He / she is diagnosed as a TB case. For asymptomatic children under 6 years, chemoprophylaxis with isoniazid (5 mg per kg body wt) should be administered daily for a period of six months. This is regardless of the BCG vaccination status.

### Management of Extra - Pulmonary Tuberculosis

Extra - pulmonary TB (EPTB) comprises about 10% to 15% of all new TB cases in our country. Among them, 75% have lymph node or pleural TB. A person with extra - pulmonary TB may have symptoms related to the organs affected, such as, swelling of lymph nodes, occasionally with discharge of pus; pain and swelling of the joints; headache, fever, stiffness of the neck and mental confusion when the brain or meninges are involved. In addition, the following general symptoms like weight loss, fever, particularly with rise of temperature in the evening and night sweats may be present. Patients with suspected EPTB should be referred to a competent medical practitioner for expert opinion. Diagnosis of such patients may be made by using appropriate diagnostic procedures (such as FNAC/Biopsy/culture from the site of disease) as well as clinical methods. Patients with EPTB who also have cough of any duration, should have 3 sputum samples examined. If the smear result is positive, the patient is classified as pulmonary TB. Intermittent short course chemotherapy regimens of 6 - 9 months are recommended internationally for all forms of extra - pulmonary TB. In cases of Tubercular Meningitis (TBM), initial hospitalization is recommended. In TBM, ethambutol should be replaced by streptomycin in the intensive phase and continuation phase of the treatment is for 6-7 months. Adjunctive steroids may be useful in pericardial & meningeal TB.

### Management of Patients with HIV Infection and Tuberculosis

People co - infected with HIV and TB have a higher risk of developing TB disease. Irrespective of HIV status RNTCP diagnostic algorithm should be followed for all TB suspects. Anti - TB treatment is the same for HIV - infected persons as it is for HIV negative TB patients. Hence they should be treated with RNTCP regimens. All new TB cases known to be HIV positive are classified as seriously ill and treated with Category I regimen. The re - treatment cases are to be treated with Category II regimen. It is important to maintain confidentiality regarding HIV status of individuals including TB suspects and patients, in order to prevent stigmatization and discrimination. TB patients

should be encouraged to voluntarily share their HIV status with the treating physician for the purpose of taking clinical decisions like categorization for treatment of TB, treatment of other opportunistic infections and provision of ART. The HIV - positive status should not be disclosed by the treating physician to any other staff involved in RNTCP. In addition, the HIV - positive status should not be mentioned in any RNTCP records. TB patients who have other HIV - associated opportunistic infections, or report risk behaviour for HIV, should be offered referral to the nearest Voluntary Counseling and Testing Centre (VCTC) for voluntary counseling and HIV testing. Routine HIV testing of all TB suspects/patients is not the national policy.

**Drug Resistance**

Drug resistance is more common among patients who show poor compliance, develop TB disease again, after having taken anti tubercular treatment in the past, or come from areas where drug - resistant TB is common (16).

MDR - TB

(Multidrug Resistant TB) describes strains of tuberculosis that are resistant to at least the two main first - line TB drugs - isoniazid and rifampicin. Two thirds of all cases of MDR are found in China, India and the Russian Federation. In 2007, the estimated number of cases of MDR-TB were 4,24,000 and the estimated number of deaths due to MDR-TB were 1,16,000 (17). In India MDR-TB estimates are placed at less than 3.5% of new cases and 12% of retreatment cases. RNTCP advocates using a standardised treatment regimen comprising of six drugs (kanamycin, ofloxacin, ethionamide, pyrazinamide, ethambutol and cycloserine) during 6 - 9 months of the Intensive Phase and 4 drugs (ofloxacin, ethionamide, ethambutol and cycloserine) during the 18 months of the Continuation Phase for cases of MDR-TB (18).

XDR - TB

Extensive Drug Resistant is MDR - TB that is also resistant to three or more of the six classes of second - line drugs. In 2007 the estimated number of cases were 27,000 and the estimated number of deaths due to XDR TB were 16,000 ( 1 7 ) . 28 countries have published cases of XDR - TB and/or reported cases to WHO.

**Prevention and Control of Tuberculosis**

Early diagnosis and treatment, particularly of sputum smear positive cases is the cornerstone of tuberculosis control. The Revised National Tuberculosis Control Programme has focused on achieving high cure rates. The protective efficacy of BCG has ranged between 0 to 80% in different studies. Details on the vaccine are given in the chapter on Immunization.

The Stop TB Strategy has six major components: DOTS expansion and enhancement; addressing TB/HIV, MDR - TB and other challenges; contributing to health system strengthening; engaging all care providers; empowering patients and communities; and enabling and promoting research (1).

Action on Occurrence of a Case (Armed Forces) (11, 12)

In case a diagnosis of tuberculosis is arrived at in a serving person, the individual is promptly transferred to one of the referral centres for tuberculosis for further management. However, in the event that tuberculosis is detected amongst ex - servicemen or the family members / dependents of serving personnel, they are given domiciliary treatment from dependent hospitals preferably with DOTS. The various referral hospitals for treatment of tuberculosis cases amongst services are:

(a) MH (CTC) Pune for:
  (i) Officers / Nursing Officers / Cadets of the three services.
  (ii) Multi - drug resistant TB
  (iii) Cases requiring chest surgery
  (iv) TB patients from all fmn except Eastern Command zone and UP Area

(b) MH Namkum for all cases from Eastern Command zone

(c) MH Dehradun for cases from UP Area

(d) INHS Asvini

(e) Comd Hosp (AF) Bangalore

**Research**

It is evident that new tools are urgently needed to improve treatment, detection and prevention of TB. The Stop TB Partnership of WHO has created three specific research working groups devoted to new drugs, diagnosis, and vaccine development, respectively. The need for new rapid and inexpensive diagnostics for diagnosing tuberculosis and drug resistance is obvious. An effective

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# Avian Influenza

### Introduction

Avian influenza is an infectious disease of birds caused by type A strains of the influenza virus. The disease, which was first identified in Italy more than 100 years ago, occurs worldwide. All birds are thought to be susceptible to infection with avian influenza, though some species are more resistant to infection than others. Migratory waterfowl – most notably wild ducks – are the natural reservoir of avian influenza viruses. Avian influenza viruses do not normally infect species other than birds and pigs. Of the 15 avian influenza virus subtypes, H5N1 is of particular concern for several reasons. H5N1 mutates rapidly and has a documented propensity to acquire genes from viruses infecting other animal species (1, 2)

### Current Avian Influenza Outbreak

Some time prior to 1997, the H5N1 strain of avian influenza virus began circulating in the poultry populations of parts of Asia, quietly establishing itself. The virus first erupted in its highly pathogenic form in 1997, but did not appear again. Then, towards the end of 2003, H5N1 suddenly became highly and widely visible. Infection by the H5N1 strain has now been documented in either domestic poultry or migratory birds in over twenty countries spread across Asia and Europe. Over a 140 million birds have been destroyed worldwide in efforts to control the spread of this virus (3).

The ability of the H5N1 strain to cause severe disease in humans has now been documented on at least two occasions. The first documented infection of humans with an avian influenza virus occurred in Hong Kong in 1997, when the H5N1 strain caused severe respiratory disease in 18 humans, of whom 6 died (4). In its second documented outbreak, since December 2003, the H5N1 strain has infected at least 340 people and killed 208 in 13 countries, mostly in South East Asia (5).

### Lessons from History

An influenza pandemic is a rare but recurrent event. Three pandemics occurred in the previous century: "Spanish influenza" in 1918, "Asian influenza" in 1957, and "Hong Kong influenza" in 1968. The 1918 pandemic killed an estimated 40–50 million people worldwide. That pandemic, which was exceptional, is considered one of the deadliest disease events in human history. Subsequent pandemics were much milder, with an estimated 2 million deaths in 1957 and 1 million deaths in 1968. . Experts agree that another influenza pandemic is inevitable and possibly imminent. Striking similarities exist between the 1918 virus and the H5N1 strain. The 1918 pandemic is believed by many experts to have begun following adaptive mutation of an avian virus which acquired, following stepwise changes during subsequent human infections, the adaptations needed to sustain efficient human-to-human transmission. Recent publications have suggested other similarities between H5N1 and the 1918 virus in the severity of disease, its concentration in the young and healthy, and the occurrence of primary viral pneumonia in the absence of secondary bacterial infection (6, 7).

## Mode of Transmission

### Bird to Bird Transmission

Transmission among birds: Infected birds shed the virus in oculonasal discharges and feces, and contaminated drinking water is commonly implicated as the source of infection among birds. Once introduced into a flock, infected birds, contaminated equipment, insects, rodents, and personnel have all been implicated in the spread of the virus. When birds are in close proximity and air movement is conducive, airborne transmission can occur (7).

### Transmission form Birds to Humans

Direct contact with infected poultry, or surfaces and objects contaminated by their faeces, is presently considered the main route of human infection. To date, most human cases have occurred in rural or periurban areas where many households keep small poultry flocks, which often roam freely, sometimes entering homes or sharing outdoor areas where children play. Moreover, because many households in Asia depend on poultry for income and food, many families sell or slaughter and consume birds when signs of illness appear in a flock, and this practice has proved difficult to change. Exposure is considered most likely during slaughter, defeathering, butchering, and preparation of poultry for cooking. There is no evidence that properly cooked poultry or eggs can be a source of infection (7).

### Human to Human Transmission

There is no definite evidence of human to human transmission in the current episode. A new virus adapted for efficient human-to-human transmission would spread very rapidly. The respiratory tract is the most likely route of entry.

### People at risk of contracting Avian Influenza (8)

(a) Workers handling poultry in farms, markets & involved in culling activity, veterinary workers and health workers are at higher risk of acquiring the infection. Even the family members of these workers are at higher risk.

(b) Any type of Influenza tends to be more serious in children, elderly persons above 65 years of age and the chronically sick persons.

### Spread from one Country to another

The disease can spread from country to country through international trade in live poultry. Migratory birds, including wild waterfowl, sea birds, and shore birds, can carry the virus for long distances and have, in the past, been implicated in the international spread of highly pathogenic avian influenza. Migratory waterfowl – most notably wild ducks – are the natural reservoir of bird flu viruses, and these birds are also the most resistant to

infection. They can carry the virus over great distances, and excrete it in their droppings, yet develop only mild and short-lived illness.

## Clinical course

The incubation time for influenza ranges from 1 – 5 days with an average of 2 days. In most cases, virus is found in specimens from the respiratory tract from 1 – 2 days before to 4 – 5 days after onset of disease, corresponding to the period of communicability. There is no chronic carrier state, but in young children viral shedding tends to last longer than in adults. Clinical onset is characterized by abrupt fever, headache, malaise and myalgias. Systemic symptoms usually last for 3 days. Sore throat, rhinitis and non-productive cough may continue for several days after the systemic symptoms have ceased. Influenza may be misdiagnosed clinically: several infectious agents including respiratory syncytial virus may cause outbreaks of influenza-like disease, illustrating the importance of laboratory based confirmation of the clinical diagnosis (9).

The incubation period of influenza A(H5N1) is currently uncertain. Based on limited experience from 6 cases in Viet Nam, the median time between exposure and onset of illness is 3 days (range 2–4 days). Cases have been characterized by high fever (above 38 °C), cough and shortness of breath. Lower respiratory symptoms or signs developed early and include dyspnoea and auscultatory signs. Clinically apparent pneumonia with chest X-ray changes was seen in all patients, although the X-ray changes were nonspecific and included diffuse, multifocal or patchy infiltrates, interstitial infiltrates, and segmental or lobular consolidation with air bronchograms. The illness rapidly progressed to respiratory distress and subsequent respiratory failure within 1 week of the onset of symptoms. Most cases have died in spite of ventilatory support. Common laboratory findings were lymphopenia ($<1 \times 10^9$/litre) and slightly or moderately raised alanine aminotransferase and aspartate transaminase (10).

## Laboratory Diagnosis (11)

The optimal specimen for influenza A virus detection is a nasopharyngeal aspirate obtained within 3 days of the onset of symptoms, although nasopharyngeal swabs and other specimens can also be used. The WHO recommended procedure for collection and dispatch of human and animal specimens is given as Appx 'A' and Appx 'B' respectively. WHO guidelines for storage and transport of specimens are given as Appx 'C'. Assays available for the diagnosis of influenza A virus infections include:

**(a) Rapid antigen detection :** Results can be obtained in 15–30 minutes.

(i) Near-patient tests for influenza. These tests are commercially available

(ii) Immunofluorescence assay. A widely used, sensitive method for diagnosis of influenza A, B virus infections and other clinically important respiratory viruses.

(iii) Enzyme immunoassay. For influenza A nucleoprotein (NP).

**(b) Virus culture :** Provides results in 2–10 days. Both shell-vial and standard cell-culture methods may be used to detect clinically important respiratory viruses. Positive influenza cultures may or may not exhibit cytopathic effects but virus identification by immunofluorescence of cell cultures or haemagglutination-inhibition (HI) assay of cell culture medium (supernatant) is required.

**(c) Polymerase chain reaction and Real-time PCR assays** : Primer sets specific for the haemagglutinin (HA) gene of currently circulating influenza A/H1, A/H3 and B viruses are becoming more widely used. Results can be available within a few hours from either clinical swabs or infected cell cultures.

Any specimen with a positive result using the above approaches for influenza A virus and suspected of avian influenza infection should be further tested and verified by a designated WHO H5 Reference Laboratory. Laboratories that lack the capacity to perform specific influenza A subtype identification procedures are requested to forward specimens or virus isolates to a National Influenza Centre or to a WHO H5 Reference Laboratory for further identification or characterization. For the Indian Armed Forces, all specimens from suspected human cases or of animal origin should be forwarded in accordance with the guidelines, through courier, to Head, Department of PSM, Armed Forces Medical College, Pune 411040. In case of extreme urgency human specimens can be forwarded directly to National Institute of Virology, Pune under intimation to Department of PSM, AFMC. In similar situations animal specimens may be forwarded directly to High Security Animal Diseases Laboratory Bhopal. Contact details of these two laboratories are given in Appx 'D'.

## Treatment

Two drugs (in the neuraminidase inhibitors class), oseltamivir (commercially known as Tamiflu) and zanamivir (commercially known as Relenza) can reduce the severity and duration of illness caused by seasonal influenza. The efficacy of the neuraminidase inhibitors depends on their administration within 48 hours after symptom onset. For cases of human infection with H5N1, the drugs may improve prospects of survival, if administered early, but clinical data are limited. The H5N1 virus is expected to be susceptible to the neuraminidase inhibitors. An older class of antiviral drugs, the M2 inhibitors amantadine and rimantadine, could potentially be used against pandemic influenza, but resistance to these drugs can develop rapidly and this could significantly limit their effectiveness against pandemic influenza. Some currently circulating H5N1 strains are fully resistant to these the M2 inhibitors. However, should a new virus emerge through reassortment, the M2 inhibitors might be effective. Guidelines for management of suspected case of H5N1 influenza are given as Appx "E" to this document.

## Prevention and control strategies (12)

Vaccination and the use of antiviral drugs are two of the most important response measures for reducing morbidity and mortality during a pandemic. On present trends, neither of these interventions will be available in adequate quantities or equitably distributed at the start of a pandemic and for many months thereafter. In such a situation surveillance to provide early warning and health education to reduce human exposure are the most important control measures.

**Surveillance (13)**

(a) Surveillance is the cornerstone of pandemic preparedness and response. The following events need to be reported to local, state or National health authorities on priority :

(i) Individuals with, and clusters of, acute respiratory illness on or during admission;

(ii) Unexplained deaths due to acute respiratory illness in the community;

(iii) Unexplained deaths due to acute respiratory illness in health care facilities;

(iv) Monitoring sales of antiviral drugs for influenza A viral infection, antimicrobials commonly used for the treatment of acute respiratory infections, decongestant drugs, or antitussive drugs.

(b) For countries and territories where influenza A/H5 viruses have not been identified as a cause of illness in human or animal populations since 1 October 2003, like India, the WHO recommends that the decision on whether to test for influenza A/H5 viruses should be the result of a risk assessment that considers both geographical proximity to countries or territories where HPAI outbreaks are reported in animal populations and the following case-based factors: (Case definitions are given as Appx 'F' to this document):

(i) Clinical presentation, including death due to unexplained acute respiratory illness

(ii) Occupational exposure; (At-risk occupations such as a domestic fowl or swine farm worker, domestic fowl processing plant worker, domestic fowl culler (catching, bagging, or transporting birds, disposing of dead birds), worker in live animal market, chef working with live or recently killed domestic fowl, dealer or trader in pet birds, worker in a laboratory where specimens are tested for influenza A/H5 viruses, health care worker.

(iii) Living in an area in which there are rumours of deaths of domestic fowl;(Domestic fowl are birds that are commonly reared for their flesh, eggs, or feathers and are kept in a yard or similar enclosure, including chickens, ducks, geese, turkeys, guinea-fowl)

(iv) History of travel, during the 7 days before the onset of symptoms, to a country or territory with reported HPAI outbreaks due to influenza A (H5N1) in the animal populations AND one or more of the following:

- contact (within 1 metre) with live or dead domestic fowl, wild birds, or swine in any setting;
- exposure to settings in which domestic fowl or swine were or had been confined in the previous 6 weeks;
- Contact (within touching or speaking distance) with a confirmed human case of influenza A/H5 infection;
- contact (within touching or speaking distance) with a person with an unexplained acute respiratory illness that later resulted in death;
- positive laboratory result for influenza A.

**Vaccination**

Vaccines are universally regarded as the most important medical intervention for preventing influenza and reducing its health consequences during a pandemic. In the past, however, vaccines have never been available early enough and in sufficient quantities to have an impact on morbidity and mortality during a pandemic. Past problems, related to the special nature of pandemic vaccines and the inadequacy of manufacturing capacity, have endured. Several companies are trying to make an effective vaccine against H5N1. While initial testing of an avian flu vaccine shows promise and trials should be completed by the end of 2005, questions remain about the vaccine's ability to protect large numbers of people. Potential problems include a high initial dose, the requirement of two doses, and requirement of about six weeks for effective immunity to develop. Another major concern is the inability to produce adequate number of doses, once the vaccine is approved (14-15).

**Chemoprophylaxis**

The current recommendation for chemoprophylaxis against H5N1 influenza is one oseltamivir phosphate 75 mg tablet each day for at least 7 days beginning as soon as possible after exposure. Antiviral prophylaxis should begin immediately or at least within 2 days of exposure and may continue for up to 6 weeks (15).

**Non Medical Measures**

In resource-poor settings, non-medical interventions may be the main line of defence throughout the first wave of a pandemic. Health education to inform the general public especially small poultry farmers is essential to reduce exposure risk. Key advice for the general public as well as biosafety measures for poultry farm workers is given as Appx 'G'. Stringent sanitary measures and appropriate bio-security practices should be applied, including the control of human traffic and introduction of birds of unknown disease status into the flock. Carcasses of suspected and confirmed poultry case of Influenza should preferably be incinerated or buried deep using lime and soil in the ratio of 1:3.

The H5N1 avian influenza virus is not transmitted to humans through properly cooked food. The virus is sensitive to heat. Normal temperatures used for cooking (so that food reaches 70°C in all parts) will kill the virus. To date, no evidence indicates that any person has become infected with the H5N1 virus following the

consumption of properly cooked poultry or poultry products, even in cases where the food item contained the virus prior to cooking. Poultry and poultry products from areas free of the disease can be prepared and consumed as usual, with no fear of acquiring infection with the H5N1 virus. As a standard precaution, WHO recommends that poultry and poultry products should always be prepared following good hygienic practices, and that poultry meat should be properly cooked. This recommendation protects consumers from some well-known and common

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## Appendix 'A'

### WHO guidelines for the collection of human specimens for laboratory diagnosis of Avian Influenza infection

General information

Respiratory virus diagnosis depends on the collection of high-quality specimens, their rapid transport to the laboratory and appropriate storage before laboratory testing. Virus is best detected in specimens containing infected cells and secretions. Specimens for the direct detection of viral antigens or nucleic acids and virus isolation in cell cultures should be taken preferably during the first 3 days after onset of clinical symptoms.

**Type of specimens**

A variety of specimens are suitable for the diagnosis of virus infections of the upper respiratory tract:

- Nasal swab
- Nasopharyngeal swab
- Nasopharyngeal aspirate
- Nasal wash
- Throat swab.

In addition to swabs from the upper respiratory tract, invasive procedures can be performed for the diagnosis of virus infections of the lower respiratory tract where clinically indicated:

- Transtracheal aspirate
- Bronchoalveolar lavage
- Lung biopsy
- Post-mortem lung or tracheal tissue.

Specimens for the laboratory diagnosis of avian influenza A should be collected in the following order of priority:

- Nasopharyngeal aspirate
- Acute serum
- Convalescent serum.

Specimens for direct detection of viral antigens by immunofluorescence staining of infected cells should be refrigerated and processed within 1–2 hours. Specimens for use with commercial near-patient tests should be stored in accordance with the manufacturer's instructions. Specimens for virus isolation should be refrigerated immediately after collection and inoculated into susceptible cell cultures as soon as possible. If specimens cannot be processed within 48–72 hours, they should be kept frozen at or below –70 °C. Respiratory specimens should be collected and transported in virus transport media. A number of media that are satisfactory for the recovery of a wide variety of viruses are commercially available.

Procedures for specimen collection

**Nasal swab**

A dry polyester swab is inserted into the nostril, parallel to the palate, and left in place for a few seconds. It is then slowly withdrawn with a rotating motion. Specimens from both nostrils are obtained with the same swab. The tip of the swab is put into a plastic vial containing 2–3 ml of virus transport medium and the applicator stick is broken off.

**Nasopharyngeal swab**

A flexible, fine-shafted polyester swab is inserted into the nostril and back to the nasopharynx and left in place for a few seconds. It is then slowly withdrawn with a rotating motion. A second swab should be used for the second nostril. The tip of the swab is put into a vial containing 2–3 ml of virus transport medium and the shaft cut.

**Nasopharyngeal aspirate**

Nasopharyngeal secretions are aspirated through a catheter connected to a mucus trap and fitted to a vacuum source. The catheter is inserted into the nostril parallel to the palate. The vacuum is applied and the catheter is slowly withdrawn with a rotating motion. Mucus from the other nostril is collected with the same catheter in a similar manner. After mucus has been collected from both nostrils, the catheter is flushed with 3 ml of transport medium.

**Nasal wash**

The patient sits in a comfortable position with the head slightly tilted backward and is advised to keep the pharynx closed by saying "K" while the washing fluid (usually physiological saline) is applied to the nostril. With a transfer pipette, 1–1.5 ml of washing fluid is instilled into one nostril at a time. The patient then tilts the head forward and lets the washing fluid flow into a specimen cup or a Petri dish. The process is repeated with alternate nostrils until a total of 10–15 ml of washing fluid has been used. Dilute approximately 3 ml of washing fluid 1:2 in transport medium.

**Throat swab**

Both tonsils and the posterior pharynx are swabbed vigorously, and the swab is placed in transport medium as described above.

**Sera collection for influenza diagnosis**

An acute-phase serum specimen (3–5 ml of whole blood) should be taken soon after onset of clinical symptoms and not later than 7 days after onset. A convalescent-phase serum specimen should be collected 14 days after the onset of symptoms. Where patients are near death, a second ante-mortem specimen should be collected. Although single serum specimens may not provide conclusive evidence in support of an individual diagnosis, when taken more than 2 weeks after the onset of symptoms they can be useful for detecting antibodies against avian influenza viruses in a neutralization test.

## Appendix 'B'

### WHO laboratory guidelines for the collection of animal specimens for diagnosis of influenza infection

General information

The success of virus diagnosis depends largely on the quality of the specimen and the conditions under which the specimen is transported and stored before it is processed in the laboratory. Specimens for isolation of respiratory viruses in cell cultures or embryonated chicken eggs and for the direct detection of viral antigen or nucleic acids should generally be taken during the first 3 days after onset of clinical symptoms of influenza. In mammals, including humans, pigs and horses, influenza is primarily a respiratory tract infection while in avian species it can be an infection of both the respiratory tract and the large intestinal tract.

Type of specimens

A variety of specimens from animals and birds are suitable for the diagnosis of virus infections of the upper respiratory tract:

- Nasal swab
- Throat swab
- Tracheal swab

In addition to swabs from the upper respiratory tract, sampling of avian species for influenza infection should include:

- Cloacal swab
- Faecal specimen

Whenever possible, cloacal swabs should be collected from live or freshly killed birds. Faecal specimens collected from cages or from the environment are often the only specimens that are available and cannot be assigned with total certainty to the species of origin. If dead animals are found as part of the investigation, highly pathogenic avian influenza virus should be suspected, and representative internal organs, including brain, spleen, heart, lung, pancreas, liver and kidney, should be sampled together with sampling of the respiratory and intestinal tracts.

Specimens for the laboratory diagnosis of influenza infection should be collected in the following order of priority:

- From live animals
  - Tracheal
  - Throat/nasal
  - Cloacal
  - Faecal (environmental)
- Drinking-water
- From dead animals
  - Lung lavage
  - Pooled tissue (including trachea and lung)
  - Faecal (environmental)
  - Cloacal
- Drinking-water

**Procedures for specimen collection**

Virus transport medium

**Transport medium 199**

- Tissue culture medium 199 containing 0.5% bovine serum albumin (BSA)

To 1 litre of 0.5% BSA add:

- Benzylpenicillin (2 x $10^6$ IU/litre)
- Streptomycin (200 mg/litre)
- Polymyxin B (2 x $10^6$ IU/litre)
- Gentamicin (250 mg/litre)
- Nystatin (0.5 x $10^6$ IU/litre)
- Ofloxacin hydrochloride (60 mg/litre)
- Sulfamethoxazole (0.2 g/litre)

- Sterilize by filtration and distribute in 1.0–2.0-ml volumes in screw-capped tubes.

- OR -

Glycerol transport medium

| | |
|---|---|
| NaCl | 8 g |
| KCl | 0.2 g |
| $Na_2HPO_4$ | 1.15 g |
| $KH_2PO_4$ | 0.2 g |

**Phosphate-buffered saline (PBS):**

- Autoclave PBS and mix 1:1 with sterile glycerol to make 1 litre
- To 1 litre PBS / glycerol add:
  - Benzylpenicillin (2 x $10^6$ IU/litre)
  - Streptomycin (200 mg/litre)
  - Polymyxin B (2 x $10^6$ IU/litre)
  - Gentamicin (250 mg/litre)
  - Nystatin (0.5 x $10^6$ IU/litre)
  - Ofloxacin hydrochloride (60 mg/litre)
  - Sulfamethoxazole (0.2 g/litre).

Preparing specimen collection vials

To sterile plastic screw-cap vials dispense 1.0–2.0 ml of transport medium. It is preferable to store these vials at 20 °C until use. However, they can be stored at 4°C for 48-96 hours (optimally less than 48 hours) or at room temperature for short periods of 1–2 days.

**Preparing to collect specimens**

The following information should be recorded: type of animal sampled, species, type of specimen, date of collection, and geographical location of specimen collection, etc.

Tissue culture medium (A) is widely used for collection and transport of clinical specimens from all species. The glycerol-based medium (B) provides longer-term stability of specimens where cooling is not immediately possible; it is suitable for egg inoculation but not suited for tissue culture inoculation.

Clinical specimens should be collected as described below and added to transport medium. All specimens should be kept on ice or at 4 °C.

Standard precautions should always be followed, and barrier protections applied whenever samples are obtained from patients.

**Nasal swab**

A dry polyester swab is inserted into the nostril, parallel to the palate, and left in place for a few seconds. It is then slowly withdrawn, with a rotating motion, down the inside of the nose. Specimens from both nostrils are obtained with the same swab. The tip of the swab is put into a vial containing 2–3 ml of transport medium and the applicator stick is broken off.

**Throat swab**

The posterior pharynx is swabbed vigorously, and the swab is placed in transport medium as described above.

**Tracheal swab**

The trachea of live birds is swabbed by inserting a polyester swab into the trachea and gently swabbing the wall. The swab is then placed in transport medium as described above.

Tracheal swabs from dead animals, including pigs at slaughterhouses, can be taken after removal of the lungs and trachea from the carcass. The trachea is held in a gloved hand and the swab inserted to its maximal length with vigorous swabbing of the wall. The swab is then placed in transport medium as above.

**Cloacal swab**

A cloacal swab from a live bird is taken by inserting a swab deeply into the vent and vigorously swabbing the wall. The swab should be deeply stained with faecal material. The swab is then placed in transport medium as above.

**Faecal specimens**

Faecal specimens from the cages of live poultry in bird markets or from wild birds in the field are collected from freshly deposited wet faeces; the swab should be heavily coated with faeces. The swab is then placed in transport medium as above.

Sera collection for influenza diagnosis and surveillance

**Tissue specimens**

Tissue specimens should ideally be frozen immediately, without transport medium, and later ground in transport medium before inoculation of eggs or tissue culture.

For diagnosis, an acute-phase serum specimen (3–5 ml of whole blood) should be taken soon after onset of clinical symptoms, and not later than 7 days after onset. A convalescent-phase serum specimen should be collected 2–4 weeks later. In serological surveillance studies at slaughterhouses or of free-flying wild birds that are bled and released, a single sample of serum is collected. The blood is allowed to clot then centrifuged at 2500 rpm for 15 minutes to separate red blood cells and serum. The serum should be pipetted off, and the red cells may be discarded. Serum samples are stored at –20 °C.

## Appendix 'C'

**WHO guidelines for the storage and transport of human and animal specimens for laboratory diagnosis of suspected Avian Influenza A infection**

Specimen storage

Specimens in viral transport medium for viral isolation should be kept at 4 °C and transported to the laboratory promptly. If specimens are transported to the laboratory within 2 days, they may be kept at 4 °C; otherwise they should be frozen at or below –70 °C until they can be transported to the laboratory. Repeated freezing and thawing must be avoided to prevent loss of infectivity. Sera may be stored at 4 °C for approximately one week, but thereafter should be frozen at –20 °C. Specimens should be collected and transported in a suitable transport medium on ice or in liquid nitrogen. Standard precautions should always be followed, and barrier protections applied whenever samples are obtained from patients. Specimens for influenza should not be stored or shipped in dry ice (solid carbon dioxide) unless they are sealed in glass or sealed, taped and double plastic-bagged. Carbon dioxide can rapidly inactivate influenza viruses if it gains access to the specimens through shrinkage of tubes during freezing.

Specimen transport

Transport of specimens should comply with the WHO guidelines for the safe transport of infectious substances and diagnostic specimens (WHO, 1997). The receiving laboratory should be notified before shipment of specimens in order to arrange for an import license for the specimens. Transport of specimens within national borders should comply with the procedures detailed within each country's regulations. International air transport of human specimens known or suspected to contain the avian influenza agent or of specimens from avian influenza infected animals must follow the current edition of the International Air Transport Association (IATA) Dangerous Goods Regulations.

Packaging shall be constructed and closed so as to prevent any loss of contents that might be caused under normal conditions of transport, by vibration or by changes in temperature, humidity or pressure. Primary receptacles shall be packed in secondary packaging in such a way that, under normal conditions of transport, they cannot break, be punctured or leak their contents into the secondary packaging. Secondary packaging shall be placed in a final outer package with suitable cushioning material. Any leakage of the contents shall not substantially impair the protective properties of the cushioning material or of the outer packaging.

For liquids

The primary receptacle(s) shall be leakproof and shall not contain more than 500 ml. There shall be absorbent material placed between the primary receptacle and the secondary packaging; if several fragile primary receptacles are placed in a single secondary packaging, they shall be either individually wrapped or separated so as to prevent contact between them. The absorbent material shall be in sufficient quantity to absorb the entire contents of the primary receptacles and there shall be a secondary packaging that shall be leakproof. The primary receptacle or the secondary packaging shall be capable of withstanding without leakage an internal pressure producing a pressure differential of not less than 95 kPa (0.95 bar). The outer packaging shall not contain more than 4 litres.

For solids

The primary receptacle(s) shall be sift-proof and shall not contain more than 500 g. If several fragile primary receptacles are placed in a single secondary packaging, they shall be either individually wrapped or separated so as to prevent contact between them and there shall be a secondary packaging which shall be

## Appendix 'D'

**Reference laboratories in india**

Animal specimens

**High Security Animal Diseases Laboratory (BSL-4)**, Anand Nagar, Bhopal, MP 462 021.

Tel: 275 9204 Fax: 2758842

Human specimens

**National Institute of Virology**

20-A Dr Ambedkar Road, P.O. Box 11, Pune, India. Tel: 020 26124386. Email: nivicl@pn3.vsnl.net.in

WHO designated "National Influenza Centres"

**India, Pune**

Dr V. Padbidri, National Institute of Virology, 20-A Dr Ambedkar Road, P.O. Box 11, Pune, India. Tel: 020 26124386. Email: nivicl@pn3.vsnl.net.in

**India - Kasauli (H.P.)**

Dr Usha Soren Singh, National Influenza Center Central Research Institute, Kasauli (H.P.) , India. Tel: +91 (1792) 72114.

Fax: +91 (1792) 72016

Email: dircri@yahoo.com

**India - Mumbai**

Dr Ranjana Deshmukh, Department of Virology, Acharya Donde Marg, Parel, Mumbai, India Tel: +91 (22) 416 0947. Fax: +91 (22) 416 1787 Email : rad21350@yahoo.com

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## Appendix 'E'

**Management of a suspected case of Avian Influenza**

leak proof. The outer packaging shall not contain more than 4 kg. For air transport, the smallest overall external dimension of a completed package must be at least 10 cm.

General considerations

Existing infection control measures include the application of standard precautions to all patients receiving care in hospitals. If the diagnosis of influenza A(H5N1) infection is being considered on the basis of clinical features, additional precautions should be implemented until the diagnosis can be ruled out. Transmission of human influenza is by droplets and fine droplet nuclei (airborne).

Transmission by direct and indirect contact is also recognized. Because of the high mortality of the disease and the possibility of the virus mutating to cause efficient human-to-human transmission, WHO is currently recommending the use of high-efficiency masks in addition to droplet and contact precautions

Precautions while handling patients

The following precautions must be observed while handling admitted patients suspected to be suffering from H5N1 influenza.

- Isolate the patient to a single room. If a single room is not available, cohort patients separately in designated multi-bed rooms or wards; beds should be placed more than 1 metre apart and preferably be separated by a physical barrier (e.g. curtain, partition).
- Reinforce standard precautions with droplet and contact precautions. Appropriate personal protective equipment (PPE) for all those entering patients' rooms consists of mask (highefficiency mask if available or surgical mask), gown, face shield or goggles, and gloves.
- Limit the number of HCWs who have direct contact with the patient(s); these HCWs should not look after other patients. The number of other hospital employees (e.g. cleaners, laboratory personnel) with access to the environment of these patients should also be limited. Designated HCWs should all be properly trained in infection control precautions.
- Restrict the number of visitors and provide them with appropriate PPE and instruct them in its use.
- Ask HCWs with direct patient contact to monitor their own temperature twice daily and report to hospital authorities any febrile event. An HCW who has a fever (>38 ºC) and who has had direct patient contact should be treated immediately
- HCWs who are unwell should not be involved in direct patient care since they are more vulnerable and may be more likely to develop severe illness when exposed to influenza A(H5N1)

viruses.

- Dispose of waste properly by placing it in sealed, impermeable bags which should be clearly labelled "Biohazard" and incinerated. Linen and reusable materials that have been in contact with patients should be handled separately and disinfected.

Case management

The following steps may be followed for managing suspected cases:

- Take respiratory and blood specimens for laboratory testing for influenza and other infections as clinically indicated
- Treat with a neuraminidase inhibitor such as oseltamivir (75 mg orally, twice daily for 5 days) as early in the clinical course as possible. Refer to product information sheets for dosage and current limitations on paediatric use.
- Provide supportive care. Monitor oxygen saturation & treat desaturation with supplemental oxygen as required. As nebulizers and high-air-flow oxygen masks have been potentially implicated in the nosocomial spread of severe acute respiratory syndrome, use these measures only if clinically justified and apply them under strict infection control, including airborne transmission precautions.
- Take respiratory and blood specimens serially to check for possible bacterial infection.
- Consider intravenous antibiotic therapy to control secondary bacterial infections as required.
- Do not use amantadine or rimantadine because of the risk of increasing the selective pressure for development of a resistant influenza virus with pandemic potential. Preliminary results from WHO collaborating centres suggest that influenza A(H5N1) viruses recently isolated from humans are resistant to amantadine and rimantadine
- Avoid administration of salicylates (such as aspirin) in children under 18 years of age because of the risk of Reye syndrome. Use paracetamol or ibuprofen, either orally or by suppository, for management of fever as clinically indicated.
- Immunomodulators such as corticosteroids should be used only in the context of clinical trials. The immune response of humans with influenza A(H5N1) infection requires further study.
- Do not use ribavirin. There is no evidence to support its effectiveness against influenza viruses; moreover, adverse reactions such as anaemia are frequent and may further compromise the patient.

Discharge policy

Studies are required to provide better understanding of viral excretion patterns in humans infected with the influenza A(H5N1) viruses associated with the current outbreaks in Thailand and Viet Nam. Until further evidence is available, WHO recommends that infection control precautions for adult patients remain in place for 7 days after resolution of fever. Previous human influenza studies have indicated that children younger than 12 years can shed virus for 21 days after onset of illness. Therefore, infection control measures for children should ideally remain in place for this period. Where this is not feasible (because of a lack of local resources), the family should be educated on personal hygiene and infection control measures (e.g. hand-washing and use of a paper or surgical mask by a child who is still coughing). Children should not attend school during this period.

Public health measures

Report to the local public health authority all patients for whom the diagnosis of influenza A(H5N1) virus infection is being considered. Identify contacts as well as those persons who may have been exposed to the common source of infection. These persons should be monitored for 7 days after their last exposure to the

## Appendix 'F'

### Management of a suspected case of Avian Influenza

Case defintions for h5n1 influenza

**Patient under investigation**

- Any individual presenting with fever (temperature >38˚C)
- AND one or more of the following symptoms:
  - Cough;
  - Sore throat;
  - Shortness of breath;
- Who is under clinical observation and laboratory investigations are under way.

**Suspect influenza A/H5 case**

Any individual presenting with fever (temperature >38˚C)

- AND one or more of the following symptoms:
  - Cough;
  - Sore throat;
  - Shortness of breath;
- AND one or more of the following:
  - Laboratory evidence for influenza A by a test that does not sub-type the virus;
  - Having been in contact during the 7 days prior to the onset of symptoms with a confirmed case of Influenza A/H5 while this case was infectious.
  - Having been in contact during the 7 days prior to the onset of symptoms with birds, including chickens, that have died of an illness;
  - Having worked in a laboratory during the 7 days prior to the onset of symptoms where there is processing of samples from persons or animals that are suspected of having highly pathogenic avian influenza (HPAI) infection.

  OR
- Death from an unexplained acute respiratory illness
- AND one or more of the following
  - Residing in area where HPAI is suspected or confirmed;

- Having been in contact during the 7 days prior to the onset of symptoms with a confirmed case of Influenza A/H5 while this case was infectious.

**Probable influenza A/H5 case**

Any individual presenting with fever (temperature >38˚C)

- AND one or more of the following symptoms:
- Cough;
- Sore throat;
- Shortness of breath;
- AND limited laboratory evidence for Influenza A/H5 (H5 specific antibodies detected in a single serum specimen).

**Confirmed influenza A/H5 case**

- An individual§ for whom laboratory testing demonstrates one or more of the following
- Positive viral culture for Influenza A/H5;
- Positive PCR for Influenza A/H5;
- Imunofluorescence antibody (IFA) test positive using Influenza A/H5 monoclonal antibodies;
- 4-fold rise in Influenza A/H5 specific antibody titre in paired serum samples.
- Individuals infected with Influenza A/H5 virus are considered to be infectious starting from one day before the onset of symptoms up to 7 days after onset of symptoms.

## Appendix 'G'

**Advice for health education of all people**

The spread of bird flu in affected areas can normally be prevented.

- People should avoid contact with chickens, ducks or other poultry unless absolutely necessary. This is the best way to prevent infection with the bird flu virus.
- Children are at high risk because they may play where poultry are found. Teach your children the following basic guidelines:
- Avoid contact with any birds, their feathers, faeces and other waste.
- Do not keep birds as pets.
- Wash hands with soap and water after any contact.
- Not to sleep near poultry.
- Do not transport live or dead chickens, ducks or other poultry from one place to another even if you think your birds are healthy.
- If you unintentionally come into contact with poultry in an affected area, such as touching the bird's body, touching its faeces or other animal dirt, or walking on soil contaminated with poultry faeces:
- wash your hands well with soap and water after each contact;
- remove your shoes outside the house and clean them of all dirt; and
- check your temperature for 7 days at least once daily. If you develop a high temperature (>37.5˚C), visit a doctor or the nearest health care facility immediately.
- If you encounter sick and dead poultry for the first time and are unsure of the situation, inform the authorities immediately and leave the handling of the poultry to experienced personnel (cullers, clean-up personnel, etc.)

Take all precautionary measures to ensure that poultry and poultry products are properly prepared and safe to eat.

- Chicken prepared hygienically and cooked thoroughly, i.e. no pink juices should be observed, can be considered safe to eat. However, remember, if the bird has a transmittable disease, such as bird flu, the person preparing the food is at risk of becoming infected and the environment may become contaminated.
- Eggs, too, may carry pathogens, such as the bird-flu virus inside or on their shells. Care must be taken in handling raw eggs and shells. Wash shells in soapy water and wash hands afterwards. Eggs, cooked thoroughly (hard boiled, 5 minutes, 70°C) will not infect the consumer with bird flu.
- In general, all food should be thoroughly cooked to an internal temperature of 70˚C or above.

General Biosafety Measures for Poultry Farm Workers

- Proper clothing and equipment to protect workers involved in the culling of poultry flocks. These workers should wear protective clothing, preferably coverall, apron or surgical gowns and gumboots.
- Use N-95 respirator masks are preferred. In the absence of N 95 masks, standard well-fitted surgical masks should be used.
- A person exposed to infected chickens or poultry farms should be closely monitored.
- All the clinically suspected human cases should be treated in isolation with universal precautions to prevent spread of infection.

Wg Cdr Rajesh Vaidya

# Severe Acute Respiratory Syndrome (SARS)

## Introduction

Severe Acute Respiratory Syndrome (SARS) is a new disease which came into notice when a patient was admitted in Hanoi (Vietnam) on 26th Feb. 2003 with respiratory illness. Seven health workers who cared for this patient also became ill on 5th March 2003. Since then, the cases have been reported from 29 countries. International travel has facilitated its spread rapidly among six continents. Later on, it was found that the disease initially emerged in China (Guangdong province) in November 2002 from where it spread to other countries. (1- 4)

## Epidemiology

The evidence suggests that a newly discovered variant of Corona virus (SARS corona virus) is accountable for this syndrome. Most SARS cases till date have occurred in previously healthy young adults. A few suspected cases have been reported among children. WHO estimates that case fatality ratio ranges from 0% to 50% depending on the age group affected, with an overall estimate of about 15%. (1-4)

## Incidence

### World

As on 15th May 2003, a cumulative total of 7548 probable cases and 573 deaths due to SARS have been reported from 29 countries. The affected areas were: the People's Republic of China (PRC), particularly the Hong Kong Special Administrative Region and the Beijing Municipality, Guangdong, Inner Mongolia, Shanxi, Tianjin, Taiwan Province (China), Toronto (Canada), Singapore (Singapore), India and Manila (Philippines). As of now, China has reported more cases than the rest of the world combined. (1-7)

### India

As on 14th May, 2003, three probable cases of SARS have been reported from India, one each in West Bengal, Karnataka and Gujarat. (1-2)

### Armed Forces

There has been no case of SARS in the Indian Armed Forces.

### Current SARS Situation

Currently, there is no known SARS transmission anywhere in the world. The most recent human cases of SARS-CoV infection were reported in China in April 2004 in an outbreak resulting from laboratory-acquired infections. CDC and its partners, including the World Health Organization, continue to monitor the SARS situation globally. (1-4)

## Agent

SARS corona virus is an enveloped RNA virus. The SARS virus has fulfilled the Koch's postulates, and it has been successfully cultivated in vitro (In VERO cell line) as well as in vivo (Experimental infection has been established in monkeys). The genome of the SARS corona virus is 29,727 nucleotides in length and the genome organization is somewhat similar to that of other corona viruses, however the detailed sequence data confirm that this SARS corona virus is a previously unrecognized corona virus. The recent studies carried out in the WHO network laboratories have shown that the SARS virus can survive after drying on plastic surfaces for upto 48 hours. The studies conducted in Hong Kong have shown that virus can survive in faeces for at least 2 days and in urine for up to 24 hours. (1, 2, 5-9)

## Incubation period

The incubation period is usually 2-7 days but may extend upto 10 days. (1, 2)

## Transmission

SARS virus appears to spread most commonly by close person-to-person contact involving exposure to infectious droplets, and possibly by direct contact with infected body fluids. It is also possible that SARS is transmitting through other unidentified routes. Persons having close contact with the cases, especially the health care workers and family members are at higher risk.

## Clinical features

The illness begins with sudden onset of fever, sometimes associated with chills and rigors and sometimes accompanied by other symptoms e.g. headache, malaise and myalgia. Some people also experience mild respiratory symptoms at the onset. Typically, rash and neurologic findings are absent. Many patients have reported diarrhoea, especially in Hong Kong. After 3 -7 days a lower respiratory phase begins with the onset of a dry, non-productive cough or dyspnea that may be accompanied by or progress to hypoxemia. In 10% to 20% of cases, disease may become severe enough to require intubation and mechanical ventilation. The main symptoms of SARS are high fever (more than 38°C or 100.4°F), dry cough, or difficulty in breathing. Changes in X-ray indicative of pneumonia also occur. (1, 2, 8-10)

## Diagnosis

As SARS is currently a diagnosis of exclusion, the status of a reported case may change over time. (11-14)

(a) A case should be excluded if an alternative diagnosis can fully explain the illness after considering the possibility of co-infection.

(b) Cases that meet the surveillance case definition for SARS should not be discarded on the basis of a negative laboratory test.

(c) A patient should always be managed as clinically appropriate, regardless of their case status.

## Role of laboratory for defining a case

A variety of laboratory tests have been developed and are being validated for diagnosis of SARS as given below:

(a) Virus Detection Test

(b) Molecular Test (PCR) : PCR can detect very minute quantities of the genetic material of the SARS virus in various clinical specimens in the early phase of the disease.

(c) Cell culture : Virus in clinical specimens from SARS patients can also be detected by infecting certain cell lines (VERO cell lines). Once isolated, the virus must be identified as SARS virus with further tests. Cell culture is the only test to indicate the infectivity of a SARS case.

(d) Antibody Detection Test

(i) ELISA test detects antibodies in the serum of SARS patients reliably as from day 21 after the onset of clinical symptoms and signs.

(ii) Immunoflourescence assays (IFA) detect antibodies in serum of SARS patients 10 days after the onset of illness.

(iii) Neutralization test (NT): This test assesses and quantifies, by means of titration, the ability of patients' sera to neutralize the infectivity of SARS-Co V on cell culture.

The test which has been most widely used so far is PCR test which is supposed to have a high specificity but low sensitivity. The clinical samples from suspect/ probable SARS cases should only be subjected to laboratory tests. Testing of samples from asymptomatic contacts is not recommended.

The following laboratories are equipped for analysis of the samples:

(a) National Institute of Virology (NIV), 20-A, Dr. Ambedkar Road, Pune-411001; Tel: 020-6127301, 6126302, 6127303, 6126304, Fax: 020-6122669,

E-mail: icmrniv@icmrniv.ren.nic.in

(b) National Institute of Communicable Diseases (NICD), 22 Sham Nath Marg, Delhi-110054; Tel: 011-23928700, 23971326, 23913148, 23971272, 23912836, Fax: 011-23922677

E-mail: dirnicd@bol.net.in.

(c) Tuberculosis Research Centre, (TRC), Mayor V. R. Ramanathan Road, Chetput, Chennai-600031. Tel: 044-28265403.

(d) National Institute of Cholera and Enteric Diseases (NICED), P-33, CIT Road, Scheme XM, Beliaghata, Kolkata-700010; Tel: 033-23500448, 23537469, 23537470; Fax: 033-23505066; E-Mail: )

(e) National AIDS Research Institute (NARI), Plot No. 73, G-Block, MIDC, Bhosari, Pune - 411026. Tel: 020-7121072, 7121343 Fax: 020-7121071

Collection, storage and transportation of clinical samples

**The following specimens should be collected from suspected/probable cases of SARS:**

(a) Acute & convalescent blood/serum for serology (at 21 days interval)

(b) Throat swab in viral transport medium.

(c) Nasopharyngeal swab or aspirate in viral transport medium (2 ml).

(d) Stool for virology: fresh or in viral transport medium.

(e) Whole blood (5-10 ml) with anticoagulant (EDTA).

**If available, the following samples may also be sent to the laboratory**

(a) Urine sample (50 cc) in a sterile container.

(b) Bronchoalveolar lavage fluid or tracheal aspirate in a sterile container.

(c) CSF, if additional symptoms of meningitis are present.

(d) All tissues from biopsy or autopsy, fresh & fixed

All the samples should be collected in sterile leak proof containers taking all biosafety precautions. While throat swab, nasopharyngeal swab or bronchoalveolar lavage and frozen tissues should be stored at -70˚C, serum may be stored at 4-8˚C for 1-2 days and at -20˚C for a long period. All specimens should be sent under cold chain condition (2-8˚C) within 24 hours. If a urine sample cannot be sent to the laboratory within 2 hours, it should be centrifuged and the deposit resuspended in a viral transport medium and should be sent to the laboratory under strict aseptic conditions. All samples should have three-layer packaging and be properly labelled. Always notify the receiving laboratory in advance. The clinical samples should be accompanied by proper clinical information of the case as per the "Case Information Proforma".

General bio-safety measures for clinical samples

(a) Clinical samples should be collected by hospital staff working for care of SARS cases and not by the laboratory staff.

(b) All clinical samples have to be collected with standard precautions.

(c) Always use N95 (0.3 mm pore size) masks while taking samples. In case of non-availability of N95 mask, triple layered surgical mask may be used.

(d) Use latex disposable gloves.

(e) Wear laboratory coat/disposable apron.

(f) Always cover your hair with head cover.

(g) Use protective eyewear/face shields, if the procedure is likely to generate aerosols or splashes of secretions.

(h) All waste while collecting specimen has to be handled with standard precautions. The waste should be placed in an appropriate leak proof and autoclavable biohazard bag and autoclaved before disposal. Contaminated non-disposables should be treated properly.

(j) The Clinical samples should be processed only in the designated laboratory having the appropriate containment facilities.

**Guidelines for personal protective equipments (regarding face mask)**

WHO has revised guidelines regarding the use of Personal Protective Equipment. In the light of this, a Technical sub group on management of SARS has given the following recommendations regarding facemask:

(a) Surveillance settings: In surveillance settings such as at airports / sea ports triple layered surgical mask should be used by the surveillance teams.

(b) Casualty / Triage Area / Inpatients settings: Patients and health care workers should wear P100 or P99 filter level or equivalent comparable masks. N95 or equivalent comparable masks can be worn when higher protection alternatives are not available.

(c) Critical care setting: During intubations, artificial ventilation and endotracheal suctioning, special mask developed by DRDO India should be used.

One should avoid the use of masks made of woven materials such as cotton or gauze as viral particles can pass through them.

**How to use the N95 mask**

Press the mask firmly against your face with the nosepiece on the bridge of the nose. Stretch and position the top band high on the back of the head, stretch the bottom band over the head and below the ears. Use both hands to mould the metal nose piece to the shape of the nose. The masks can be discarded appropriately after 4 hours of continuous use or once it comes into contact with any fluids. The mask should be discarded in autoclavable biosafety bags which should be autoclaved before the final disposal.

**Treatment and prognosis**

As of now, there is no vaccine or specific treatment available for SARS. However, good supportive treatment has been found effective in many cases. (1, 2, 9-12)

(a) Ribavarin and steroids have shown to be useful in treating critically ill patients. Ribavarin may be given 8mg/kg every 8 hours intravenously or 1.2g every 12 hours orally, with an oral loading dose of 4g for those with normal renal functions. Administer for 7-14 days depending upon the response.

(b) Give hydrocortisone 2mg/kg every six hours or 4 mg/kg every 8 hours intravenously. Tail off over one week when there is clinical improvement.

(c) For severe and rapidly deteriorating cases give methyl prednisolone 10mg / kg every 24 hours intravenously for two days, and then continue with hydrocortisone as above.

(d) Antibiotics treatment (coverage for typical and atypical agents for 7-14 days using drugs such as levofloxacin and macrolides) is advocated to prevent superadded infection.

Investigation to exclude other causes of pneumonia should be carried out. Patients who require mechanical ventilation generally fulfill the diagnostic criteria for ARDS with diffuse infiltrates on chest radiography and hypoxaemia without evidence of left ventricular failure. All suspect or probable cases of SARS must be treated in isolation with barrier nursing and universal precautions should be taken by the health care workers to prevent the further spread of disease. All the States/UTs have identified the hospitals where cases of SARS should be referred for treatment. List of such hospitals may be obtained from the respective State Health Authorities. Nebulization should not be done. If patient is on a ventilator, close system suctioning catheter and bacterial filter on expiratory and inspiratory limbs of ventilator circuit should be used.

**A patient may be considered for discharge when the followings are present:**

(a) Afebrile for 48 hours and resolving cough

(b) White cell and platelet count, creatine phosphokinase, liver function tests, plasma sodium and C reactive protein are returning to normal, if previously abnormal

(c) Improving chest X-ray changes.

Following discharge from the hospital, convalescent cases should remain at home for 10 days and keep minimum contact with others. Further confinement may be recommended after clinical assessment. Nevertheless, cases must contact their hospitals from where they were discharged if their condition deteriorates and symptoms reappear at any time.

**Prevention and control**

Isolation of suspect and probable cases of SARS and universal precautions taken by the healthcare workers and others who are likely to come in contact with SARS cases would prevent the further spread of disease. WHO recommends that international travellers departing from the places on the affected areas list should be screened for possible SARS at the point of departure. Travellers with one or more symptoms of SARS and having a history of exposure or who appear acutely ill should be assessed by a clinician and may be advised to postpone their trip until they feel better. Under the International Health Regulations all aircraft pilots and masters of ships are required to provide a General Declaration on Health to the Airport/Port authorities and APHOs/PHOs wherein any sickness on board is declared. This needs to be further strengthened by sensitizing all concerned to remain vigilant. Unless absolutely necessary, people should not visit hospitals where the SARS cases have been isolated to avoid any contact with them. Similarly avoid going to the crowded areas, otherwise keep your stay as short as possible.

All persons who come in contact with the suspect and probable cases of SARS should contact the local health authorities if they develop symptoms of SARS within 10 days of exposure. Temperature should be recorded daily as this is the first symptom which is likely to appear. Contact cases should restrict their movement and remain voluntarily confined to their homes.

All persons disembarking in India are required to fill up a proforma. Any person meeting the criteria of suspect/ probable SARS should be referred to the hospitals identified by Central/State Governments for further investigations and treatment in isolation. The cases should also be reported to Director, NICD, Delhi, respective State Health Authorities and Director, EMR. Healthy passengers are advised to contact local health authorities if they develop symptoms of SARS in the next 10 days.

WHO guidelines/documents on case definition, preliminary clinical description, case management, hospital discharge and follow-up policy, and hospital infection control have been circulated to all the States/UTs, Central Government Hospitals, Ministry of Home Affairs, Ministry of Civil Aviation/Airport Authority of India, and APHOs/PHOs.

Infection Control Guidance at the Hospitals

(a) All persons requiring assessment for SARS at the hospital should be assessed at a separate area to minimize transmission to others.

(b) Wherever possible, cases under investigations for SARS should be separated from the probable cases.

(c) All suspect/probable cases to wear N95 mask or three layered surgical facemask or any mask of 0.3 µm filter size as recommended.

(d) Healthcare staff involved in the treatment, or cleaning should wear personal protective equipments (disposable masks, gloves, gown, goggles, shoes, etc).

(e) Hand washing is very important and should be practised before and after contact with any patient, after activities likely to cause contamination, and after removing gloves.

(f) Alcohol based skin disinfectants can be used.

(g) Cases should be isolated or cohort placement should be done with independent air supply, exhaust system, and bathroom facilities.

(h) Turn off the air-conditioning and open window, if independent air supply is not possible.

(j) Strict barrier nursing using precautions for airborne, droplet and contact transmission.

(k) Movement of patients outside the isolation unit should be avoided; otherwise they should wear a N-95 or triple layer surgical or a 0.3 µm filter size mask.

(l) Non-essential staff and visitors should not be allowed in the ward.

(m) Disposable equipments should be used wherever possible and disposed of appropriately. All devices to be reused should be sterilized in accordance with manufacturers' instructions. Surfaces should be cleaned with broad-spectrum disinfectants of proven antiviral activity.

(n) All sharps should be dealt with promptly and safely.

**Cleaning and Disinfection of the SARS Patient Environment**

In-patient rooms housing SARS patients should be cleaned and disinfected daily and at the time of patient transfer or discharge. Daily cleaning and disinfection should include horizontal surfaces (e.g., over-bed table, night stand), surfaces that are frequently touched by patients and healthcare personnel (e.g., bed rails, phone), and lavatory facilities. Terminal cleaning and disinfection following transfer or discharge should include the type of surfaces described above plus obviously soiled vertical surfaces, frequently touched surfaces (e.g., light cords and switches, door knobs), and durable patient equipment (e.g., bed, night stand, over-bed table, wheel chair, commode etc). Curtain dividers should also be changed and laundered as appropriate for the curtain fabric. Patient care equipments such as mechanical ventilators, pulse oximeters, blood pressure cuff, should be cleaned and disinfected in accordance with current recommendations and manufacturer's instructions.

Cubicles or rooms in OPD areas where patients with suspected SARS are evaluated should be cleaned and disinfected before another patient is seen or cared for in that environment. Areas that should be specifically targeted for cleaning include the examination table and horizontal surfaces that may have been touched by the patient or healthcare providers. Solutions used for cleaning and disinfection should be discarded after use. Thoroughly rinse and clean housekeeping equipment after use in a SARS room or area and allow the equipment to dry. Launder reusable mop heads and cleaning clothes according to current practice.

Screening of International Travellers

(a) All International passengers and crew coming to the international airports and ports must be screened for SARS by a medical officer through the specially designed proforma available at all International Airports/Ports.

(b) The suspected case should be provided mask by the airport authorities/Port Organizations and isolated in an identified room at Airports/Ports till transported to the hospitals identified by the State Government.

(c) The identified hospital should be informed by Airport authorities/ Port Organization about the arrival of a suspected case and then transported to the identified hospital in ambulance.

(d) The details of the case should be provided to the identified nodal officers of the States, Ministry of Civil Aviation, National Institute of Communicable Diseases, Delhi and Directorate General of Health Services, Nirman Bhavan, New Delhi-110011 by Airport authority/ Port Organizations.

(e) All identified hospitals in Centre/ States should treat the cases in isolation with nursing barriers and observe universal precautions.

(f) The standard management protocols evolved by WHO and circulated to the Central and State Govts. should be followed. The same has also been mentioned in the text.

(g) The hospital authorities may take the help of the Regional Centres situated in Chennai (Tuberculosis Research Centre-ICMR), Mumbai (Enterovirus Research Centre-ICMR), Kolkata (NICED-ICMR), Delhi (NICD) and Pune (NIV, NARI-ICMR) to collect the samples.

(h) The case discharge protocol issued by WHO and already circulated should be followed.

(j) The hospital infection control guidelines already circulated should be followed to prevent the spread of infection in the hospital.

(k) All Indian Nationals disembarking by the same flight/ ship from which the SARS patient came should be followed up by the concerned State Governments to which they belong to for further 10 days. Ministry of Civil Aviation and Ministry of Shipping would provide the list of passengers to the State Governments for follow-up. (9, 14-16)

## References


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# Bio-Medical Sciences

## Contact Diseases


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## Introduction

Diseases spread from one person or organism to another by direct or indirect contact are usually called 'contagious' diseases' or 'Contact diseases' (1). By an unopposed convention the use of the word 'Contagious' and contact-transmission is reserved in medical literature for those diseases which are transmitted only through direct or indirect personal contact (2) and not through the other routes of transmission. Such infections cause mainly the skin and sexually transmitted infections (STI) and also diseases like trachoma, conjunctivitis and so on. Direct contact is necessary for transmitting skin infections like scabies and STIs. Indirect contact can transmit infections like fungal or pyogenic infections, trachoma and so on. Indirect infections can take place mainly through clothing and use of common soaps, towels, combs, razors, cosmetics like surma and so on. Some common infective and non-infective skin diseases, STIs and trachoma are briefly discussed in this chapter. Standard text books should be referred to for a detailed study. (3-5)

# Contact Diseases Other than Sexually Transmitted Infections (STI)

## Skin Diseases

### Introduction

Structure and Functions of Skin

The skin is the outermost protective structure of the body which intervenes between the internal structure of an organism and his environment. With the surface area of 2 $m^2$ and accounting for 16-20% of the total body weight, the skin is the largest organ of the body. The main functions of the skin are :

(a) Protection of the organism from noxious environmental, physical, chemical, mechanical, biological agents and radiations.

(b) Perception of sensory stimuli through cutaneous nerve endings

(c) Prevent fluid loss and regulate body temperature.

(d) Plays a role in social and sexual communication.

(e) Psychosomatic disorders may cause purely skin manifestations and the skin conditions may produce psychological disturbances (6).

Although the mortality due to skin diseases are negligible, but they contribute immensely in morbidity affecting the performance of a soldier besides causing great amount of stress and depression. The skin diseases results in ;-

(a) Considerable loss of effective manpower as 10 percent of all admissions to hospitals are due to skin diseases.

(b) A large number of personnel suffering from skin diseases may not be admitted to hospitals or invalided out, but they always suffer from partial incapacity.

(c) Diseases in this group have always shown a rapid increase under conditions of military expansion and actual warfare.

(d) A large number of ambulatory patients are in skin diseases than in diseases of any other organs. Therefore, the number of persons who report to the medical officer is far less than the actual incidence. On a survey carried out in a certain theatre of war the ratio of hospitalised to non-hospitalised skin cases was roughly 3:5.

However, much of the manpower wastage due to skin diseases is avoidable. The RMO is in a key position to help and cut down the morbidity and man-day wastage by advising the unit commander and subunit-commanders regarding the preventive and control measures. He should continuously educate all ranks in personal hygiene, early detection of cases and deal with them more effectively.

How to take Care of the Skin?

Where a good healthy skin improves the personality and confidence of an individual, a dull and unhealthy skin may cause psychosocial problems. As it is said 'skin is the mirror of oneself', the stress and happiness is reflected in the skin. Some tips to take care of the skin are :

(a) The skin and its appendages should be kept clean by regular washing with soap and clean water. In temperate climate one bath daily with warm water and soft toilet soap is adequate. If the work involves excessive sweating, either due to environmental or working conditions or after games, a second bath may be necessary.

(b) During bathing, give particular attention to body folds viz. webs of the fingers and toes, antecubital areas, armpits, groins, gluteal folds, perineum and popliteal areas.

(c) The scalp must be washed with good toilet soap or conditioning shampoo for removing dirt, debris or any excess of oil. Hair should always be kept short.

(d) Shaving should be always done with clean razors and preferably by oneself then unit barber. Blades should be kept clean, sharp and should be replaced frequently.

(e) It is a common practice with men to massage the body with oil before or after the bath. Vigorous

massaging with unclean hands causes inapparent injury and infection of the hair roots. However, a very thin layer of oil applied on the skin immediately after bathing keeps it elastic.

(f) Clothes should always be clean, specially the undergarments. They should be changed and washed daily.

(g) Early recognition and prompt treatment of skin diseases reduces the manpower wastage. Troops should be educated about self examination and common skin ailments and they should be encouraged to report to the unit RMO for further treatment.

How can we take care of the hands and feet?

Disorders of the skin of the feet, cause significant morbidity in soldiers. This is due to the increased usage of boots and socks over prolonged periods in uncongenial climate. The general measures to keep the skin of the feet healthy are:-

(a) Proper washing and cleaning of feet with soap should be done and well dried before wearing socks and shoes. Shoes should be well fitting, neither loose nor too tight, smooth, pliable, comfortable and of a permeable material.

(b) Rubber and canvas shoes in hot-humid environments cause sweat retention and sodden skin; hard leather causes callosities; projections like nails inside the shoes predispose to corns.

(c) Every person must use only his own pair of shoes and socks. Socks should be changed and washed daily. After daily work, personnel should take off their shoes and socks and use footwear which is of the open, chappal type to dry and aerate interdigital areas.

Care of the Hands

Adequate hand washing facilities should be provided at dining hall, bathrooms, work place etc. Occupations involving handling of strong chemicals and infectious materials should be done with proper work gloves. Harsh scrubbing with strong chemicals and detergents, too frequent washing of the hands with soap and water and prolonged immersion of hands in water should be avoided.

Table - 1 : Morphology of Skin diseases

| Primary lesions | Secondary lesions | Special lesions |
|---|---|---|
| Macule | Crust | Burrow |
| Papule | Erosion | Comedo |
| Plaque | Excoriation | Milium |
| Nodule | Ulcer | Telangiectasis |
| Wheal | Scar | Target lesion |
| Vesicle | | |
| Bulla | | |
| Pustule | | |
| Cyst | | |

Skin lesions are classified as primary or secondary and besides this there are some special lesions given in Table - 1 that are diagnostic of a particular disease (7).

**Classification of Skin Diseases**

(a) Bacterial Infections
  (i) Acute Pyodermal Infections
    - Furunculosis
    - Impetigo
    - Ecthyma
    - Folliculitis
    - Sycosis Barbae
  (ii) Chronic Infectious Sores
    - Tropical Ulcers
    - Desert Sore

(b) Fungal Infections
  (i) Dermatophytosis (TIneas)

(c) Parasitic Infestation
  (i) Scabies

(d) Leprosy

(e) Others

Important service related skin infections are briefly mentioned in coming paragraphs.

## Bacterial Infections

**Introduction**

A healthy person and healthy skin resists physical, chemical, mechanical and biological trauma. Infection develops when the right combination of agent, host and environmental factors exists. The usual bacteria involved are pyococci, fusiform bacilli, diptheroid bacilli, spirochetes and M. leprae.

**(a) Acute Pyodermal Infections**

Pyodermas are the skin infections caused by Staphylococci and Streptococci. The chief organisms which are responsible to initiate the infection are coagulase positive staphylococcus aureus, the haemolytic streptococci usually are secondary invaders.

Reservoir and Source of Infection

The reservoir of infection is the human carriers with the nasal, oropharyngeal and gastro-intestinal commensal organisms. The foci of overt infection in these sites, infected sores or wounds, discharging sinuses, draining furuncles in the ears and so on, also act as sources of infection to self or others.

Mode of Transmission

The organisms are transferred to the site by autoinfection or from one person to another by contact. However, the infectivity of the lesions of pyoderma is not very high except for the vulnerable individual under adverse conditions, and in children. Contaminated clothing and dressings are also a means of transfer of organisms from

one person to another.

Predisposing Conditions

Children are more susceptible to these conditions. Scaly, dry and hairy skins are more vulnerable. Maceration increased sweating, friction between surfaces or from clothing are the most important factors increasing vulnerability. Cuts, wounds, abrasions, burns, skin conditions like eczema, fungal infections, viral exanthemata or itchy dermatoses like insect bites, urticaria, mite and louse infestation (which on scratching cause excoriation), obesity, diabetes mellitus, malnutrition, blood dyscrasias, hypogammaglobulinaemia, unhygienic habits, infrequent baths and overcrowding, all increase the liability to develop pyodermas.

Clinical Entities

The clinical classification of common pyodermas is mainly based on the site of skin affected and severity of the disease. The following common conditions are recognized:-

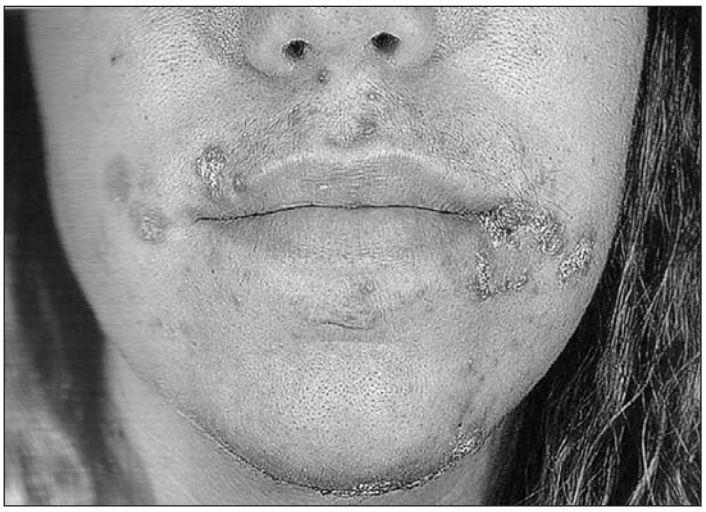
(i) Furunculosis

A boil is an inflammation of a pilosebaceous follicle or a ceruminous gland commonly caused by Staphylcoccus aureus. Often the boils are multiple and cause considerable disability. Aggregations of boils (carbuncles) occur in conditions like diabetes mellitus. The common sites for furunculosis are hairy, sweaty parts liable to friction and maceration, such as the buttocks, neck, face, axillae and the area underlying the belt. Favoured sites for carbuncles are the back of the neck, the upper back, and the lateral thighs (8). Bad personal hygiene is an important factor causing recurring furunculosis. The infection is quite common in athletes. Although boils may occur in otherwise healthy individuals, they are commonly seen in persons suffering from some pre-existing disease. The important conditions predisposing to furunculosis are prickly heat, acne, pediculosis, scabies, septic foci in the tonsils, throat, discharging ear, diabetes, nephritis, malaria and other debilitating diseases or obesity. Many individuals suffering from recurrent boils are carriers of staphylococci in their anterior nares or the perineum. However, furunculosis may occur in the absence of any apparent predisposing cause.

(ii) Impetigo

A common contagious superficial inflammatory disease generally caused by streptococcus pyogenes, staphylococcus aureus or a combination of both. The lesions consist of fragile vesicles which quickly rupture and the serum which exudes forms typical honey-coloured crusts on the skin. As a primary condition it affects the face, particularly the chin and beard area, but may complicate other skin conditions like scabies, pediculosis, prickly heat and so on. The condition is very infectious spreading rapidly within 48 hours of direct contact, or contact with contaminated toilet articles or through insanitary barbers.

Fig - 1 : Impetigo



(iii) Ecthyma

This is essentially a deep type of impetigo caused by haemolytic streptococci. It ordinarily begins with a blister which erodes through the epidermis to produce a shallow ulcer. Oozing occurs with formation of a hard, adherent, thick crust which may conceal the underlying ulcer completely. The most common sites are on the legs. Lesions may occur repeatedly after minor trauma. Poor hygiene and neglect of a primary skin condition are predisposing factors. The lesions may follow insect bites, minor scratches, chickenpox, vaccinia and herpes zoster.

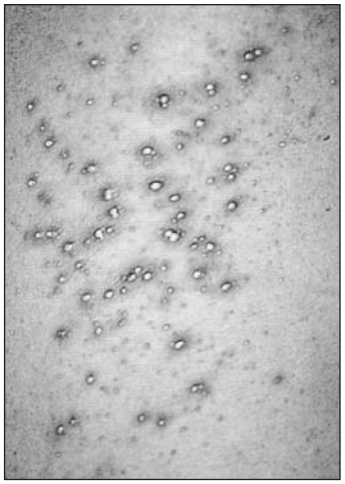
(iv) Folliculitis

This is of two types

**Follicular impetigo (superficial form)**

Folliculitis means an inflammation of the hair follicle. This is also a form of impetigo characterized by small dome shaped pustules at the mouth of the follicles, generally on the legs and thighs, caused by coagulase- positive staphylococci aureus. The process is superficial; therefore, there is no scarring. This type of infection is quite common among the troops and causes considerable disability. Massaging the extremities with dirty hands causing trauma and infection of the hair follicles is one of the predisposing factors. It occurs commonly in persons with a tendency to seborrhoeic dermatitis. It may develop as a complication of shaving. It may become extremely chronic and persist in the absence of any bacterial infection. Cutting oils and tar products are occupational causative agents of folliculitis.

Fig - 2 : Folliculitis



### Sycosis Barbae (Barber's rash)

It is a staphylococcal pustular folliculitis affecting male beard area and upper lip. The disease may be contracted from infected razors, shaving brushes or towels; often it is preceded by chronic blepharitis. Seborrhoeic men are somewhat more prone to sycosis barbae. In many cases there is gross sepsis in the gums, nasal sinuses or antra. The disease usually commences in a localized area and spreads rapidly. The primary lesion is a papulopustule from each of which a hair protrudes. These rupture and crusts are formed. Adjacent follicles are infected and as resistance of the skin weakens, the lesions become nodular. Suppuration occurs in the nodules, and the hair may come off even by a gentle pull.

Prevention and Control

Prophylaxis against these pyococcal conditions is achieved by:

(a) A high standard of personal cleanliness, a daily bath and avoidance of using each others' toilet articles such as shaving kit and towels.

(b) The unit barber's shop should be regularly inspected to ensure that razors, scissors, brushes, combs and linen are kept clean and disinfected. Blades should be thrown after every single use and proper disposal of such blades to be implemented preferably by deep burial. Self-shaving is in fashion today.

(c) Certain common personal hygiene measures like washing of hands after ablution, avoiding nose picking or thumb sucking, keeping the nails short, avoiding the massage of hairy areas especially legs and forearm with irritant oils like mustard oil, need emphasis.

(d) Early treatment curbs transmission by destroying the source of organisms. Strict aseptic measures in self-handling infected lesions, soiled clothing and dressings prevent spread of the disease among other personnel.

Treatment

(a) Squeezing or early incising is harmful. Hot compresses and permitting the infection to follow its normal course without much interference is enough for solitary boils. When the lesion 'points', it may be gently nicked aseptically, drainage established and an aseptic dressing applied. The pus should be wiped, collected on dressings and removed without allowing it to drain over the surrounding skin.

(b) The cleanliness of the surrounding area of skin is of paramount importance, otherwise satellite furuncles occur.

(c) Adherent crusts can be removed by intermittent hot compresses with normal saline. Thereafter, anti-bacterial creams like 1% silver sulfadiazine should be applied and penicillin or sulphonamide creams should be avoided.

(d) Warm magnesium sulph-glycerine dressing done daily for a few days causes pointing of the furuncles. Ordinary impetigo should show distinct evidence of clearing within 48 hours and will be healed within a week.

(e) Systemic antibiotics may become necessary if the disease becomes widespread and or severe. In such cases or if the condition becomes resistant or recurrent, hospitalization and or treatment by a dermatologist is necessary.

Table - 2 : Key points : staphylococcal skin infections

- Staphylococcus aureus is the most common cause of skin infection.
- Staphylococcus aureus has replaced streptococcus pyogenes as the most common cause of impetigo.
- Bullous impetigo is always caused by S aureus strains, usually phage II, type 71, that produce exfoliative toxins.
- Approximately 20% of the population is colonized by S. aureus.
- The anterior nares is the most common site of S.

### (b) Chronic Infectious Sores

Any trauma causing break in the continuity of the skin surface can get infected by specific organisms such as B. anthracis, M. tuberculosis or common pyococci and cause ulceration and formation of chronic, intractable sores covered with slough or crust and discharging pus or sero-sanguinous discharge when the crust is disturbed. The lymph nodes draining the area get inflamed and systemic symptoms may occur. Some sores manifest a specific natural course and appearance. Tropical ulcers and desert sores are typical examples of such specific sores.

(i) Tropical Ulcers (Ulcer Tropicum)

These are confined to the hot and humid tropical regions and thus the name Tropical Ulcers. In moist foothill areas of the northeastern regions of India they commonly occur amongst road labourers and others who, from the nature of their work, are liable to receive minute injuries on exposed parts such as the legs. The ulcers are often named after the region in which they are specially prevalent e.g. Naga sore, Annam ulcer. The starting point is a cut, abrasion, insect bite or other minor injury often trivial in nature and hence neglected. A small, tender, papule or bleb develops on the infected abrasion. This soon breaks down and after a short period of inflammatory reaction the ulcer becomes sub-acute or chronic, indolent and spreading. It rapidly deepens and becomes covered with a yellow, thick, purulent, foul smelling slough. The margins are indurated and raised; edges are undermined, and the depth is often difficult to determine on account of the presence of the tenacious slough. These sores are extremely painful, but in the absence of secondary infection there is little constitutional disturbance and generally there is no fever.

Healing is very slow and leaves a whitish scar. Regional lymph nodes are not involved.

(ii) Desert Sore

It occurs in deserts and arid areas and usually in men associated with horses, camels and mules. The sores occur at the site of abrasion or insect bite, on the exposed parts of arms and legs, covered by hair such as dorsum of the hands and forearm, elbows and knee joints. The lesion starts with a painful vesicle full of straw-coloured fluid. When the vesicle bursts a shallow, tender ulcer covered with a thin grey slough is left. The chronic ulcer has a characteristic circular punched out appearance with undermined edges, thickened margins and the base covered with grey coloured thin debris beneath which an adherent membrane is present. There is little or no discharge.

Prevention and Control

Prophylactic measures are as follows :

(a) Protection from injuries, abrasions, insect bites and brushing against bush and vegetation or scrub by use of long trousers and shirt sleeves rolled down.

(b) A high standard of personal hygiene is very important.

(c) Early efficient treatment of even the trivial injuries.

(d) In an endemic area of tropical ulcers i.e. North-Eastern India, all labourers, who are prone to receive minor injuries should immerse their legs in a solution of bleaching powder (one teaspoon to 5 l) at the end of the day's work.

(e) Management involves rest, limb elevation and treatment. Penicilin and /or metronidazole are the drugs of choice along with local dressings. Cases not responding to this regime early should be referred to the dermatologist. 2000 units of antidiphtheritic serum injected locally clears the desert ulcers which show C. diphtheriae and a course of PAM injections clears the soft sores showing spirochaetae.

## Fungal Infections

### Dermatophytosis (Tinea, Ringworm, Dermatomycosis, Epidermophytosis, Trichophytosis, Microsporosis )

Definition

Dermatophytosis and tinea are general terms, essentially synonymous, applied to mycotic disease of keratinized areas of the body i.e. skin, nails and hair without giving rise to the disease of the internal organs caused by a group of fungi called dermatophytes. Out of a large number of fungi present in nature only a few are pathogenic to human beings. The dematophytoses are subdivided according to the site of infection. (Table - 3)(9).

Tinea Barbae

Fungal disease that begins as a small papule and spreads peripherally, leaving scaly patches of temporary baldness. Infected hairs become brittle and breaks off easily. Occasionally boggy, raised and suppurative lesions develop called Kerions.

Table - 3 : Clinical presentations of dermatophyte infections

| Infection | Location |
|---|---|
| Tinea Barbae | beard |
| Tinea Capitis | Scalp |
| Tinea faciei | face |
| Tinea Cruris | groin |
| Tinea Corporis | Trunk, extremities |
| Tinea Unguium | Nails |
| Tinea manuum (manus) | hands |
| Tinea Pedis | feet |

Tinea Cruris

Fungal disease of the groin characteristically appears as a flat, spreading, ring shaped lesions. The periphery is usually reddish, vesicular or pustular and may be dry and scaly or moist and crusted. As the lesion progresses peripherally, the central area often clears, leaving apparently normal skin.

Tinea Pedis

Fungal disease of foot with characteristic scaling or cracking of the skin, especially between the toes, or blisters containing a thin watery fluid; commonly called Athelete's foot. Adults are more often affected than children, males more than females. Infections are more frequent and more severe in hot humid weather.

Agent

The pathogenic fungi belong to the three principal genera. Microspora infect hair and skin; Trichophyton infects hair, skin or nails; and Epidermophyton infects skin or nails. The different species can only be distinguished by a study of the morphological characteristics of their conidia (spores) and other accessory structures after culturing them. Microspora may be identified by a direct microscopic examination of infected hair. However, the cutaneous lesions are in most cases indistinguishable.

Reservoir and Source

The reservoir and source of infection in the community is a person suffering from an infection. Another important source of infection is the animal reservoir. This causes highly inflammatory, resistant lesions (10).

Mode of Transmission

Direct skin to skin or indirect contact especially from toilet seats, barber clippers, combs, hairbrushes, bath boards, neck rests, towels and hats contaminated with hair of infected people or animals. Undergarments may play some part but this has not been authentically proved. However, in cases of T. pedis the shoes of the affected individual, in cases of T. capitis the combs, barber's scissors and clippers are factors in transmission.

Susceptibility

Local skin peculiarities and intertriginous areas which are subject to friction, maceration, perspiration and increased temperature predispose to development of the disease after acquiring the infection. All ages are susceptible. Viable fungus may persist on contaminated materials for long periods.

Incubation Period

| | |
|---|---|
| Tinea barbae and capitis | Usually 10-14 days |
| Tinea cruris | Usually 4-10 days |
| Tinea Pedis and unguium | Unknown |

Predisposing Conditions

Fungal infections are extremely common in hot-damp areas. Persons who habitually perspire more, suffer more. Mild cases easily become severe by friction and sweating, rendering the sufferer unfit for duty. The commonest sites are therefore the sweaty areas of the body liable to be exposed to friction like the armpits, groins and feet, especially in between the toes. The superimposing secondary pyococcal infections increase the disability.

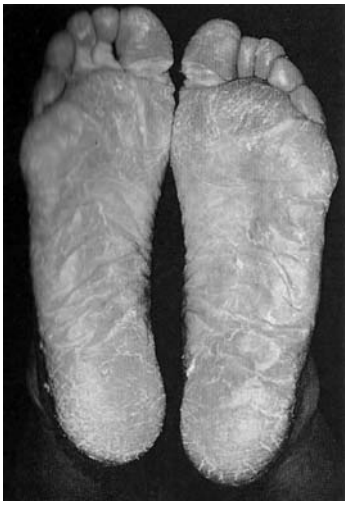
Clinical Varieties

The commonest manifestation of this fungal infection of the skin is a ring (annular) lesion; hence, the lay term 'ringworm' (Tinea and dermatophytosis are other names). The manifestations vary with the anatomical site involved and the species of fungus affecting. The commonest clinical types are the T. pedis and T. cruris, T. barbae comes next, followed by T. corporis. Infection of the armpits, scalp and nails are less important among troops. In children any part of the body may be affected but they are more susceptible to T. capitis which subsides as they grow. In women T. pedis is uncommon but skin under the breast and around the waist is commonly affected. In adult men, the feet are usually the first to be infected to produce what is commonly known as 'Athlete's foot'. Intertriginous, vesiculo-bullous or dry squamous lesions may occur.

Intertriginous Ringworm ("Athletes foot")

It is the commonest type affecting the skin, between and underneath the toes and producing maceration, sogginess, peeling and fissuring, accompanied by foul odour and pruritis. The initial lesion is a group of small vesicles occurring most commonly in the 4th and 5th interspaces; but extension to all interdigital spaces occur in severe cases, and subsequent extension to the under surface of the toes and adjacent part of the soles is frequent (Fig - 3).

Fig - 3 : Athelet's Foot



Vesiculo-bullous Ringworm

It most commonly affects the insteps of the soles and balls of the foot. In severe cases, the whole sole may be involved. Deep- seated vesicles of variable size and number develop and often fuse to form bullae or multilocular blisters which contain yellowish gelatinous fluid. Pruritis is severe.

Squamous Ringworm

Scaling, relative lack of inflammation and extreme chronicity usually affects the entire plantar surface extending over the sides of the foot These may be associated with intertriginous involvement of the toes.

Tinea Cruris (Jock Itch)

It is another common type occurring in males. It is essentially an intertriginous type of infection starting in the crural or perineal folds with extension posteriorly, anteriorly and on to the upper-inner surfaces of the thigh. The disease is not seriously disabling by itself, but it frequently becomes so by inappropriate and irritating treatment. In patients who are fat and sweat easily, the affected areas may become severely macerated and ooze; secondary infection with pyogenic organisms then readily occurs and increases suffering and disability (Fig - 4).

Prevention and control of fungal infections.

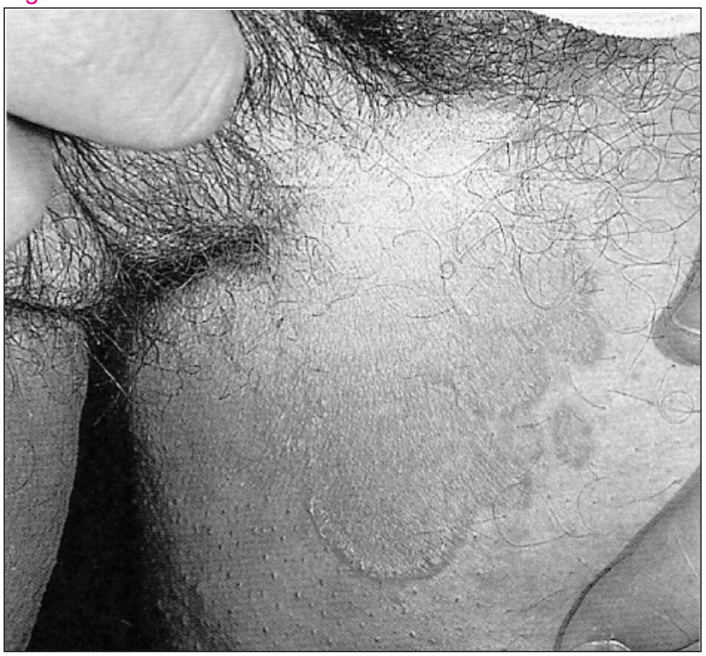
Prophylaxis is achieved by the following general measures:-

(a) Maintenance of strict personal hygiene with special care in drying the area. Areas between the toes, and armpits and in crotches should be more carefully dried after a bath, especially among athletes or in persons who excessively sweat due to any cause.

(b) Use foot powder or dusting powder before wearing socks and boots /shoes and undergarments, this helps in maintaining the skin dry in these places.

(c) Education of all ranks concerning the nature of the

Fig - 4 : Tinea Cruris



infection and its mode of spread is necessary.

(d) The towel which is used for drying the vulnerable parts of the body should be washed frequently and dried.

(e) Men should not exchange each others' towels, footwear and items of underclothing.

(f) Clothing should be of cotton, loose and non-irritating.

(g) Whether infection spreads through fomites or not is doubtful but general cleanliness in the ablution rooms and swimming baths have proved helpful. Floors and duckboards should be scrubbed and washed with cresol or bleaching powder solution. Shallow footbath containing a solution of bleach (1 scoop to 10 lit of water) may be provided at the swimming baths and showers, for use of all persons entering the bath. Coconut coir matting should not be used as it always remains wet.

The control of spread of ringworm infection in a unit is intimately related to early detection and effective treatment of all cases suffering from ringworm. A routine foot inspection should be conducted by RMOs and those infected should be given prompt active treatment by the RMO or specialist in the hospital.

Treatment

(a) The prescription of Griseofulvin is the specific treatment of all fungal infections. Average adult dose is 0.5 g a day for 3 to 4 weeks.

(b) Regular use of 5 to 10 percent acid salicylic ointment for several months is an alternative treatment in the absence of the facilities or pending specialist advice and in mild cases. Moderate tinea cruris can be relieved with the application of Whitfield's ointment every night and Castellani's paint during the day.

(c) Acute flare-ups can be relieved with soaks of 1:8000 potassium permanganate lotion (colour should be light pink) for 20 min twice a day and dressed with calamine lotion.

## Parasitic Infections

Table - 4 : Antifungal Drugs (7)

| | |
|---|---|
| **Systemic Antifungals** | |
| Griseofulvin | |
| Amphotericin B | |
| Allylamines | |
| Azole compounds | |
| Imidazoles : miconazole, clotrimazole, ketoconazole | |
| Triazoles : Fluconazole, terconazole | |
| **Topical Antifungals** | |
| Tolnaftate | Potassium Iodide |
| Whitfields ointment | Natamycin |
| Nystatin | Selenium sulphide |
| Gentian Violet | Sodium Thiosulphate |
| Castellani's paint | Zinc pyrithione |

### Scabies

Definition

Scabies or 'the itch' is a specific contagious disease caused by the presence of Sarcoptes scabiei var hominis in the stratum corneum of the human skin. Historically, scabies is the most likely cause of 'the seventh year itch'. It is characterized by the formation of burrows and intense itching which is most troublesome when the infested person is in bed or in a warm room. Prolonged loss of sleep or the disturbed sleep produced by almost intolerable itching adversely affects the efficiency of the person. Besides itching, suffering in a case of scabies is mainly due to a secondary pyogenic infection of the scabies lesions, such as follicular pustules, boils, impetigo and even abscesses. It is uncommon for scabies to present in just one member of a family.

Agent

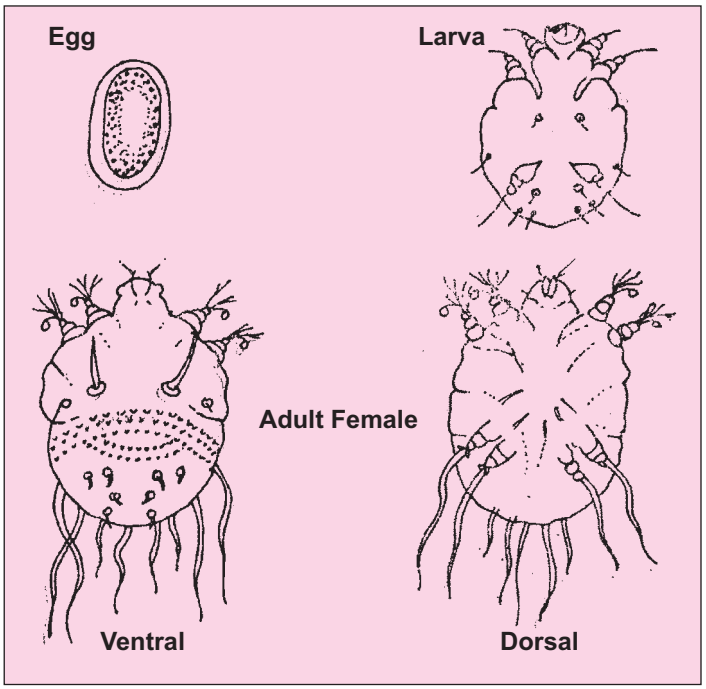
Sarcoptes scabiei is a very small mite just visible to a person with good eyesight. The female measures 0.4 mm. It is oval in shape and dirty white in colour (11). The male, which is rarely found, is about 2/3 the size of the female (Fig - 5).

Sarcoptes Scabiei (Itch Mite)

**Life Cycle**

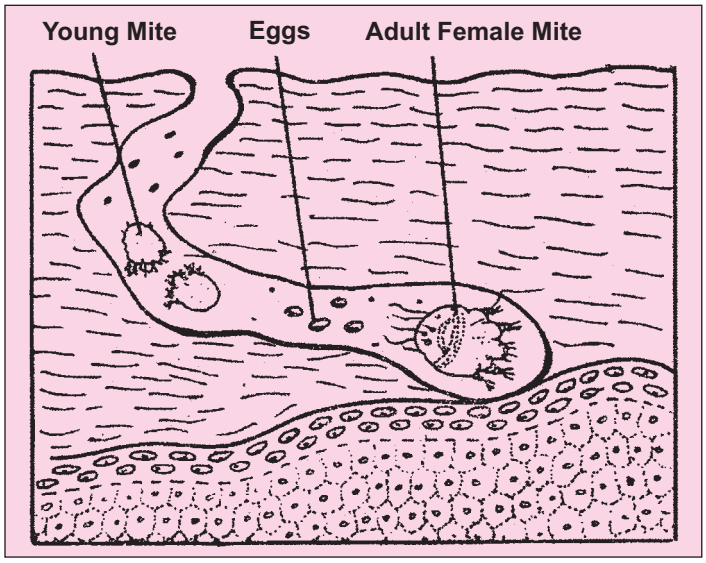
The female of the species is responsible for the symptoms. She burrows within the stratum corneum, and lays 2 to 3 eggs a day for 2 months. The eggs hatch out in 3 to 4 days. The larvae leave the burrow and take a temporary residence in the neighboring hair follicles. Here they moult into nymphs and then into immature adults in 6 to 8 days. The life cycle from egg to adult may take 10 -15 days. Adult mite lives for 1-2 months. The life cycle is passed solely in the skin. Successive generations

Fig - 5 : Sarcoptes Scabiei



cause further infestation (Fig - 6).

Fig - 6 : Itch mite in a burrow made in the skin




### Reservoir and Source

The itching is due to sensitization of the skin produced by absorbed products of the acarus metabolism and occurs after a month after infestation. Therefore, a person infested with scabies is unlikely to report sick and get treated up to a month. Thus he has ample opportunity and time to infect other individuals in the house, barrack or community, before the symptoms start.

### Mode of Transmission

Scabies spreads rapidly from one person to another through intimate contact, especially at night when the family sleeps huddled together in a one-room tenement. It is primarily a family disease. The older child brings it home from school or from the neighborhood and gives it to the younger ones and also to the parents. This is also one of the important infestations of residential schools. The infestation is brought in by children returning from home after vacation.

In Armed Forces barracks, it spreads from one person to another when there is overcrowding and poor personal hygiene. The infestation is generally brought in by new recruits and personnel returning from leave. The communal use of sports shirts and shorts and perhaps also towels used immediately after removal from an infested person may, although very rarely, cause transmission. It is not transmitted through blankets or if clothes are left aside for some time after removal by the infested person, since the female S scabei can survive only for 2 to 3 days away from the warm skin (12). When living on a person, an adult female mite can live up to a month. Pets do not transmit scabies as they become infested with a different kind of scabies mite.

### Diagnosis

The diagnosis is made by finding a mite in the burrow. The typical burrow is 5 to 10 mm long. In a fair skinned individual it may appear grey to black, due to dirt and the faeces of the mite within it, and is therefore easily mapped out. To extract the mite, a burrow should be selected in which it can be seen as a wax- like speck near the blind end of the burrow. A sterile needle is driven in the horny layer below the mite, keeping it almost parallel with the skin surface. The tip of the needle is then raised so that the burrow is opened out. The mite will be found clinging to the needle tip or on the under surface of the skin flap.

The sites of predilection for the burrow are : the sides and webs of the fingers, the front of the wrist, the points of the elbows, the anterior folds of the axillae, but not their hollows, the umbilical region, the prepuce, glans penis, scrotum and lower gluteal regions, in fact all areas of the skin which are soft and folded. There is almost always a large number of red, scratched patches on the sites of predilection. In troops, burrows may be rare on the fingers and, when short sleeves are worn, not so common on the wrists. When secondary infection occurs burrows often become obscure. If the diagnosis is not immediately apparent the man should be stripped and examined in good light when lesions in the other covered sites may be seen. In the lax tissues of the penis and scrotum a small papule is often seen, across the top of which, (unless it has been scratched or ulcerated) a typical burrow can often be detected. These lesions at times are mistaken for, and are occasionally complicated by, venereal sores. Similar but distinctly elongated papules are often found around the umbilicus and in axillary folds. The lesions on the gluteal folds and the elbows are often accompanied by secondary impetigo and such a condition should arouse suspicion of underlying scabies. On the presence of a rash with typical distribution, but without any typical burrows, one should not hesitate to diagnose scabies, particularly if there is a history of itching.

### Prevention and Control Measures

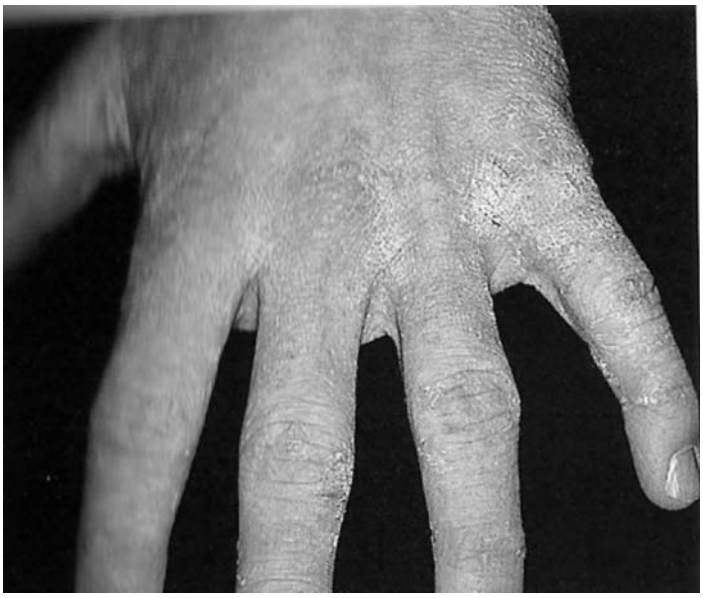
All ranks should be educated regarding the nature, mode of spread and precautions, especially, before going home on leave. Infestation rapidly spreads in overcrowded barracks unless relieved by proper spacing of beds. Interchange of clothing and sleeping huddled together should be forbidden. Personal hygiene among men in barracks should be maintained at a very high level. Bathing and laundering facilities in barracks should be adequate. Men usually report sick only when they suffer from intolerable itching, which usually takes place in a later stage after the infestation. Early detection followed by prompt and thorough treatment of the infested area is the most important control measures. All men returning from leave should be inspected from this point of view.

### Radical Treatment

The radical treatment of every case is one of the most important control measures. Mass treatment may be necessary in the case of widespread infestation especially in training and recruiting centers/ depots and other large units. The treatment of scabies is as follows:

(a) Apply a mite-killer cream like Permethrin (brand

Fig - 7 : Scabies



name: Elimite). These creams are applied from the neck down, left on overnight, then washed off. This application is usually repeated in seven days. An alternative treatment is application of an emulsion containing 25 percent benzyl benzoate to the entire body, except the head and face. In the case of babies, the head must also be treated. If it is thoroughly carried out, one application is usually adequate; 2nd application after an interval of 10 days may sometimes be needed. Applications on two consecutive days without washing may be occasionally required for individual cases of severe infestation. A bath is given after 24 h of the treatment. Cases showing complications of secondary bacterial infection and secondary eczematous changes should be admitted to hospital. The whole family or company or unit should be treated at the same time as a 'drill'.

(b) A single dose of oral Ivermectin is also safe and effective for most patients. The CDC recommends taking this drug at a dosage of 200 micrograms per kilogram body weight as a single dose, followed by a repeat dose two weeks later. It should be used with caution in elderly. Ivermectin and topical treatment provide a higher cure rate (8).

(c) Antihistamines, such as diphenhydramine can be useful in helping provide relief from itching.

(d) Because mites don't live long away from the body, it is not necessary to dry-clean the whole wardrobe, spray furniture and rugs, and so forth. No sterilisation of clothing is necessary; ordinary laundering in hot water is sufficient.

(e) Treat sexual contacts or relevant family members (who either have symptoms or have the kind of relationship that makes transmission likely).

Just as the itch of scabies takes a while to reach a crescendo, it takes a few days to subside after treatment. After a week or two, relief is dramatic. If that doesn't happen, the diagnosis of scabies must be questioned.

## Leprosy (Hansen's Disease)

### Definition

Leprosy is a chronic granulomatous immunological disorder caused by M. leprae primarily affecting the peripheral nerves and secondarily involving skin and mucosal membrane etc. It also affects eye, certain internal organs such as the kidney, liver, adrenal glands and in the male, testicles (4). The disease is clinically characterized by one or more of hypopigmented patches or partial/ total loss of sensation in the affected area or presence of thickened nerves or presence of acid fast bacilli in the skin smears.

### Importance of Leprosy

The seriousness of endemic leprosy in relation to other diseases cannot be evaluated solely by the number of patients or by the prevalence rates. The duration of the disease, the disabilities it causes, and the human and social consequences to the leprosy patients and their families, must also be taken into account. It is not only the long duration of the disease for lepromatous cases that is discouraging, but also the uncertainty of ultimate freedom from infection even after long periods of treatment. The anxiety may follow leprosy patients and their relatives throughout their lives and cast a permanent shadow over their families and their professional and social activities.

### Leprosy problem in World

The overall target for the global elimination of leprosy as a public health problem has been attained (13). The fall in prevalence rate is mainly due to an improvement in management of cases, very low rates of relapse, high cure rates, absence of drug resistance and shorter duration of treatment with MDT (14). The WHO estimates for 1994 were 2.4 million cases, a reduction of more than three fourths as compared to the estimated 10.6 million cases in 1976 (15). As of now, there is continued decline and in beginning of 2006, the number of leprosy cases in the world was around 0.2 million and global prevalence rate of leprosy was below 1 per 10,000 population. About 2.9 lakh cases are newly detected in 2005 which is 27% fall as compared to 2004. No drug resistance to MDT was reported (16). At present the highest burden is concentrated in 6 countries (India, Brazil, Indonesia, DRC, Bangladesh and Nepal ).

### Leprosy Problem in India

In last few years there is marked reduction in cases of Leprosy. As on 31$^{st}$ Mar 2006 the number of reported cases came down to 95150 giving prevalence rate of 0.84 cases per 10,000 population. India achieved elimination level of less than one case per 10,000 population by 31$^{st}$ Dec 2005. The disease shows high prevalence in 7 states (1-2 per 10000 population) viz. UP, Chattisgarh, Gujarat, Jharkand, Orissa, West Bengal and Delhi. These states contribute 67% of the total case load (17). Now the focus

of attention under national Leprosy Control Programme has shifted from endemic states to high priority districts and blocks. A Focused Leprosy Elimination Plan (FLEP) was carried out in 2005 targeting high endemic distts and blocks which included Block Leprosy Awareness campaign (BLAC). The hospital admission rate in Armed Forces is about 0.3 per 1000 (18).

### Agent

In 1873, Gerhard Armauer Hansen, a Norwegian scientist demonstrated these bacilli in leprosy lesions. Later they are called Mycobacterium leprae. The bacilli are acid fast and with ZN stain appear pink/red; and resemble the tubercle bacilli morphologically. The bacilli may be arranged in small or large clumps or bundles (called Globi) or may occur singly. They are less toxic and less pathogenic than many other organisms and their generation time is around 13-14 days. Thus the incubation period of the disease is much longer than that of most other infectious diseases. Other than man, it has multiplied in the footpads of mice, in tissues of immunosuppressed rodents and in the nine banded armadillo.

Reservoir

Man is the only known reservoir. Though natural infection has been reported in Armadillo and certain primates but it is not epidemiologically important. "Active or Open" cases who are shedding the organisms mainly through nasal discharges more so in Lepromatous cases are the chief source of infection.

Mode of Transmission

The exact mechanism of transmission is still unclear (19).

**Exit of M. leprae**

The major exit points of M. Leprae from untreated lepromatous patients are the nose, mouth, and in some cases abraded skin lesions.

**Entry of M. leprae**

Most likely sites of entry are skin and nasal mucosa. The bacilli from nasal discharges of infectious patients gain entrance through the skin or respiratory tract. House hold contact is important. Untreated lepromatous patients act as 'source case' or 'pool of infection' in the community.

The different modes of transmission are

(a) Droplet infection
  (i) Respiratory tract
  (ii) Aerosols containing bacilli
(b) Contact transmission
  (i) Direct (skin-to-skin)
  (ii) Indirect (soil and fomites)
(c) Other routes
  (i) Breast milk
  (ii) Tattooing needles

### Host

Infection can take place at any age to any sex depending upon the opportunities for exposure in endemic areas. In areas where leprosy is rare, the first contact may not take place early in life and thus the disease may appear late. However, a high incidence of infection among children means the disease is active and spreading. Incidence rates are highest in 10 to 20 yrs of age gp and then fall. In general, leprosy is more commonly seen in men then women due to their greater mobility and increased opportunity to contact the infection. Only a few people exposed to infection develop clinical signs of leprosy, although immunological conversion takes place in large proportions of contacts. It is now recognized that the effective immune response in leprosy is a cell-mediated one. In lepromatous leprosy there is a complete breakdown in the cell mediated immune response.

Incubation Period

(a) Long incubation period
(b) Average :3-5 years
(c) Tuberculoid type has shorter incubation period

Communicability

A patient is infective, if morphologically solid-staining (viable) bacilli are demonstrable.

### Classification of Leprosy

Leprosy is a disease of numerous classifications. This is probably a reflection of great variation in individual host resistance to the disease. These classifications are based on clinical, bacteriological, immunological and histological status of patients. The various classification in use are:

(a) Indian Classification
(b) Madrid classification
(c) Ridley and Jopling classification.
(d) WHO operational classification

The Indian classification is the official classification of the Indian Leprosy Association and most widely used in India. It is clinico-bacterial classification and described as under:-

Indian Classification (20) is as follows :

**(a) Indeterminate type**

Early cases with one or two vague hypopigmented macules and with and without sensory impairment. Lesions are bacteriologically negative.

**(b) Tuberculoid type:**

Cases with one or two well defined lesions which may be flat or raised, hypopigmented or erythematous and are anaesthetic.

**(c) Borderline type:**

Cases with four or more lesions which may be flat or raised, well or ill defined, hypopigmented or erythematous and shows sensory impairment or loss. Bacteriological positivity is variable and if left untreated can progress to lepromatous type.

**(d) Lepromatous type:**

Cases with diffuse infiltration or numerous flat or raised lesions, symmetrical without any sensory loss.

**(e) Pure neuritic type**

Cases show nerve involvement but do not have any lesion in skin. Cases are bacteriologically negative.

In 1987, WHO study group endorsed that all the patients showing smears positivity should be classified as having multibacillary leprosy for the purpose of MDT treatment. Same study group in 1993 gave clinical classification into two groups

(a) Paucibacillary leprosy (1-5 skin lesions).

(b) Multibacillary leprosy (more than 5 skin lesions)

**Diagnosis**

The following features assist in the diagnosis of the disease:-

(a) Clinical features.

(i) Skin lesions. (Infiltration, macules, papules, tubercles and nodules)

(ii) Paraesthesia. History of numbness and loss of hot and cold sensations in the extremities.

(iii) Thickening of nerve trunks

(iv) Anhidrosis.

(b) Histamine test

0.1 ml of 1/1000 solution of histamine chlorhydrate or phosphate is injected intradermally into the hypopigmented patches. In normal persons it gives rise to wheal surrounded by an erythematous flare (Lewis triple response) within a few minutes. In cases of leprosy where nerve supply is destroyed this response is lost.

(c) Skin smears

The skin smears, nasal smears and nasal scrapings are collected, fixed and stained with ZN method. This is used to distinguish between paucibacillary and multibacillary leprosy. A negative result, which is usual in indeterminate and tuberculoid cases, does not eliminate the diagnosis of leprosy. In certain cases histopathological examination may be necessary.

(d) Immunological Tests.

Lepromin Test

The lepromin test, also called Mitsuda reaction, was first described by the Japanese worker, K Mitsuda in 1916. It is an intradermal immunological test employed to detect CMI and classify the type of disease and to find out the prognosis in a given case. Lepromin is a suspension of lepromatous tissue rich in M.leprae in an isotonic solution of sodium chlorides sterilized by heating. The test is performed by injecting intradermally 0.1 ml of lepromin or lepra antigen in the forearm of a patient and the reaction is examined at the end of 48 hours and 21 days. The test results in 2 types of reaction.

**(a) Early reaction (Fernandez reaction)**

If there is erythema and induration measuring more than 10 mm in diameter at the end of 48 hours at the site of injection it is considered positive.

**(b) Delayed reaction**

At the end of 21 days, if there is a nodule more than 5 mm in diameter at the site of inoculation, it is said to be positive. This delayed reaction is also known as the classical or Mitsuda reaction. In strongly positive individuals there may be ulceration.

The early positive reaction shows that person has been previously sensitized by exposure to leprosy bacilli. The test is often positive in healthy persons and in those suffering from tuberculoid form of leprosy, and positivity gets weaker as we pass to lepromatous form of disease indicating a failure of CMI. The lepromin test is not a diagnostic test, its value lies in estimating prognosis, positive test indicating good prognosis.

(e) Other tests are :

(a) Lymphocyte Transformation Test (LTT)

(b) Leucocyte Migration Inhibition Test (LMIT)

(c) Fluorescent Leprosy Antibody Absorption Test (FLA-ABS test)

(d) ELISA

**Reactions in Leprosy**

Reactions are acute exacerbations of disease either due to alteration in CMI status (type 1 reaction) or immune complexes (type II or ENL reaction). Clinically there is increase in number and infiltration of lesions, neuritis, associated with constitutional symptoms and involvement of various organs like eyes, bones, testis and viscera. Reactions are best managed in hospital, whereby along with specific antileprosy treatment, anti-inflammatory drugs, steroids or antireactional drugs (Clofazimine, thalidomide,) may be administered (21).

**Prevention and Control**

(a) Problem estimation and early diagnosis

A quick random sample survey is done to collect base line data in the community. Contact surveillance of households with a lepromatous case is recommended for a minimum period of 10 years after case is declared bacteriologically negative, and for 5 years in households with a non-lepromatous case from the time of diagnosis of the index case. Mass surveys are expensive but repeated annual examinations of school children yield better results at relatively low cost (22, 23).

(b) Chemotherapy

WHO study group has recommended multi-drug therapy for both multi- bacillary and pauci bacillary leprosy (24). However, all cases in Armed Forces should be referred to Dermatologist immediately on suspicion. Any case of Leprosy is unfit for recruitment.

**Objectives of treatment**

(a) To interrupt transmission of infection in the

Table - 5 : Principles of Leprosy Treatment (25)

- Stop the infection with chemotherapy.
- Treat infections
- Educate the patient about leprosy.
- Prevent disability.
- Support the patient socially and psychologically.

community by sterilizing infectious patients as rapidly as possible with bactericidal drugs.

(b) To ensure early detection and treatment of cases, to prevent deformities

(c) To prevent drug resistance

(d) Curtailing the duration of treatment

**Recommended Regimens**

**(a) Multibacillary leprosy**

As per the recent recommendations, following groups of patients are to be given MDT :-

(a) All smear positive cases

(b) Skin lesions more than five in number

(c) More than one nerve trunk thickening

(d) All cases of relapse/reactivation

(e) All cases who have been treated with Dapsone monotherapy earlier.

**(b) Paucibacillary leprosy:**

MDT is not contraindicated in patients with HIV infection.

| | | |
|---|---|---|
| Rifampicin | : | 600mg once monthly, supervised |
| Dapsone | : | 100mg daily, self administered |
| Clofazimine | : | 300mg once monthly, supervised and 50mg daily, self administered. |

**Duration of treatment**

| | | |
|---|---|---|
| Rifampicin | : | 600mg once a month for 6 months supervised |
| Dapsone | : | 100mg daily for 6 months self |

**Multibacillary leprosy :** for 12 months, can be extended to 18 months and continued where possible upto smear negativity. Highly bacilliferous LL/BL patients may need 2-3 years or more of MDT for achieving bacteriological negativity.

**Paucibacillary leprosy :** for 6 months.

Follow-up of cases

Follow up of patients after completion of treatment is an important part of MDT. For paucibacillary cases follow up for at least once a year for 2 yrs after completion of treatment and for multibacillary cases at least once a year for 5 yrs.

BCG vaccination

Mycobacterium W vaccine has been released for human use for immuno modulation therapy.

Rehabilitation

It is an important aspect of leprosy control. It means the medical, surgical, social, educational, and vocational restoration as far as possible of treated patients to normal activity so that they resume their place in the home, in society and industry. Early treatment helps in disability limitation.

Health education

The education should be directed towards general public and to patients helping them develop attitudes and behavior by their own actions and efforts and seeking professional help whenever required. Early recognition of symptoms, prompt diagnosis, health seeking behavior, personal care, treatment adherence and rehabilitation are important aspects of health education.

In the Armed Forces, all suspected cases of leprosy are transferred to the nearest leprosy centres which are Command Hospital (Southern Command) Pune, MH Agra, Base Hospital Barrackpore, Delhi, Lucknow and MH Ramgarh. All cases are given institutional treatment. Family members of personnel suffering from leprosy are authorized only out-door treatment. Medical Officers are also advised to refer to Army Orders 150 of 1975 and 36 of 1987.

Table - 6 : Key Points - Hansen's Disease (Leprosy)

- Leprosy is a chronic granulomatous infection caused by Mycobacterium leprae, affecting primarily skin and peripheral nerves.
- Mode of transmission of leprosy is still not proven, but current evidence favors respiratory transmission.
- The diagnosis of leprosy is usually made based on skin lesions, cutaneous anesthesia, and enlarged superficial nerves and by demonstrating leprosy bacilli in the skin.
- Patients with tuberculoid leprosy have a high degree of immunity against M. leprae and have few skin lesions and few organisms in their skin.
- Patients with lepromatous leprosy have low immunity against M. leprae and have many skin

## Physical agents

### Prickly Heat (Miliaria)

This is an erythematous eruption resulting from blocking of the sweat pores by horny plugs of the excoriated cutaneous debris and a dried decomposition product of sweat, leading to a rupture of the occluded sweat ducts with subsequent extravasation of sweat into the epidermis or less commonly into the dermis. This occurs by excessive sweating in a hot humid climate aided by the removal of the natural cutaneous lipoid covering by frequent washing with soap and a maceration of the epidermis due to friction by rough clothing. Men from the hills are specially liable and acclimatized individuals suffer less. Prickly heat is not a grave matter but is sufficiently distressing so as to interfere with efficient occupational pursuits because of the incessant burning itch. On the other hand, it may be so extensive as to lead to a relative anhidrosis and precipitate heat stroke (26, 27).

**It is of following types** (28)

**(a) Miliaria Crystallina**

The blockage of sweat pores leads to either accumulation of fluid under the stratum corneum in clear colored vesicles.

**(b) Miliaria Rubra**

Leakage of sweat within the epidermis and resultant superficial papulovesicular eruption.

**(c) Miliaria Pustulosa**

Leakage of sweat within the epidermis and resultant papulopustular eruption.

**(d) Miliaria Profunda**

The blockage of pores lead to bursting of duct in upper dermis and resultant dermal inflammation seen as persistent deep seated papules.

Clinical Features

Clinically prickly heat appears as erythematous vesicles mostly on the sides of the trunk, abdomen, anticubital and popliteal fossae and sites such as the belt line and the areas where clothing rubs. The face, palms and soles escape. The lesions are usually bilateral. The eruption waxes and wanes in close correlation with the heat load. Vigorous exercise may also cause the rash. Secondary infection may give rise to furunculosis and bullous impetigo.

Prophylaxis

It is achieved by rapid evaporation of sweat and avoidance of friction by clothing. Any unnecessary exercise or work which promotes sweating should be avoided. Too much starch on clothing promotes sweating and friction, and should be avoided. A bare body suffers less from prickly heat. Ointments are occlusive and should be avoided. Excessive bathing with use of harsh, irritant agents, too much soap and friction by a rough towel are all contributory factors which should be avoided. However after activity leading to increased sweating, bathing without use of soap is helpful.

The treatment in the MI Room focuses on measures which inhibit sweating. At present the prickly heat powder containing 1 part each of sulphur precipitatum, camphor and pulverised boric acid, 2 parts of zinc oxide and 3 parts of starch powder is useful.

## Contact Dermatoses

Contact dermatitis refers to cutaneous inflammation resulting from the interaction of an external agent and the skin. These reactions occur through one of two mechanisms: a nonimmunologic irritant contact dermatitis (ICD) or an immunologic allergic contact dermatitis (ACD). ICD accounts for 80% and ACD is responsible for 20% of contact dermatitis. While over 2800 substances have been identified as contact allergens, almost any substance can act as an irritant (29). A serviceman may come in contact with potentially dangerous substances or he may be particularly sensitive to some substances which are used in the modern weaponry and equipment. The contact dermatoses are recognized by the following points:-

(a) Eruption is localized to the point of contact.

(b) Remission on removal from the source and exacerbation on re-exposure occurs.

(c) Distribution and correlation exist with the nature of duties.

(d) Similarity of results of patch testing with a suspected agent is diagnostic (this should not be attempted when the dermatoses is in an acute stage).

### Precipitating factors

Some materials in their natural state or in the form of dust, fume, gas or radiation are particularly harmful owing to the following properties:-

(a) Physical properties

Physical properties causing friction as by abrasives, foreign body reaction by piercing minute slivers or particles and local effects by heat, cold, moisture or radiation.

(b) Chemical properties

Chemical properties cause contact dermatitis by a primary irritant or by sensitization. The primary irritant reaction is due to interaction between the acidic or alkaline substances and skin proteins causing desiccation, keratolysis, protein precipitation or oxidation.

(c) Biological agents

Biological agents like anthrax, fungus and lice may be associated with the occupation of servicemen.

Table - 7 : Key points - Contact Dermatitis (8)

- Eighty percent of contact dermatitis reactions are due to irritation and 20% are due to allergic causes.
- Location of the dermatitis can help identify the causative agent.
- Patch testing is the only way to distinguish between allergic and irritant contact dermatitis.
- ACD is frequently patchy and can spread beyond the site of maximal contact.
- Allergen and irritant avoidance, moisturisation, and topical therapy are the keys to therapy.

## Psychocutaneous Disorders

Psychocutaneous diseases can be classified into three major categories:

(a) Primary psychiatric disorders with dermatologic manifestations

(b) Primary dermatologic disorders that result in secondary psychiatric problems

(c) Primary dermatologic disorders exacerbated by stress

### Mechanism

The mechanisms by which psychocutaneous disorders are brought about are :

(a) Increased physiological vasomotor responses.
(b) Hyperhidrosis and increased sebaceous activity changing the metabolism of the skin.
(c) Certain skin disorders termed as 'reaction-pattern disorders' are precipitated while certain disorders are aggravated by psychic stresses. Self infliction and malingering to obtain physical well-being and monetary gains may also be contributory factors.

**Common Psychocutaneous Disorders**

(a) Hyperhidrosis of palms and soles
(b) Trichotillomania
(c) Alopecia
(d) Vitiligo
(e) Neurodermatitis or lichen simplex, atopic dermatitis
(f) Pruritis
(g) Urticaria
(h) Nail dystrophies
(j) Aggravated by psychic factors :
  (i) Lichen planus
  (ii) Psoriasis
  (iii) Seborrhoeic dermatitis
  (iv) Acne vulgaris

**Diagnosis**

Although a skin disorder may be a manifestation of anxiety the patient may be completely unaware of the tensions unless deeply probed. A casual question, "Do you have any worries?" will be answered in the negative and any amateurish, attempt to unravel anxieties will be unsuccessful and harmful. Psychocutaneous disorders present a clinical picture showing a bizarre pattern, the diagnosis of which is not obvious. A disturbing experience before the onset, multiplicity of complaints, personal and family history of mental abnormality and a history of childhood experiences will aid in the diagnosis.

**Prevention**

It is by elimination of emotionally unstable individuals or those with a familial background of psychic disorders at the time of recruitment. The life in the Armed Forces presents far too many occasions for stressful situations with its resulting psychosomatic disorders. Man management which reduces strains and stresses, mental anxiety, oppressed emotions, boredom and monotony and promotes relaxation, is necessary to minimize such conditions.

## Trachoma

**Definition**

It is a chronic communicable kerato-conjunctivitis of insidious or abrupt onset. It is characterized by conjunctival inflammation with lymphoid follicles and papillary hyperplasia associated with vascular invasion of the cornea (pannus) and in its later stages by conjunctival cicatrization which may lead to gross deformity of the eyelids, progressive visual disability and blindness (30).

Table - 8 : Key points - Psychocutaneous Disorders (8)

- Forty percent of all dermatologic patients have associated psychologic morbidity
- Patients with delusions of parasitosis have monosymptomatic hypochondrial psychosis; the remainder of their mental functions are typically normal.
- Pimozide is the treatment of choice for delusions of parasitosis.
- Trichotillomania is most common in young girls and, in most cases, has an excellent prognosis.
- Adults who develop trichotillomania are more likely

This condition may be associated with bacterial infection.

**Epidemiology**

Geographical Distribution

Trachoma is a major preventable cause of blindness in developing countries. About 6 million people currently suffer from blindness due to trachoma in Africa and Asia. The incidence and prevalence of trachoma has shown a significant decrease in many endemic countries of SEAR during the past few decades. The decrease is due to improved sanitation, water, housing and implementation of control measures but it still remains a problem in parts of Myanmar, western region of Nepal and in few rural areas in India (31).

Incidence

Mild and quiescent trachoma is no longer a health problem in the Armed Forces. It is no longer a common cause of rejection during recruitment.

Agent

The infectious agent is chlamydia (Bedsonia) trachomatis which includes several antigenic types.

**Reservoir**

Man is the only reservoir. The eyes of infected individuals (especially children from 1 to 15 years of age) are the sources of infection.

**Mode of Transmission**

Transmission occurs by close contacts, hands, towels, handkerchief, pillow cases, flies and dust. A dry and hot climate with dust, dirt squalor and crowding in houses, dormitories, hostels, barracks, swimming pools and general unhygienic conditions leading to fly breeding and midget breeding favour the spread of disease. The use of common family vial of eye cosmetics, such as 'surma' and 'kajal' or towels and wipe clothes is a potent cause of spread in families and close institutions such as schools, hostels and so on. One can, thus, summarize the main environmental risk factors which are involved in the transmission of trachoma as six Ds (dry, dusty, dirty, dung, discharge and density (over- crowding) or five Fs (flies, faeces, face (eyes) fingers and fomites) (32).

Host

No person is immune. In endemic areas children have

active disease more frequently than adults. The severity of the disease often is related to environmental conditions. Lack of water and exposure to dry winds, dust and fine sand may contribute to the severity of the disease.

**Incubation Period**

It is 5 to 12 days.

**Communicability Period**

This is very prolonged and starts before the appearance of the follicles and continues until cicatrization has occurred.

**Clinical features**

Trachoma is classified as Blinding and non blinding. Trachoma inflammation may undergo spontaneous resolution or may progress to conjunctival scarring which can cause inward deviation of eyelashes (trichiasis) or of the lid margin (entropion). The abrasion of the cornea by eyelashes frequently results in corneal ulceration, followed by scarring and visual loss.

**Prevention and Control**

(a) Chemotherapy

Mass treatment done when prevalence is more than 5% of severe or moderate trachoma cases in children under 10 years is seen. With prevalence less than this, selective treatment is done. Trachoma usually responds to modern drugs (sulphacetamide, aureomycin, 1% tetracycline, chloromycetin, erythromycin). Field trials on trachoma control have shown that the "intermittent schedule" of treatment i.e. local application of one of the broad spectrum antibiotics twice a day for 5 days in a month at monthly intervals for a period of at least 6 months, is satisfactory.

(b) Surgical correction

Individuals with lid deformities (trichiasis, entropion) will require surgical correction to avoid complications like blindness.

(c) Health Education

Long term antibiotic treatment must be carried out by the affected population itself. This is important to get co-operation of people in maintaining personal and community hygiene. It has been shown that once a member of family is infected others are invariably affected. Therefore, health education is of paramount importance and will require permanent change in the behaviour patterns and in environmental factors.

(d) Hygiene and Sanitation

Ultimately, only environmental improvements can reduce transmission and reinfection. These measures comprise control of flies, safe water supply and improvement in personal and general hygiene.

Lt Col Sunil Agarwal

# Sexually Transmitted Infections (STI)

## Introduction

STI are a group of contagious diseases transmitted predominantly by sexual contact and caused by wide range of bacterial/viral, protozoal, fungal and ectoparasites. During the past two decades, STD's have undergone a dramatic transformation like.

(a) Greatly reduced rates of the STIs due to effective public health programs and changing sexual behaviour.

(b) Changing patterns of STI rates due to HIV/AIDS calling for intensified AIDS-STI control efforts.

(c) The growing evidence that certain STI's function as risk factor for transmission of HIV infection.

Attention is now given not only to specific diseases but also to clinical syndromes associated with STI's. Most of the recently recognised STI's are now referred to as second generation STI's. AIDS is the most recently recognized (33).

## Epidemiological Pattern of STD (34)

Global

True incidence of STI's is not known because of stigma involved but the trend in gonorrhoea and primary syphilis is on the increase. The matter of concern is emergence of antimicrobial resistance agents of STI. Second generation STIs are tending to replace the classical bacterial diseases (syphilis, gonorrhoea, chancroid). Minimal estimates of new cases for major STDs are

| | | |
|---|---|---|
| Gonorrhoea | : | 62 million/yr |
| Genital chlamydial infection | : | 92 million/yr |
| Syphilis | : | 12 million/yr |
| Chancroid | : | 07 million/yr |
| Genital herpes | : | 20 million/yr |
| Genital human papilloma infection | : | 30 million/yr |

On an average 900,000 people are believed to be infected each day.

India

In India the yearly incidence of STI's is 4-5% which accounts for 40 million cases per year.

(a) Syphilis: Prevalence of 1.4 2.4% in serological surveys.

(b) Gonorrhoea: More widely prevalent than syphilis, 80% of the infected women are asymptomatic carrier.

(c) Chancroid: widely prevalent in India.

(d) LGV: Its more prevalent in southern states of Tamil Nadu, AP, Maharashtra and Karnataka than in northern states. Greater prevalence in coastal areas is found. Information on other STI's are not available because of poor reporting system.

## Importance of STDs in the Armed Forces

The incidence of sexually transmitted disease in the Indian Army has always been low and has now dropped so low that it cannot be considered as of any real medical significance. However, the underlying factors which cause increased incidence in a unit, points directly or indirectly to bad discipline low moral and lack of man-management. These factors also have considerable importance in determining the efficiency of unit administration and fighting reliability (36).

The rates increased progressively during war years and remained high till 1948. From 1949 onwards the incidence of STDs declined and from 1962 to 1972 when the Armed Forces expanded and were actively deployed during the national emergency the rates marginally increased. Thereafter it has shown decline and is stabilized. Even the WHO has felt that members of Armed Forces form a high risk group for STDs.

**Classification of sexually transmitted agents**

| Bacterial | Ectoparasites |
|---|---|
| Neisseria gonorrhoea | Sarcoptes scabiei |
| Chlamydia trachomatis | Phthirus pubis |
| Treponema pallidum | Viral agents |
| Haemophilus ducreyi | Human(alpha) herpes virus1 and 2 |
| Mycoplasma hominis | Human(beta)herpes virus 5 |
| Ureaplasma urealyticum | Hepatitis virus B |
| Calymmatobacterium | Human papilloma virus |
| Granulomatis | Molluscum contagiosum |
| Shigella | HIV |
| Campylobacter | Protozoal agents |
| Group B Streptococcus | Entamoeba histolytica |
| Bacterial vaginosis related Organism | Giardia lamblia |
| Fungal agents | Trichomonas vaginalis |
| Candida albicans | |

## Syndromic Management of STI/RTI

Many STIs/RTIs can be identified and treated on the basis of characteristic symptoms and signs. Symptoms and signs can be grouped together into Syndromes, upper respiratory infection, gastroenteritis and vaginal discharge are examples of common syndromes. It is often difficult to know exactly what organism is causing the syndrome, and treatment may need to cover several possible infections. Syndromic management refers to the approach of treating STI/RTI symptoms and signs based on the organisms most commonly responsible for each syndrome. Laboratory tests require resources, add to the

cost of treatment, may require clients to make extra visits to the clinic and almost always result in delays in treatment. For these reasons, syndromic management guidelines are widely used for syndromes such as lower abdominal pain, urethral discharge and genital ulcer, even in developed countries with advanced laboratory facilities.(37)

WHO has developed simple flowcharts (also called algorithms) to guide health care providers in using the syndromic approach to manage syndromes.

Syndromic Approach

Most STD patients consult a doctor or health care provider with complaints related to one of the following syndromes:

(a) Urethral discharge
(b) Vaginal discharge
(c) Genital ulcer
(d) Inguinal swelling

Table - 1 : Using the Syndromic Approach (38)

| | Syndrome | Possible STI/RTI |
|---|---|---|
| Men | Urethral discharge | Chlamydia, gonorrhea |
| Women | Lower abdominal pain | Chlamydia, gonorrhea |
| | Vaginal discharge | Chlamydia, other bacteria, bacterial vaginosis, candidiasis, trichomonas |

(e) Lower abdominal pain

Table - 2 : How to avoid Sexually Transmitted Diseases

| Avoid high-risk behaviors and practice safe sex |
|---|
| ✎ Though not necessarily practical or desirable, abstinence is the only way to completely prevent STDs. |
| ✎ Avoid sex with many different partners. The less sexual partners a person has, the lower the risk of infection. |
| ✎ Sexually transmitted diseases can be avoided to a large extent by practicing safe sex (eg using |

These syndromes apply to possible STIs/RTIs as in Table - 1

## Syphilis

### Agent

The causal organism is *Treponema pallidum*. In vivo replication time, relative to most bacteria is about 30 hrs. The organism is 6 to 15 microns in length to 0.15 micron wide.

Mode of Transmission

Syphillis is usually acquired by sexual contact. Infants acquire congenital infection by transplacental transmission of *T. pallidum*.

### Stages of Syphillis

Both congenital and acquired syphilis are divided into early and late stages. Early acquired syphilis is further subdivided into an incubation period, primary, secondary and early latent stages. The following types and stages are recognized :-

Acquired Syphilis (7)

**(a) Early Syphilis (diagnosed in first two years of infection)**
(i) Primary stage
(ii) Secondary stage
(iii) Recurrent stage
(iv) Early latent stage

**(b) Late Syphilis (diagnosed after the second year of infection)**
(i) Late latent stage
(ii) Late Benign stage (gumma)
(iii) Cardiovascular Syphilis
(iv) Central Nervous System Syphilis

Congenital Syphilis

(Since *T. pallidum* is introduced directly into the fetal circulation, there is no primary stage as seen in acquired syphilis)

**(a) Early Phase (within the first two years of life)**

Analogous to the secondary stage of acquired syphilis

**(b) Late Phase (after two yrs of age)**

Analogous to the tertiary stage of acquired syphilis

**(c) Stigmata-scars and deformities resulting from early or late lesions which have healed.**

### Pathogenesis

*T. pallidum* enters the body through a break in squamous or columnar epithelium during sexual contact. The incubation period has a mean of 21 days with extremes of 10 to 90 days. Variation in expression of disease reflect differences in the immune status of the hosts.

### Clinical Features

Primary Syphillis

The first clinical manifestation is usually a local lesion at the site of entry. The lesion starts as dull red macule, which rapidly becomes papular and then ulcerate. A small, clean, painless, hard ulcer (Hunterian chancre) appears on the site. The early chancre has a clear red base, but later covers with a gray slough. Untreated, a chancre will persist for 3 to 6 wks and then heal. Regional lymphadenopathy develops within a week and the nodes are painless, nontender, small to moderate in size, rubbery and nonsuppurative.

Secondry Syphillis

*T. pallidum* disseminate widely throughout the body. After 3-6 weeks, the disease is seen to be systemic. The more common symptoms include sore throat, malaise,

headache, weight loss, fever, musculoskeletol pains. A rash of early secondary stage appears on the back, chest, abdomen, arms and thighs, and also on the mucous patches in the mouth. Rash characteristically includes the palms and the soles. Rashes can be of follicular, annular or papular type. Papular rashes may become large and raised and may resemble viral warts, but they are characteristically broad and flat so called Condylomata lata. Generalised lympadenopathy is common with moderately enlarged nodes rubbery, discrete and nontender. Even the rash may subside with a little treatment but infective relapses occur with varying intervals of latent periods.

Tertiary Syphilis

Involvement of other systems occurs in 10 percent of cases or less. After3 to 4 years, the benign manifestations as gumma in bones, deeper parts of the skin, muscles or liver make their appearance. After about 5-10 years or upto even 20 years the vital organs like the brain, heart, nerves and big arteries are affected and the severe signs of cardiovascular and neuro-syphilis may appear. The predominant features of cardiac syphilis are aortic regurgitation, aortic aneurysm, arrhythmias and angina. The neurosyphilis can present in a variety of ways meningovascular syphilis, tabes dorsalis and general paresis.

**The classification of Neurosyphillis is (39) :**

(a) Asyptomatic neurosyphillis
(b) Meningeal neurosyphillis
(c) Meningovascular neurosyphillis
(d) Parenchymatous neurosyphillis
(e) Gummatous neurosyphillis

**HIV infection and Neurosyphillis**

Conventional syphilis treatment often fails in HIV infected patients. Moreover HIV patients demonstrate accelerated progression to early neurosyphilis. As a result of AIDS epidemic neurosyphilis is becoming more common in young adults.

Spontaneous cure may occur at any time after the late secondary manifestations subside or this latent phase may prolong throughout life. The disease is almost completely curable in the early stages but becomes progressively resistant as it advances. Infected man infects other women perhaps including his own wife during infective relapses. The disease is transmitted by the infected mother to the foetus after the 4$^{th}$ intrauterine month. Some of them are still born; others die soon after birth. Those who survive may become crippled, blind, deaf and mentally subnormal called congenital syphilis.

**Diagnosis**

The diagnosis of the primary hard chancre is confirmed by finding of *T. pallidum* on the dark-ground examination of the discharge from the ulcer. In the late primary or further stages and in congenital infection it is confirmed by the WR, Kahn or VDRL reaction. Skin biopsy may be quiet helpful. Other tests are FTA-ABS (Fluorescent antibody absorption test, MHA-TP (Microhemagglutination assay for antibodies to *T.pallidum*) and HATTS (Hemagglutination treponemal test for syphilis).

**Treatment**

(a) Early Syphilis

**(i) In HIV Negative patients**

- Procaine Penicillin 8 lac IU IM OD after test dose for 10 days or Bezathine Penicillin 2.4 MU IM after test dose divided half in each buttock.

**(ii) In HIV Positive patients**

- Procaine Penicillin 24 lac IU IM OD after test dose for 14 days or Crystalline Penicillin 30 lac QID IV for 10 days after test dose or Crystalline Penicillin 30 lac QID IV for 10 days after test dose.

(b) Late Syphilis

**(i) In HIV Negative patients**

- Procaine Penicillin 8 lac IU IM OD after test dose for 14-21days or crystalline Penicillin 10 lac IU IV QID for 14 days.

**(ii) In HIV Positive patients**

Table - 3 : Key points - Syphilis

- Syphilis is sexually transmitted disease that can also be transmitted from the mother to the fetus.
- Syphilis is produced by the spirochete Treponema pallidum, ssp. Pallidum
- Acquired syphilis is sexually transmitted and if untreated passes through primary, secondry and may into tertiary stages.
- The first two years of infection are termed early syphilis (infectious) and the later part called late syphilis (non infectious)
- Secondry syphilis is protean in its clinical appearance and can be difficult to recognise.
- Patients with syphilis have an increased incidence of other sexually transmitted infections such as gonorrhea, HIV infection, and veneral warts.

- Procaine Penicillin 24 lac IU IM OD after test dose for 14 days or Crystalline Penicillin 20-40 lac IU 4 hrly IV for 14 days after test dose.

## Gonorrhoea

This is the commonest cause of urethritis in India. Gonorrhoea is caused by Neisseria gonorrhoeae, Gram-negative intracellular diplococcus, a bacteria that grows and multiplies quickly in moist, warm areas of the body such as the cervix, urethra, mouth, or rectum. In women, the cervix is the most common site of infection. However, the disease can also spread to the uterus (womb) and fallopian tubes, causing pelvic inflammatory disease leading to infertility. Gonorrhoea is most commonly

spread during genital contact, but can also be passed from the genitals of one partner to the throat of the other during oral sex. Gonorrhoea of the rectum can occur in people who practice anal intercourse. In pregnant women, gonorrhoea can be passed from an infected woman to her newborn infant during delivery if left untreated.

Although transmission from males to females is easier, in females the infection is often mild, and many women who are infected have no visible symptoms of the disease. Most patients are males only. If symptoms of gonorrhoea develop, they usually appear within 2 to 10 days after

| Symptoms in women (40) |
|---|
| Painful, burning sensation when urinating |
| Yellowish or bloody discharge from the vagina |
| Bleeding between periods |

sexual contact with an infected partner, although a small percentage of patients may be infected for several months

| Symptoms in men |
|---|
| Burning sensation during urination |
| Yellowish-white discharge from the penis that usually stains the undergarments. |

without showing symptoms.

Men are more likely to show symptoms than women. The symptoms in men include:

A diagnosis is made through detection of bacteria in samples taken from the urethra, cervix, throat or rectum. The condition is treated with antibiotics, and treatment should also be given to the patient's partner. As with Chlamydia, further testing is recommended once treatment has ended to check whether the infection has cleared. The complications of Gonorrhoea are posterior urethritis, urethral stricture, cystitis, prostatitis, seminal vesiculitis, epididymo-orchitis and urethral fistulae (watercan Perineum).

It is generally more cost effective to treat presumptive chlamydial infection also in all persons with gonorrhoea. The treatment includes single dose Ceftriaxone 125 mg IM or Cefixime 400 mg orally or Ciprofloxacin 500 mg orally or Ofloxacin 400 mg orally along with Doxycycline 100 mg orally twice a day for 7 days.

## Chlamydia

Chlamydia is the most common and fastest spreading sexually transmitted disease. It stems from a bacterium, Chlamydia trachomatis. One of the three species within the genus Chlamydia, is an important cause of blindness and STD in humans.

Women diagnosed with Chlamydia can also infect their newborn infant during delivery. Symptoms usually appear approximately 7 to 21 days after infection and differ for men, women and children.

| **Chlamydia infections : Clinical features** |
|---|
| Symptoms in men (40) |
| Inflammation of the urethra (the bladder duct within the penis) |
| Stinging feeling when passing water |
| Clear discharge from penis and possible itchiness around the opening |
| Pain or tenderness in the testicles. |
| Symptoms in women |
| Stinging feeling when passing water |
| Unusual vaginal discharge |
| Pain caused by pelvic inflammation (PID) |
| Pain during intercourse |
| In some cases, bleeding between periods |
| Symptoms in infants |
| Inflammation of the eye (conjunctivitis) at birth |
| Breathing Problems |
| Premature birth |

One of the most common ways of testing for Chlamydia is for the MO to collect a cell sample from the infected area (cervix or penis) with a cotton swab. This is then sent to a laboratory for evaluation. Treatment consists of antibiotics, and should also be given to the patient's partner. A further swab is recommended once treatment has ended to check whether the infection has cleared. The recommended regimens are: Doxycycline 100 mg orally 2 times a day for 7 days or Azithromycin 1 gm orally, once.

## Herpes Genitalis (genital herpes)

Gential herpes is a highly contagious viral condition caused by the herpes simplex virus (HSV). It principally infects the skin and mucous membranes of the genitals and rectum, but can also appear in areas such as the mouth. It is transmitted primarily through physical and sexual contact. During birth, the presence of herpes simplex virus on the genitalia or in the birth canal is a threat to the infant. Infection in the newborn infant can lead to herpetic meningitis, herpetic viremia (herpes virus particles present in the blood) and chronic skin infection.

The symptoms of herpes simplex virus usually occur a week after infection, but sometimes take longer to appear. Initially, the skin becomes reddened and multiple small blisters filled with a clear, straw-coloured fluid appear. Prior to the presence of blisters, the infected individual may also experience increased skin sensitivity, tingling, burning or pain at the site where blisters will appear. Later, the blisters burst leaving shallow, painful ulcers which eventually scab and heal over a period of 7 to 14 days.

There is no cure for the herpes simplex virus; once infected, patients will remain a carrier for the rest of their

lives. Some remedies, however, can reduce the duration of the eruption. In addition, by being more aware of the initial symptoms of recurrence (skin sensitivity and tingling), timely treatment with medication such as Acyclovir will often abort the outbreak of blisters.

Although the symptoms of genital herpes may not be present, it is important for those infected to inform their partner that they have the disease. This will encourage both parties to use barrier protection (condoms) to prevent the spread of the illness. Using condoms and not sharing towels are good ways of reducing the chance of infection in the first place.

### Genital Warts

Warts, or condylomata acuminata, are caused by the human papilloma virus (HPV). Up to nine months can pass from the time of infection to the actual development of warts. In women, human papilloma virus can lead to changes in the cervix and to the development of cervical cancer. Therefore, it is important that this condition is diagnosed and treated.

The common symptoms are raised, rough, wart-like growths that may occur singly or in clusters. In men, they are usually found around the head of the penis. In women, they appear most often around the vaginal opening and may spread to the rectal area. It is also possible for the virus to appear on or near the cervix as whitish, flat-like lesions, usually only detectable through close visual examination of the cervix (colposcopy). In both men and women, lesions may also be present in the mouth and throat. In general, symptoms can intensify if the immune system is weakened, or during pregnancy or if the person has diabetes. The warts are very contagious, so safe sex is advisable.

A diagnosis is made when a characteristic lesion is visible. By swabbing the skin with 5 per cent acetic acid, 'invisible' warts will emerge as white-coloured patches.

### Chancroid

Chancroid is a sexually transmitted ulcerative disease often associated with an inguinal bubo. The causal organism of chancroid is Haemophilus ducreyi. The incubation period ranges between 3 to 10 days. Men usually present with ulcerative lesion or inguinal tenderness. The chancre begins with tender papule surrounded by erythema and within 2 to 3 days after the infection sloughing ulcer appears on the penis and goes on increasing until it affects a large portion of the penis. Women often present with less obvious symptoms including pain in voiding, pain on defecation, rectal bleeding, dyspareunia or vaginal discharge. Most lesions in males are on either the external or internal surface of the prepuce, on the frenulum, or in the coronal sulcus. In females, most lesions are at the entrance to the vagina and include lesions on the fourchette, labia, vestibule and clitoris. Diagnosis of chancroid depends on the isolation of H.ducreyi from a genital ulcer or bubo. Direct examination by a gram stain reveals gm ve organisms in a 'school of fish' pattern. It is best to confirm the diagnosis by culture.

The patients of chancroid who are HIV positive are more likely to have treatment failure. If both pathogens are present they act synergistically with increased infectivity, susceptibility and failure to respond to treatment. Chancroid is one of the major reason for the rapid heterosexual spread of HIV -1 in eastern and southern Africa.

### Control of STDs in the general population

Male promiscuity is due to immature sexual interest, the result of internal emotional disharmony with situation in life and maladjustment with intrinsic or extrinsic conflicts. Professional, commercialized and, to some extent, amateur female prostitution provides this opportunity for male promiscuity. Various chains and combinations of complex social, economic behavioural, environmental, and other intrinsic and extrinsic factors are at the root of this social evil. Economic distress, lack of security in childhood and adolescence, disharmony in married life, social persecution of or an apathy for abandoned, abducted, waylaid, 'fallen' or forlorn women and failure to rescue and rehabilitate them are some of the important causes which lead women to take refuge in prostitution. Adolescent delinquency is the next important cause.

### Treatment of partners

Breaking the cycle of infection is a critical part of STI prevention, and so the client should be encouraged to refer his or her partner(s) for treatment, even when no clinical signs of infection are evident. Providers should advise clients to notify their partners (including those without symptoms) of their exposure and encourage them to seek treatment.

### Policy regarding STDs in the Armed Forces

Detailed methods of prevention and control of STDs in Armed Forces are given in recent instructions, and Medical Officers are advised to refer to them (41, 42).

The following facts should be recognized and brought home to the Commanders by Medical Officers in order to evolve a correct policy regarding STD in the Armed Forces:-

(a) All responsibilities for control of STD should devolve on the regimental officers, JCOs and NCOs under the advice of Medical Officers. All STD control work should start from the unit officers.

(b) Promiscuity among men should not be recognized and condoned as a necessary evil associated with life in the Armed Forces.

(c) While concealment of STDs is a military offence in accordance with DSR 351 and 352, its contraction is not an offence. No punishment or discrimination should be made against a STD case during or after treatment.

(d) Full information of the perils of promiscuity should be conveyed to the Armed Forces personnel. Education in this respect deters the person from indulging freely in promiscuity.

(e) At the same time, facilities to protect oneself from results of promiscuity should be made available.

Experience has proved that this is not likely to increase promiscuity while it definitely reduces the incidence of STD.

(f) Incorrigible addicts of sexual promiscuity may be discharged from service as 'not likely to be efficient soldiers'. (DSR para 352 (f) and Army rule 13).

Preventive measures include the primary preventive measures, the secondary preventive (or control) measures and the administrative measures which support them. Prevention is achieved by inhibiting promiscuous tendencies amongst Armed Forces personnel. The extent of promiscuity depends upon the following factors:-

(a) The availability to brothels/prostitutes in the locality.

(b) Manner in which the energies of Armed Forces personnel are used during their leisure period.

(c) The higher the education the greater the possibility of diverting energies to creative healthy pursuits; education also disuades them from promiscuity or persuades them to use prophylactics.

**Primary Prevention**

(a) Provide alternative healthy diversions, incentives and facilities for education and betterment in careers and providing a healthy psychological atmosphere for a tranquil regimental life. Excellent facilities should be provided for indoor and outdoor recreation, organized games, educational and recreational outings, amateur dramas and concerts.

(b) Man-management should be of a high standard. Grant of full entitled leave should be ensured and regular letters are some remedies.

(c) Develop good Officer-men relationship in the units.

(d) The officers and JCOs should themselves set an example by always maintaining a high moral and ethical standard. The education officer, the welfare officer and the religious teacher should keep the social, religious, ethical and the moral virtues before the service personnel.

(e) Health education should be carried out through lectures, multimedia, flip charts, gp or indl discussions and articles in the periodicals read by service personnel. These lectures should follow the general patterns as under :

(i) Lectures should bring out all the scientifically accurate facts clearly, briefly, with simplicity and without ambiguity.

(ii) Salient features and the possible after effects on self, wife and children on the transmission of infection to them in respect of these important diseases should first be brought out in simple language without exaggeration.

(iii) The necessity for self control from promiscuous habits should be emphasized;

(iv) Use of prophylactic means to avoid STD if an exposure does occur should be explained;

(v) Treatment from the Armed Forces Medical Services, and faithful observance of surveillance should be emphasized.

**Secondary Prevention**

As a practical consideration, main objectives should be to reduce opportunities for promiscuity by administrative measures and acquaint them with hazards of STD and methods of avoiding contraction by use of prophylactics. Use of condoms during coitus is the simplest prophylactic method. It should be made easily available in MI Room/ RAP.

**Administrative Measures**

Following administrative measures must be adopted to augment the measures described above:-

(a) All known and suspected areas in the cantonment habited by prostitutes should be placed 'out of bounds' to all ranks and watched by the military police.

(b) Personnel should be warned on roll calls and through unit part I order repeatedly against promiscuity, concealment of STD and about the places and areas placed 'out of bounds'. Contravention of these orders then becomes a military offence in accordance with paras 351 and 352 of the DSR.

(c) A thorough epidemiological investigation of cases enables location of infective foci in the towns or locality.

(d) Regular six monthly medical examinations and special inspection before proceeding on and after reporting from leave, temporary duty and courses of instructions and for permanent duty should be carried out. Regular periodical anti-STD lectures and supply of condoms should be arranged.

(e) One who has contracted STD should be immediately admitted to hospital.

**Surveillance**

Post hospital surveillance must be carried out to ensure radical cure. All units should maintain a STD register compiled from the particular given in AFMSF-6. The unit should ensure that the person reports on due dates to RMO who should carry out the treatment or send him to hospital whichever is indicated. The examination and treatment of his wife and, if necessary, of the children should also be arranged.

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# Acquired Immuno Deficiency Syndrome (AIDS)

## Introduction

AIDS is a potentially lethal sexually transmitted disease and is caused by the HIV virus. Acquired Immuno Deficiency Syndrome (AIDS) is a severe life threatening clinical condition first recognized as a clinical syndrome in 1981. This syndrome represents the late clinical stage of infection with the human immunodeficiency virus (HIV), which most often results in progressive damage to the immune and other organ systems, including the CNS (43). This means that a person who carries the HIV virus is prone to many different illnesses and may die from diseases that are harmless to healthy people.

AIDS is still most widespread sub Saharan Africa, Asia, and the Caribbean islands, and is more common among homosexual and bisexual men. However, in more developed countries the disease is becoming more frequent among heterosexuals, especially young people. In the UK, new cases of HIV are now more prevalent among heterosexuals. Intravenous drug users and people with many different partners are particularly at risk from HIV.

## Global Occurrence

Promising development has been made in prevention and control of HIV/AIDS in recent years. Global efforts to address the AIDS epidemic, including increased access to effective treatment and prevention programmes have been commendable. However, the number of people living with HIV continues to grow, as does the number of deaths due to AIDS. According to estimates, 34.1 to 47.1 million people are living with HIV/AIDS globally. There were 4.3 million new infections and 2.8 million deaths during 2006. Sub-Saharan Africa continues to bear the brunt of the global epidemic. Two thirds of all adults and children with HIV globally live in the region, and almost 72% of all adult and child deaths due to AIDS in 2006 were in the region. More adult women are now getting infected with HIV, for every 10 adult men there are 14 adult women who are living with HIV. The interaction of HIV/AIDS with other infectious diseases is an increasing public health concern (44, 45).

As of Dec 2006, an estimated 7.2 Million people are living with HIV in the South East Asia region. On 01st Dec 2003, WHO and UNAIDS announced a detailed plan to reach the "3 by 5 target" of providing antiretroviral treatment (ART) to three million people living with HIV in the developing countries by the end of 2005.

## National Occurrence

The changing trend in the country indicate that HIV infection is spreading in two ways; from urban to rural areas and from individuals practicing high risk behaviour to the general population called type 4 pattern, first described in Thailand. Estimates at the National level are 5.2 million people were suffering from HIV infection at the end of 2005. The cumulative number of AIDS cases in the country has risen to 124995 by 2006. Majority of the HIV infections (88.5%) are in the age group of 15-49 years, out of which 31.8 % are in the 15-29 years age group. Amongst injecting drug users the infection has spread very rapidly in Manipur with HIV prevalence of more than 70% (17).

## Clinical Features

For the purpose of AIDS surveillance an adult or adolescent (>12 years of age) is considered to have AIDS if at least 2 of the following major signs are present in combination with at least 1 of the minor signs listed below, and if these signs are not known to be due to a condition unrelated to HIV infection.(17)

| Major signs |
|---|
| Weight loss > or = 10% of body weight |
| Chronic diarrhoea for more than 1 month |
| Prolonged fever for more than 1 month (intermittent or constant) |

| Minor signs |
|---|
| Persistent cough for more than 1 month |
| Generalized pruritic dermatitis |
| History of herpes zoster |
| Oropharyngeal candidiasis |
| Chronic progressive or disseminated herpes simplex infection |
| Generalized lymphadenopathy |

A more recent version of a case definition for AIDS that adds HIV serology and tuberculosis has been proposed by WHO as follows :

AIDS in an adult is defined by a positive HIV test and one of the following (in the absence of a condition unrelated to HIV infection that may cause the sign/diagnosis):

(a) Weight loss > 10% or cachexia, with diarrhoea or both, intermittent or constant, for > 1 month.

(b) Tuberculosis with weight loss > 10%, or disseminated, miliary, or extrapulmonary tuberculosis.

(c) Kaposi's sarcoma.

(d) Neurologic impairment preventing independent daily activities.

(e) Oesophageal candidiasis.

Cohort studies of HIV infected adults indicate that about 15%-20% develop AIDS within 5 years, about 50% within 7-10 years and close to 70% within 15 years. The case fatality of AIDS is very high and most patients (80-90%) die within 3-5 years after the diagnosis of AIDS is made (46).

## Screening tests (HIV Testing)

Fig - 1 : Kaposi's Sarcoma

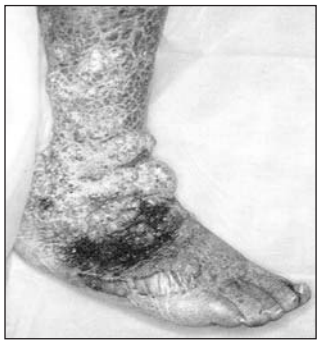


Fig - 2 : Oral Candidiasis

Once HIV enters the body, the body starts to produce antibodies. Most HIV tests look for these antibodies rather than the virus itself. There are many different kinds of HIV tests, including rapid tests and home test kits. At first a highly sensitive test is used called ELISA, while a second confirmatory test is used to weed out any false positive or to confirm indeterminate results. The confirmatory test, Western Blot is a highly specific test. Alternatively, for confirmation 3 ELISA / rapid / simple tests based on different biological systems may be performed. The "Window Period" is the interval between entry of HIV into the body and appearance of antibodies to it. This period may range between 1- 6 months and during this period the individual may test negative for HIV by conventional tests.

Western Blot Test

This is highly specialized and expensive test which detects antibodies to different antigens of HIV I and II. Patients serum is made to react against these different antigens blotted on a paper and the bands of the various reacting antibodies are noted. Presence of at least 2 envelope antigens and one core antigen is necessary for establishing the diagnosis of HIV infection. The test, when combined with a screening ELISA, is highly specific (99%) but not so sensitive (95%) and hence is used only for confirming a positive ELISA test result (28).

**Other tests for HIV infection**

Other tests that are relatively expensive but are done for research purposes or in selected cases, include p24 antigen levels in blood, viral culture and its ability to form syncitium in culture, and qualitative or quantitative tests for detection of the viral RNA viz. PCR (polymerase chain reaction) method and the bDNA method (branched chain DNA). The last two tests can detect the number of viral particles (virions) in blood and are being increasingly used to predict prognosis and monitor efficacy of antiviral therapy.

Several laboratory markers are available to provide prognostic information and guide therapy decisions. The most widely used marker is the absolute CD4 lymphocyte count. As the count decreases, the risk of opportunistic infections increases. People with healthy immune system usually have counts above 950 CD4 cells per cu mm of blood. The number falls over the course of HIV infection. People with AIDS usually have CD4 cell count below 200 per cu mm. The trend of the count is more important than a single reading (47). Any HIV testing should be accompanied by proper counselling (Tabel - 1)

Table - 1 : Post Test Counselling

| |
|---|
| **Test Result Negative** |
| ✎ Discuss transmission and need for behaviour modification |
| ✎ Safer sex |
| ✎ Advice second test 3 months after last exposure |
| **Test Result Positive** |
| ✎ Explain significance and implications |
| ✎ Organize urgent medical follow up |
| ✎ Assess coping strategy |
| ✎ Provide verbal and written information |
| ✎ Discuss confidentiality issues |
| ✎ Organize emotional and practical support |

**Infectious agent**

HIV is a Retrovirus

HIV belongs to a class of viruses called retroviruses. Two types have been identified type 1 (HIV-1) and type 2 (HIV-2). Retroviruses are RNA (ribonucleic acid) viruses, and in order to replicate (duplicate) they must make a DNA (deoxyribonucleic acid) copy of their RNA. It is the DNA genes that allow the virus to replicate. Like all viruses, HIV can replicate only inside cells, commandering the cell's machinery to reproduce. Only HIV and other retroviruses, however, once inside a cell, use an enzyme called **reverse transcriptase** to convert their RNA into DNA, which can be incorporated into the host cell's genes.

**Slow viruses**

HIV belongs to a subgroup of retroviruses known as **lentiviruses**, or "slow" viruses. The course of infection with these viruses is characterized by a long interval between initial infection and the onset of serious symptoms.

**Structure of HIV (48)**

**The viral envelope**

HIV has a diameter of 1/10,000 of a millimeter and is spherical in shape. The outer coat of the virus, known as the viral envelope, is composed of two layers of fatty molecules called lipids, taken from the membrane of a human cell when a newly formed virus particle buds from the cell. Embedded in the viral envelope are proteins from the host cell, as well as 72 copies (on average) of a complex HIV protein (frequently called "spikes") that protrudes through the surface of the virus particle (virion). This protein, known as Env, consists of a cap made of three molecules called glycoprotein (gp) 120, and a stem consisting of three gp41 molecules that anchor the structure in the viral envelope.

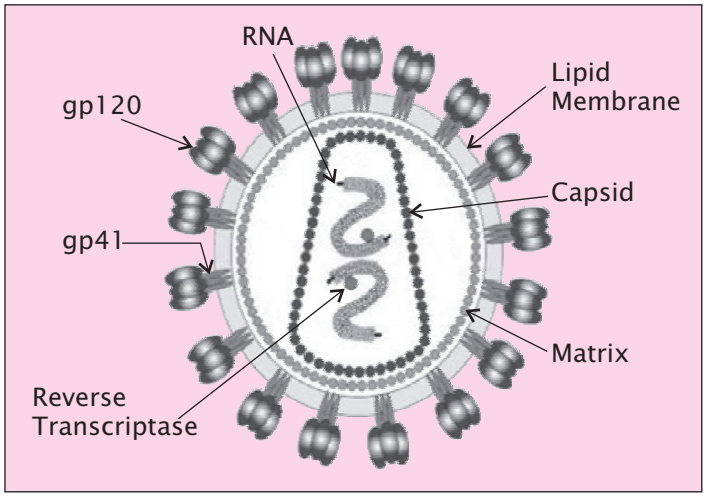
**The viral core**

Within the envelope of a mature HIV particle is a bullet-shaped core or capsid, made of 2,000 copies of another viral protein, p24. The capsid surrounds two single strands of HIV RNA, each of which has a copy of the virus's

nine genes. Three of these genes, gag, pol, and env, contain information needed to make structural proteins for new virus particles. Six regulatory genes, tat, rev, nef, vif, vpr, and vpu, contain information necessary to produce proteins that control the ability of HIV to infect a cell, produce new copies of virus, or cause disease.

Three enzymes carry out steps in the virus's life cycle:

Fig - 3 : Organisation of the HIV-1 Virion




reverse transcriptase, integrase and protease.

**Replication cycle of HIV**

Entry of HIV into cells (48)

Infection typically begins when an HIV particle, which contains two copies of the HIV RNA, encounters a cell with a surface molecule called Cluster Designation 4 (CD4). Cells carrying this molecule are known as CD4+ cells.

One or more of the virus's **gp120** molecules binds tightly to CD4 molecule(s) and co-receptor molecules on cell surface which lead to entry of the virus into the cell. The **gp41** of the envelope is critical to the fusion process.

Although CD4+ T cells appear to be the main targets of HIV, other immune system cells with and without CD4 molecules on their surfaces are infected as well. Among these are long-lived cells called **monocytes** and **macrophages** , which apparently can harbor large quantities of the virus without being killed, thus acting as reservoirs of HIV.

Reverse transcription

In the cytoplasm of the cell, HIV reverse transcriptase converts viral RNA into DNA, the nucleic acid form in which the cell carries its genes.

Integration

The newly made HIV DNA moves to the cell's nucleus, where it is spliced into the host's DNA with the help of HIV integrase. HIV DNA that enters the DNA of the cell is called a provirus.

Transcription

For a provirus to produce new viruses, RNA copies must be made that can be read by the host cell's protein-making machinery. These copies are called messenger RNA (mRNA), and production of mRNA is called transcription, a process that involves the host cell's own enzymes.

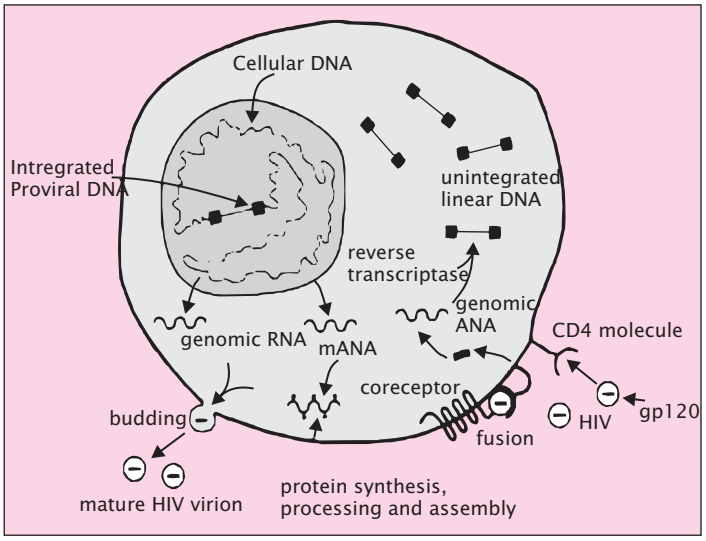
Translation

After HIV mRNA is processed in the cell's nucleus, it is transported to the cytoplasm. In the cytoplasm, the virus co-opts the cell's protein-making machinery-including structures called ribosomes-to make long chains of viral proteins and enzymes, using HIV mRNA as a template. This process is called translation.

Assembly and budding

Newly made HIV core proteins, enzymes, and genomic RNA gather inside the cell and an immature viral particle forms and buds off from the cell, acquiring an envelope that includes both cellular and HIV proteins from the cell membrane. During this part of the viral life cycle, the core of the virus is immature and the virus is not yet infectious. The long chains of proteins and enzymes that make up the immature viral core are now cut into smaller pieces by a

Fig - 4 : Replication Cycle of HIV




viral enzyme called protease.

**Reservoir : Humans**

**How HIV Is and Is Not Transmitted**

HIV is a fragile virus. It cannot live for very long outside the body. As a result, the virus is not transmitted through day-to-day activities such as shaking hands, hugging, or a casual kiss. You cannot become infected from a toilet seat, drinking fountain, doorknob, dishes, drinking glasses, food, or pets. You also cannot get HIV from mosquitoes.

**Mode of transmission**

HIV can be transmitted from person to person through:

(a) Sexual contact

(b) Sharing of HIV contaminated needles and syringes,

(c) Transfusion of infected blood or its components.

(d) Vertical transmission (i.e. from infected mother to

foetus)

(From 15% to 30% infants born to HIV-infected mothers are infected before, during, or shortly after birth; treatment of pregnant women results in marked reduction in infant infections) (43, 46).

Transmission of HIV

Among adults, HIV is spread most commonly during sexual intercourse with an infected partner. During intercourse, the virus can enter the body through the mucosal linings of the vagina, vulva, penis, or rectum or, rarely, via the mouth and possibly the upper gastrointestinal tract after oral sex. The likelihood of transmission is increased by factors that may damage these linings, especially other sexually transmitted infections that cause ulcers or inflammation (Table - 2).

Research suggests that immune system cells of the dendritic cell type, which live in the mucosa, may begin the infection process after sexual exposure by binding to and carrying the virus from the site of infection to the lymph nodes where other immune system cells become infected. A molecule on the surface of dendritic cells, DC-SIGN, may be critical for this transmission process.

**Theories of immunes system cell loss in HIV infection**

How HIV destroys or disables CD4+ T cells, and that a number of mechanisms may occur simultaneously in an HIV-infected person. Data suggest that billions of CD4+ T cells may be destroyed every day, eventually overwhelming the immune system's capacity to regenerate.

**(a) Direct cell killing**

Infected CD4+ T cells may be killed directly when large amounts of virus are produced and bud out from the cell surface, disrupting the cell membrane, or when viral proteins and nucleic acids collect inside the cell, interfering with cellular machinery.

**(b) Apoptosis**

Infected CD4+ T cells may be killed when the regulation of cell function is distorted by HIV proteins, probably leading to cell suicide by a process known as programmed cell death or apoptosis.

**(c) Innocent bystanders**

Uninfected cells may die in an innocent bystander scenario: HIV particles may bind to the cell surface, giving them the appearance of an infected cell and marking them for destruction by killer T cells after antibody attaches to the viral particle on the cell. This process is called antibody-dependent cellular cytotoxicity.

**(d) Anergy**

Researchers have shown in cell cultures that CD4+ T cells can be turned off by activation signals from HIV that leaves them unable to respond to further immune stimulation. This inactivated state is known as anergy.

**(e) Damage to precursor cells**

Studies suggest that HIV also destroys precursor cells that mature to have special immune functions, as well as the microenvironment of the bone marrow and the thymus needed for developing such cells. These organs probably lose the ability to regenerate, further compounding the suppression of the immune system.

**(f) Incubation period**

It is widely variable although the time from infection to the development of detectable antibodies is generally 1-3 months, the time from HIV infection to diagnosis of AIDS has an observed range of less than 1 year to 10 years or more.

**Course of HIV infection**

Among people enrolled in large epidemiologic studies in Western countries, the median time from infection with HIV to the development of AIDS-related symptoms has been approximately 10 to 12 years in the absence of antiretroviral therapy. However, there is a wide variation in disease progression. Approximately 10 percent of HIV-infected people in these studies have progressed to AIDS within the first 2 to 3 years following infection, while up to 5 percent of individuals in the studies have stable CD4+ T cell counts and no symptoms even after 12 or more years.

Factors such as age or genetic differences among individuals, the level of virulence of an individual strain of virus, and co-infection with other **microbes** may influence the rate and severity of disease progression.

Early events in HIV infection

Once it enters the body, HIV infects a large number of CD4+ cells and replicates rapidly. During this acute or primary phase of infection, the blood contains many viral particles that spread throughout the body, seeding various organs, particularly the lymphoid organs.

Two to 4 weeks after exposure to the virus, up to 70 percent of HIV-infected people suffer flu-like symptoms related to the acute infection. Their immune system fights back with killer T cells (CD8+ T cells) and B-cell-produced antibodies , which dramatically reduce HIV levels. A person's CD4+ T cell count may rebound somewhat and even approach its original level. A person may then remain free of HIV-related symptoms for years despite continuous replication of HIV in the lymphoid organs that had been seeded during the acute phase of infection.

One reason that HIV is unique is the fact that despite the body's aggressive immune responses, which are sufficient to clear most viral infections, some HIV invariably escapes. This is due in large part to the high rate of mutations that occur during the process of HIV replication.

Finally, the virus may hide within the chromosomes of an infected cell and be shielded from surveillance by the immune system. Such cells can be considered as a latent reservoir of the virus. Because the antiviral agents currently in our therapeutic arsenal attack actively replicating virus, they are not effective against hidden, inactive viral DNA (so-called provirus).

**Period of Communicability**

Presumed to begin early after onset of HIV infection and extend throughout life. Infectiousness increases with increasing immune deficiency; clinical symptoms and other STDs. Recent studies indicate that it may be high

Table - 2 : Factors increasing the risk of acquisition of HIV

| | |
|---|---|
| **Common to all transmission categories** | STI's especially genital ulcers |
| High Viral Load | Male to male vs heterosexual sex |
| Lower CD4 cell count | Cervical ectopy |
| AIDS | Non circumcised |
| Seroconversion | Receptive vs insertive anal sex |
| **Vertical transmission** | Increased no of partners |
| Older gestational age | Rectal or vaginal trauma |
| Vaginal vs elective caesarean | Mensturation |
| Prolonged rupture of membranes | **IV drug use** |
| No peripartum prophylaxis | Sharing equipment |
| Chorioamnionitis | Intravenous use |
| First born twin | Frequency of use |
| Lower birth weight | Cocaine use |
| **Breast Feeding** | Linked commercial sex |
| Longer duration feeding | Incarceration |
| Younger age | Lower income |
| Lower parity | **Occupational transmission** |
| Mastitis | Deep injury |
| | Previous arterial or venous siting |
| | Visible blood on device |
| **Sexual transmission** | |

during initial period after HIV infection. However patients on ART are less likely to transmit HIV infection to others (49)

**Prevention and Control**

Medical officers may note that the various details regarding epidemiology, transmission, prevention, control and various policy / medical administrative matters are given in the compilation 'Handbook on HIV/AIDS for Medical, Dental and Nursing Officers (51). These handbooks have been distributed by Armed Forces AIDS Control Organisation (ACO) to all the IEC nodes.

The various strategies of HIV/AIDS prevention includes

**(a) Information, Education and Communication (IEC)**

IEC should promote :

(i) Delay in first sexual encounter (targeting adolescents and young adults),

(ii) Reduction in number of sexual partners (ideally mutually monogamous relationship)

(iii) Increase in use of condoms.

In the Armed Forces, research, training, planning and development of IEC materials are carried out at the AIDS Control Organization (ACO) located at the Dept of PSM, AFMC Pune-40. IEC materials are produced in bulk by ACO for dissemination to the IEC nodes (located at Station Health Organizations) in the form of:

(i) Books

(ii) Posters

(iii) CD-ROMs

(iv) Video cassettes

(v) Flip charts

Station Health Organizations (SHO's) with additional inputs from ACO are carrying out IEC activities in their respective stations. The activities include:

(i) Advocacy at level of Commanders,

(ii) Health education of all ranks/families,

(iii) Peer group training to influence safe peer behaviour, etc.

(iv) Monitoring and evaluation of these activities are carried out by periodic review of relevant indicators besides repeated behavioural surveys particularly on three core areas i.e. age of first sexual encounter, number of sexual partners and prevalence of condom use.

**(b) Prevention of blood-borne HIV transmission**

All blood should be screened for HIV before transfusion. Strict sterilization practices should be ensured in hospitals and clinics. Autoclaved syringes and needles and other instruments should be used. Sharing of needles among drug addicts should be eliminated by health education.

**(c) Antiretroviral treatment and specific prophylaxis**

The prohibitive cost precludes the use of antiretroviral drugs on a mass scale in management of HIV infection in developing countries. Its use at present is limited to prevent perinatal transmission and for post exposure prophylaxis in cases of occupational exposure of Health Care Worker (HCW).

Primary prophylaxis against P. carinii pneumonia is indicated when CD4 count falls below 200 cells per cu mm. The regimens available are trimethoprim sulphamethoxazole, aerosolized pentamidine and dapsone.

**(d) Blood Safety, licensing of blood banks and exemption from licensing under certain condition-**

All blood banks in Armed Forces will transfuse blood only after it has been tested and found negative for HIV I & 2, HBsAG, Malaria, Syphilis, and other tests as specified in the current edition of Indian Pharmacopeia as well as consistent with the national Blood policy (52). All blood banks of Armed forces should therefore obtain the necessary license. An exemption has been given by Govt of India in respect of centres of Armed Forces Medical Service in border areas, small mid zonal hospitals including peripheral hospitals, Field Ambulances, Mobile Medical units and other field medical units including blood supply units in border / sensitive / field areas. The exemption from license in respect of above

establishments is, however, subject to the condition that these centers shall collect, process and transfuse blood only in life saving emergency situations; they will be under the supervision of a qualified Medical Officer as per specifications, and that they will undertake all the tests (HIV-1 and 2 / HBsAg / Malaria / Syphilis / others as specified). Concerned Medical Officers are advised to acquaint themselves with the provisions of afore-mentioned Govt of India Gazette (53).

## Policy and procedures on testing, notification and surveillance of HIV infection in the Armed Forces

The policy and procedures are contained in Office of the DGAFMS letters No 5496/HIV Policy/DGAFMS/DG-3A dt 23 May 2003, and 5496/DAFMS/DG-3A/PPTCT dt 07 May 2003 and their detail is given in separate chapter (54).

### Categories of persons to be screened for HIV

The following categories of individual are required to be screened for HIV infection in the armed forces:

(a) All blood donors
(b) All STD cases and those giving history of sexual promiscuity
(c) All antenatal cases and the husbands/children of the HIV positive cases
(d) Spouses and dependant children of HIV infected persons
(e) All personnel from foreign countries undergoing training/long courses in mil establishments.
(f) All Intravenous drug users
(g) All recipients of blood and blood products
(h) Patients on dialysis
(j) Suspected ARC/AIDS cases
(k) All cases of pulmonary & extra-pulmonary tuberculosis.
(l) Personnel proceeding to and returning from foreign missions/tenures abroad
(m) Other high risk cases e.g. those who test positive for HbsAg/ HCV/ VDRL etc
(n) Any other case which the treating physician deems necessary
(o) Cases undergoing invasive procedures/investigations where risk of transmission is high.
(p) Duty/travel overseas.

### Administration of Antiretroviral Therapy

Initiation

The Clinical Immunologist/Medical specialist/treating specialist at one of the Immunodeficiency centers shall initiate Anti retroviral therapy (ART). The personnel put on ART will be adequately monitored as indoor patients during the initial phase of ART. The basis of starting Anti retroviral therapy will be as under (any one of the following):

(a) WHO stage IV & advanced stage III disease irrespective of the CD4 count
(b) WHO stage I/II/III disease with CD4 count <200/microlitre
(c) HIV viral load >50,000 copies /ml (if done)

However there are studies which shows that, among patients with <50, 50-200, 200-350, 350-500, and >= 500 CD4 cells/$mm^3$ at baseline, respectively, 20%, 26%, 46%, 73% and 87% reached >= 800 CD4 cells/$mm^3$ within 7 yrs of starting ART. Keeping in view the long term complications of HAART and its resistance, the thresholds have been derived from prospectively monitored cohorts of HIV infected individuals which shows clear survival advantage when ART is initiated with CD4 cell counts between 200 to 350 cells/$mm^3$. (55)

Note

When facilities for CD4 count are not available, WHO Stage II & III disease besides Stage IV, with Total Lymphocyte Count below 1200 cells/$mm^3$ can be considered for initiating ART.

The following personnel are authorized treatment

(a) All service personnel with HIV infection meeting the above criteria
(b) Families and dependants of service personnel
(c) Serving personnel being boarded out and on ART, will be provided with Anti retroviral therapy for a period of two months on discharge and will be advised to continue ART thereafter.

### Blood donors' testing and reporting

The peripheral hospitals have been supplied with rapid testing kits. If the blood sample tests positive for HIV, the blood is disposed off by incineration. The individual is admitted to the nearest hospital for further investigation with the diagnosis "Immune-Surveillance for Investigation"

The hospital to which this blood donor is admitted will transfer the individual to one of the 08 'referral cum treatment hospitals' with Immunodeficiency as under: -

(a) CH(SC) Pune.
(b) BH, Delhi Cantt.
(c) CH(EC) , Calcutta.
(d) CH(CC), Lucknow
(e) CH(WC), Chandimandir
(f) CH(NC), Udhampur
(g) CH(AF), Bangalore
(h) INHS, Asvini.

### Disposal of HIV positive personnel

Medical officers are advised to acquaint themselves with the recent policy guidelines issued by office of the DGAFMS (54, 56) which have also been incorporated in the Handbook for Medical Officers as also refer to the DGAFMS Medical Memorandum on the subject (57). The detailed description is given in separate chapter.

The HIV positives will be classified as follows

(a) Not on ART

(i) Asymptomatic HIV positive individuals, not on antiretroviral drugs, will be placed in low Medical classification S1H1A1P2 (Temp) E1 for a maximum of 48 weeks.

(ii) Asymptomatic/Symptomatic HIV positive individuals, advised ART, but unwilling to take antiretroviral drugs, will be placed in S1H1A1P3E1 or an appropriate lower med classification.

(b) On ART

(i) These patients will be placed in low Medical classification S1H1A1P3 (T) E1 with appropriate employability restrictions and be observed maximum for a period of 01 year.

**Invalidment**

The guiding factor will be the functional ability of the individual. However, disabling manifestations of disease corresponding to WHO Stage IV who have shown unsatisfactory response to therapy will be considered for invalidment. These conditions include:

(a) HIV wasting syndrome

(b) Disabling neurological/psychiatric illness

(c) Disseminated Tuberculosis.

(d) HIV related malignancies.

(e) Any other AIDS defining criteria/disabling illness, including a CD4 count below 200 cells / mm3 despite having been exhibited adequate trial with ART.

Note

Cadets and recruits found to be HIV positive will not be eligible for commission/enrolment.

Asymptomatic HIV positive personnel (including cadets and recruits), on confirmation of diagnosis, will be labelled as 'Immune Surveillance' (ICD 043). They will be placed in medical category P2 (Perm) (or their equivalent in Navy and Air Force) by medical board. All restrictions applicable to med cat P2 (Perm) will be applicable. In addition, the following restrictions will be imposed: -

(a) Will not be posted to high altitude.

(b) Will not be put on flying duties.

(c) Will not be put on submarine/diving duties

(d) Will not be detailed on foreign assignments

**Attributability/Aggravation**

Attributability/Aggravation in respect of HIV/AIDS cases pertaining to invalidment and release will be guided by the policy guidelines prevailing in "Guide to Medical Officers' (Military Pensions) 2002" and as may be amended from time to time. It is imperative that utmost confidentiality and respect for human dignity be maintained while dealing with HIV positive individuals. Only the Commanding Officer and the Authorised Medical Attendant (AMA) need be aware of the individual's HIV status.

**Follow up**

The HIV positive cases will undergo a monthly evaluation by their AMA. If required, they will be referred to the Medical Specialist at the nearest service hospital. They would be required to report every year or earlier if required at the Immunodeficiency centers for evaluation, including Total lymphocyte count / CD4 counts (once a year) at these centers.

On posting of an individual from the unit /proceeding on course the previous unit will inform the receiving unit under intimation to Records office. On discharge /release/ invalidment/death of the HIV positive person /cases of AIDS the concerned unit will inform full details to ACO, AFMC, Pune for follow up action.

Note

Follow up of Family Members. Monthly and yearly follow up of HIV positive family members of a service personnel whenever living with the family, will also be carried out by the AMA and the local service hospital and all records maintained & notified to ACO.

**Information for health care workers for protection against HIV/AIDS**

Guidelines for prevention of HIV in Armed Forces have been issued vide DGAFMS DGAFMS letter No 5496/HIV Policy/DGAFMS/DG-3A dt 23 May 2003. In general the precautions required for attending patients with HIV/AIDS are identical with those for hepatitis - B.

**Post - Exposure Prophylaxis (PEP)**

An occupational exposure to risk of HIV infection is a percutaneous injury, contact of mucous membrane or contact of skin (when skin is chapped, abraded or afflicted with dermatitis or the contact is prolonged or involving extensive area) with blood, tissue or other body fluids to which universal precautions apply.

Action to be taken on occurrence of occupational exposure to HIV

The HCW are a special category of people who come in contact with patients (or their products) suffering from HIV/AIDS frequently and may contact infection in spite of all possible precautions. This becomes an occupational hazard for the HCW.

(a) Guidelines highlighted in "Guide to Medical Officers' (Military Pensions) 2002" will be taken into consideration while deciding attributability.

(b) On occurrence of Occupational exposure, in addition to taking necessary action of PEP, **"Reports of occupational exposure to HIV"** will be initiated as per **Annx 1 to Appx 'G'** of DGAFMS letter No 5496/HIV Policy/DGAFMS/DG-3A dt 23 May 2003.

(c) If a HIV positive HCW does not have a documented occupational exposure in the past, the Commanding Officer of the individual will submit a certificate as in **Annx 2 to Appx 'G'.** However, in case the Commanding Officer feels the exposure needs to be further established he may convene a Court of inquiry to determine attributability.

On exposure to a needle stick injury, blood and body

fluids from a known HIV positive, the individual will report to MO i/c MI Room/Duty Medical Officer who will send him for HIV testing and administer Tab Zidovudine (300 mg) and Lamivudine (150 mg) at the earliest (preferably within 24 hours) and continue this twice daily for four weeks.

(d) The MO i/c MI Room will take appropriate actions as mentioned in the concerned DGAFMS letter.

(e) **PEP Register :** SEMO / SMO shall be personally responsible to maintain the PEP register.

When to give PEP?

**(a) No drugs required**

(i) Small volume exposure (few drops) over intact skin /mucous membrane from a low risk individual (Asymptomatic HIV or viral load<1,500 c/mL)

**(b) 2 drug regimen**

(i) Small volume exposure (few drops) over non intact skin /mucous membrane from a high risk individual (Symptomatic HIV, AIDS, acute seroconversion, and high viral load) or from a Low risk individual (Asymptomatic HIV or viral load <1,500 c/mL)

(ii) Large volume exposure (major blood splash) over non intact skin /mucous membrane from a low risk individual (Asymptomatic HIV or viral load <1,500 c/mL)

(iii) Solid needle, superficial (Not severe), exposure from a low risk individual (Asymptomatic HIV or viral load <1,500 c/mL)

**(c) 3 drug regimen**

(i) Large volume exposure (major blood splash) over non intact skin /mucous membrane from a high risk individual (Symptomatic HIV, AIDS, acute seroconversion, and high viral load)

(ii) Severe injury (Large bore, deep injury, visible blood in device, needle in patient artery/vein) from either a low risk or high risk individual.

(iii) Solid needle, superficial (Not severe), exposure from a high risk individual (Symptomatic HIV, AIDS, acute seroconversion, and high viral load)

Monitoring

**Testing source**

If there is no recent positive or negative serology, a rapid test is preferred, since results should be available in <10 minutes. Standard serologic tests may take 3 to 7 days, but a negative EIA screening assay is usually available in 24 to 48 hours and is adequate for the decision to discontinue PEP. If the source has had an illness compatible with acute HIV syndrome, testing should include plasma HIV RNA levels.

**Testing health care worker**

HIV serology should be performed at the time of injury, and repeated at 6 weeks, 3 months, and 6 months. There have been three health care workers who seroconverted at >6 months post exposure. This represents about 4% of confirmed seroconversions in health care workers. Most health care workers who seroconverted had symptomatic acute HIV syndrome, usually 2 to 6 weeks post exposure.

**Caution**

The health care worker should be advised to practice safe sex or abstain until serology is negative at 6 months post exposure. The greatest risk is the first 6 to 12 weeks.

**Time**

PEP should be initiated as quickly as possible, preferably within 1 to 2 hours of exposure and up to 36 hours post exposure. The median time from exposure to treatment in health care workers with HIV exposure in the USA from October 1996 to September 1998 was estimated as1.8 hours .

**Side effects**

For health care workers who receive PEP, about 74% experience side effects, primarily nausea (58%), fatigue (37%), headache (16%), vomiting (16%), or diarrhea (14%). About 53% discontinue treatment before completion of the 4-week course due to multiple factors including side effects of drugs. The HCWs should therefore be properly briefed on these aspects to ensure compliance.

**Follow up of the HIV positive Mothers their Spouses & Children**

The Mothers who have tested positive will be followed up every 6 months after their delivery along with their children and spouses. The proforma to evaluate their health as well as the health of their spouse and siblings at the time they test positive and thereafter after every six months as per **Appces 'B' & 'C' to DGAFMS** office letter No 5496/DGAFMS/DG-3A/PPTCT dated 07 May 2003 will be filled in quintuplicate and distributed.

**Autopsies on HIV-positive cadavers**

An autopsy on confirmed HIV-positive cadavers is not mandatory. The details of procedure are as per Appx 'H' and DGAFMS Memorandum on the subject. No embalming will normally be undertaken in confirmed HIV cases.

Lt Col Sunil Agarwal

# Parenterally Transmitted Viral Hepatitis

## Introduction

Hepatitis means inflammation of the liver, which may be caused by viral or other infections, certain toxins and other conditions. This section deals with hepatitis B virus (HBV), hepatitis C virus (HCV), and hepatitis delta virus (HDV), which causes hepatitis as their primary clinical syndrome and are transmitted by blood or through sexual or perinatal contact. Hepatitis B is sometimes also referred as 'Serum Hepatitis'. HBV is a partially double stranded DNA of hepadnaviridae family and associated with both acute and chronic forms of hepatitis as well as hepatocellular carcinoma. This virus along with other hepatitis C and D are transmitted usually by parenteral route. Other hepatitis viruses like HAV and HEV are dealt in the chapter of Excremental diseases.

## Definition

An acute or sub acute febrile infectious disease characterized by sudden onset, nausea, anorexia & abdominal discomfort followed by dark coloured urine, light coloured stools and appearance of jaundice in sclera or skin caused by various viruses like viral hepatitis B,C and D viruses (58). A few patients develop a serum sickness like illness with urticarial rash, arthralgia, arthritis, or glomerulonephritis and vasculitis caused by immune complexes. There will be rise in the blood levels of liver enzymes especially alanine aminotransferase (ALT) and aspartate aminotransferase (AST). The blood bilirubin level also rises. Rarely patients may develop complications of acute fulminating hepatic necrosis and liver failure. This is less common with HCV than other viruses (59). Patients who are coinfected with HBV and HDV from same source may have more severe acute hepatitis, severe chronic disease and primary liver cancer.

## Prevalence

### Hepatitis B

The prevalence of HBV infection varies greatly worldwide. It is a serious global health problem, with more than 2 billion people infected worldwide, and 350 million suffering from chronic HBV infection. HBV infections result in 500, 000 to 1.2 million deaths per year caused by chronic hepatitis, cirrhosis, and hepatocellular carcinoma(60, 61). HBV virus causes 60-80 per cent of all primary liver cancer, which is one of the three common causes of cancer related death in East and SEAR, the Pacific Basin and Sub-Saharan Africa. More than one-third of the population has been infected with HBV, and it is estimated that there are 80 million HBV carriers (about 6% of the total population). Many are life long carriers, although not all are infectious, and some will clear the virus after intervals varying from many months to years. Transmission of HBV infection by blood transfusion and in other medical interventions in both modern and traditional health practices is also common in the Region(62).

In India, the carrier rate of HbsAg in hospital staff has been found to be higher (10. 87 per cent) than in voluntary blood donors (6 per cent) and in the general population (5 per cent). Sero-epidemiologic studies from Armed Forces also suggest that hepatitis carrier state is an important issue (63). In India the incidence of post transfusion hepatitis in multiple transfused patients is as high as 18 to 30 percent.

### Hepatitis C

Since HCV has been identified in the year 1989, it has been shown to be the major cause of parenterally transmitted non-A, non-B (PT-NANB) hepatitis. The incidence is world wide and estimated that 3 percent of the world's population is infected with HCB and 170 million individuals are chronic carriers at risk of developing liver cirrhosis or liver cancer.

### Hepatitis D or Delta hepatitis

Hepatitis D or Delta hepatitis is also widespread and the infection always occurs in association with Hepatitis B. HDV is believed to infect approximately 5% of the world's 300 million HBsAg carriers. The sharing of contaminated needles in intravenous drug use is thought to be the most common means of transmitting HDV. Persons who use intravenous drugs and are also positive for HBsAg, have been found to have HDV prevalence rates ranging from 17-90%. Sexual and perinatal transmissions are also

Human Blood Borne Hepatitis Viruses

| | Hepatitis B | Hepatitis C | Hepatitis D |
|---|---|---|---|
| **Virus type** | Hepadnaviridae | Unclassified | Unclassified |
| **Agent** | Partially double stranded DNA virus | Single stranded RNA virus | single-stranded RNA virus |
| **Host** | 15-29 yrs | Adults | 15-29 yrs |
| **Incubation period** | 50-180 days | 40-120 days | Coinfection with HBV |
| **Chronic carrier rate** | 5-10% | >=50% | More than HBV alone |
| **Known antigens** | HBsAg, HBcAg, HBeAg | HCV | HBsAg, HDAg |
| **Modes of Transmission** | Sexual (?), parenteral, Sexual (?) | Sexual, horizontal, parenteral, perinatal | parenteral, |

Fig - 1 : Hepatitis B antigens

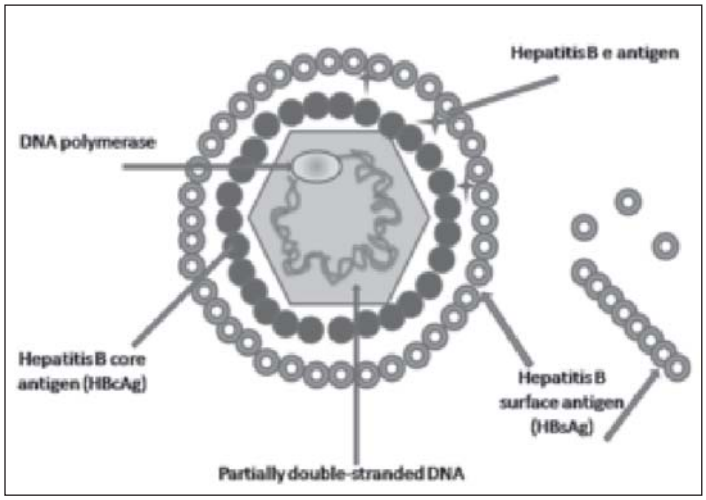
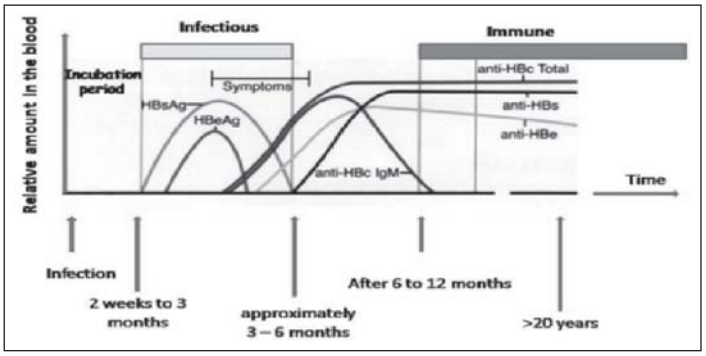



Fig - 2 : HBV markers in blood




described. Hepatitis G virus has recently been discovered in 1996. HGV can be transmitted by blood transfusion. HGV co-infection is observed in 6% of chronic HBV infections and in 10% of chronic HCV infections. However, whether HGV is actually pathogenic in humans remains unclear.

**Agent factors**

Hepatitis B

The studies of Krugman et al at the Willowbrook State School in New York confirmed the presence of at least two different epidemiologic types of hepatitis virus. The viruses he labeled were MS-1, transmitted orally causing 'Infectious hepatitis' and MS-2, transmitted parenterally causing 'Serum Hepatitis'. Hepatitis B virus is present in human blood of patients and carriers. Antigenically it is very complex. It has at least 3 separate antigens : surface antigen (HBsAg), core antigen (HBcAg) and antigen (HBeAg). HBsAg is a glycosylated lipoprotein that contains the major site for binding of neutralizing antibody. Four subtypes of HBsAg have been identified as adw, ayw, adr, and ayr which helps in epidemiologic studies to establish patterns of transmission. HBeAg is a marker for current active viral replication. HBcAg is detected in liver rather than serum and the cellular immune response to HBcAg in liver is responsible for hepatic necrosis. The virus has not yet been grown in the organ culture system. It is killed by heat at 60ºC for 10 hours or 90ºC for 1 hr in plasma.

**Hepatitis B Genotypes**

There are eight genotypes of hepatitis B Virus (A to H). Genotypes have different geographic distributions like genotype A is pandemic whereas genotype B and C are present in Asia, D in Southern Europe and US, E in Africa, F in the US, G in US and France and H in Central and South America (59).

Hepatitis C

HCV is an RNA agent similar to Flavivirus with a diameter of 55 nm. It has one serotype and multiple genotypes. The genetic variability of HCV hampers the efforts of scientists to design an effective anti-HCV vaccine.

**Hepatitis C Genotypes**

There are atleast six distinct HCV genotypes and 80 subtypes are described.

Hepatitis D

HDV is also called the 'Delta Agent' / 'Defective Virus' / 'Dane Particle'. It is a single-stranded RNA virus with a diameter of 36 nm and contains HDAg and the RNA strand. It uses HBsAg as its envelope protein. Thus, HBV co-infection is necessary for the packaging and release of HDV virions from infected hepatocytes.

Diagnosis

A number of sophisticated techniques viz. immuno electron microscopy and serological tests are available for detecting both the viruses and their antigens / antibodies. Detection of HBsAg has evolved and now done by reverse passive hemagglutination (RPHA) and more sensitive methods that utilize radioimmunoassay (RAI) or enzyme immunoassay (EIA). The presence of HBsAg indicates active HBV infection, and IgM anti-HBc determines whether HBV infection is acute or chronic. In addition HBV DNA can be detected by nucleic acid hybridization or PCR amplification.

Reservoir of Infection

Man is the reservoir for all the viruses. Both cases and carriers play major role and their continued survival is mainly due to chronic carriers which is presence of HBs Ag for more than 6 months.

Mode of Transmission (58, 65)

The capability of hepatitis viruses to transmit parenterally relates to existing in blood for long time and high viral levels in serum. HAV and HEV exist in blood for very brief intervals while HBV, HCV, HDV may be detected in the blood of asymptomatic carriers for decades. Hepatitis B virus is transmitted in the same way as human immunodeficiency virus (HIV), the virus that causes AIDS. However, HBV is 50 to 100 times more infectious than HIV.

**Parenteral Route**

Hepatitis B is a blood-borne infection. It is transmitted by infected blood and blood products through various modes like blood transfusions, dialysis, contaminated syringes and needles, infected blood handling, surgical and dental procedures, immunization, traditional tattooing, ear, nose and skin piercing etc. Accidental percutaneous inoculations by shared razors, needle stick

injuries and tooth brushes have been implicated as occasional causes of hepatitis B. With the introduction of detecting HBsAg in blood donor units, transfusion is not a common cause of transmission, except for high risk and health workers. HBV is now more commonly transmitted by nonparenteral routes.

**Perinatal Transmission**

HBV is commonly transmitted from HBsAg carrier mothers to their infants and also following acute maternal HBV infection in the third trimester. Presence of maternal HBeAg has increased risk of virus transmission to the newborn. While intrauterine transmission are noted, most infections occur at the time of birth or shortly thereafter. Infection of the baby is usually anicteric and is recognised by the appearance of surface antigen between 60-120 days after birth.

**Sexual Transmission**

HBsAg has been found in the saliva, vaginal secretions and semen of infected individuals which reflects leakage from the circulation. Both heterosexual and homosexual intercourse may transmit HBV. The sexually promiscuous, particularly male homosexuals, are at very high risk of infection with hepatitis B.

**Other Routes**

Transmission of HBV to household members of HBsAg carriers is well documented and many studies suggest that horizontal transmission, is responsible for a majority of HBV infections and carriers in parts of the world other than Asia. The exact mechanism by which this occurs is not known, the researchers believe that the spread occurs through extended period of household contact or due to unrecognized parenteral exposures to saliva or blood. Transmission by blood sucking arthropods (e. g. , mosquitoes, bed bugs) is suspected, but there is no convincing evidence to support this suggestion. Hepatitis C&D have similar modes of transmission.

**Host Factors**

Susceptibility is general

There is a direct relationship exists between the age of the patient and the likelihood to develop symptomatic infection. Usually the disease is commoner and milder in children and young adults. However, there is an inverse relationship with age and probability of developing chronic infection. About 90% of infants infected during the first year of life and 30% to 50% of children infected between 1 to 4 years of age develop chronic infection. The risk of death from HBV-related liver cancer or cirrhosis is approximately 25% for persons who become chronically infected during childhood.

The risk of chronic infection in adolescents and adults is 1% to 5%. Persons who are immunosupressed, have high rates of chronic carriage of HBV. Degree and duration of homologous immunity after attack are unknown but presumed to be long lasting. Certain occupational categories have been identified as associated with an excess risk of hepatitis B, C & D infection. The categories include dentists, nurses, laboratory technicians and the work areas include haemodialysis units, blood banks, surgical intensive care units.

Communicability Period

In hepatitis B, C & D blood remains infective many weeks before the onset of symptoms, through out the acute clinical course of the disease and during the chronic carrier state. Many persons may be carriers without having experienced a clinically recognized attack.

**Epidemiological Patterns**

Dramatic differences in HBV prevalence exist between various regions of the world. In parts of SE Asia and Africa, >90% of the population may have serologic evidence of past or current HBV infection and 10-20% of adults may be HBsAg positive. Also differences have been noticed between ethnically disparate groups living within the same geographic area. In United States, the seroprevalence generally increases with age and lower socioeconomic status and is higher among blacks and persons of Asian ancestry. Hepatitis B, C&D cases have been traced to clinics among patients who have received parenteral inoculations from contaminated and inadequately sterilized syringes and needles.

**HBV and HIV Coinfection**

Since HBV and HIV have similar modes of transmission, hence coinfection is common where 40 M worldwide are infected with HIV, almost 400 M are chronic HBV carriers. Geographically coinfection is seen in Sub Saharan Africa and Asia. In US chronic HBV infection occurs about 10 times more in HIV positive persons than HIV negatives. Persons with anti HBc are at increased risk of reactivating HBsAg after they develop HIV infection. In various studies liver related mortality was found much higher in men who were HIV positive than only HBsAg carriers. Also it is been found that HBV can increase the side effects related to Anti Retroviral therapy.

**Management**

Chronic hepatitis B in some patients is treated with drugs called interferon or lamivudine, which can help some patients. However, interferon or lamivudine therapy costs thousands of dollars and will never be available to most patients in developing countries. Patients with cirrhosis are sometimes given liver transplants, with varying success. Antiviral drugs such as interferon taken alone or in combination with ribavirin, can be used for the treatment of persons with chronic hepatitis C, but the cost of treatment is very high. It is preferable to prevent this disease with vaccine than to try and cure it.

**Prevention and Control**

Prevention and control of Hepatitis B, C and D infection is of particular importance for the Army, since these diseases are likely to lead to significant ill health and wastage of manpower. In addition, there is no treatment available, leading to substantial amount of physical and mental suffering. Finally, all these diseases have a very high potential of being transmitted by the infected person to his wife, and thereafter to the child in the womb, if the wife also gets infected. These diseases, thus, ravish the entire family.

Modern scientific knowledge has clearly demonstrated that despite their seriousness, these diseases are largely preventable. Prevention is even more relevant for the

Army, since the occurrence of these diseases in any unit is taken as a reflection of the overall discipline and Officer – men relationship. It is, therefore, imperative that Commanders at all levels ensure all possible measures for prevention of various blood borne infections. Thus, the basic principles on which prevention of these diseases devolves, are as follows :

(a) Imparting health education.
(b) Maintenance of high standards of morale and moral values.
(c) Adoption of prophylactic measures.
(d) Safe blood transfusion and injections.
(e) Administrative measures.

The prophylactic measures adopted for HBV infection include the following:

**Use of Condoms** : It is by now scientifically proven that condoms, if properly used, are very effective in preventing STDs, including sexual transmission of HIV and HBV infections. While avoidance of indulgence in illicit sexual acts remains the surest and ideal method of prevention of these diseases, there are likely to be a few persons who may still not be able to control their urge. For these reasons, the use of condoms should be promoted. Unit Commanders, in consultation with their doctors should work out ways and means of making condoms available for such persons. Efforts should be made to ensure that persons using condoms are not made fun of, or discriminated against, since such environment may prove inhibitory for persons to ask for condoms.

**Immunization**

Pre Exposure

(a) **The plasma derived vaccine** : It is a formalin inactivated sub-unit viral vaccine for intramuscular injection. It is given in 3 doses of 1 ml each at 0, 1 & 6 months. It gives 95 percent protection.
(b) **The RDNA - Yeast derived vaccine** is as effective in protection but more cost effective than the above vaccine. The schedule is 0, 1 & 6 months. Protection is up to 15 year and based on current scientific evidence, life long. Dose in adults is 10-20 micrograms and children less than 10 yrs should be given half of the adult dose. The hepatitis B vaccine does not interfere with any other vaccine and vice-versa. They can be given safely with other live vaccines also but at different sites. Vaccines when given at birth can be scheduled along with DPT. The vaccines should be stored at 2-8 degrees and freezing must be avoided.

Post Exposure

**Hepatitis B Immunoglobulin** : post exposurely for health care workers, newborn infants, sexual contacts exposed to acute hepatitis B patients should receive HBIG as early as possible (ideally with 6 to 48 hrs). Immunoglobulin (16 % solution) should be given at 0. 02 to 0. 12 ml per kg of body weight intramuscularly in two doses 30 days apart. If the person is HBsAg negative then active vaccination to be started.

Passive-active immunization

The simultaneous administration of HBIG and hepatitis B vaccine is more efficacious then HBIG alone as it does not interfere with the antibody response of hepatitis B vaccine.

**Safe blood transfusion and injections**

(a) Needles and syringes used for routine immunization must be autoclave for 20 minutes or boiled for 30 min.
(b) It is mandatory that all blood donors and blood products be screened for HBV and HCV infection and those found positive should be rejected. Voluntary blood donation should be encouraged because purchased blood has shown a higher risk of post-transfusion hepatitis.
(c) All blood units being transfused in Armed Forces Medical Establishments have been tested for HIV, HBV, Syphilis, Malaria (and other infections as specified in the instructions from time to time), and is free from these infections.
(d) All medical personnel practice proper "Universal safety precautions" and correct disinfection procedures.
(e) Hospital waste is properly disposed off as per legal specifications.
(f) Carriers should be told
    (i) Not to share razors or tooth brushes
    (ii) Use barrier methods of contraception
    (iii) Should not donate blood.

**Duties of Commanders**

Commanders at all levels will ensure that personnel and families take treatment only from the authorized sources, i. e. , from Armed Forces medical establishments, since proper safety of blood, syringes, needles and other instruments is ensured. Treatment from civil should be only in those exceptional, life saving emergencies, when Armed Forces hospital is not available in near vicinity, or else when referral to a civil hospital has been made by the Armed Forces Medical authorities themselves.

**WHO Initiative (66)**

WHO has called for all countries to add hepatitis B vaccine into their national immunization programmes in 1991. As of March 2000, 116 countries had included hepatitis B vaccine in their national programmes. However, many low income countries in sub-Saharan Africa, the Indian subcontinent do not use the vaccine. The price of the hepatitis B vaccine has been one of the main obstacles to its introduction in many of these countries.

The Global Alliance for Vaccines and Immunization (GAVI) was created in 1999. It is a unique coalition of public and private institutions where WHO has taken a leading role. The main mission of GAVI is to vaccinate as many children as possible against vaccine-preventable diseases. GAVI has introduced a new approach to international health funding: the Global Fund for Children's vaccines (GFCV). This fund will help 74 low-income countries to reinforce their national vaccine programmes and introduce hepatitis B, yellow fever and haemophilus influenzae type

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# Bio-Medical Sciences

## Healthy Lifestyle & Non-Communicable Diseases


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## Principles and Practice of Healthy Lifestyle

With modernization, rapid urbanization, industrialization and increasing level of affluence, the so called "modernization", the price that the society is paying is a tremendous load of "Non-Communicable" diseases, also referred to as "Chronic" diseases" and, often, as "Lifestyle Diseases". The list of major lifestyle diseases is displayed in Box-1. The issue is a global phenomena and not simply restricted to the developed, rich countries. In the context of our armed forces too, the problem of lifestyle and its consequent diseases needs to be addressed vigorously by all health care personnel.

**Box - 1 : Major "Lifestyle Diseases"**

- Obesity
- Heart Disease
- Hypertension
- Diabetes Mellitus
- Oral cancer
- Lung cancer
- Breast cancer
- Colonic cancer
- Other cancers
- Sexually Transmitted Diseases
- HIV & AIDS
- Mental Stress and it's sequelae
- Osteoarthritis
- Osteoporosis
- Liver Disease
- Asthma and

### What is "Lifestyle"

"Lifestyle", in the context of preventive health care, indicates the behavioral patterns which we routinely adopt and the way we tend to (involuntarily) live our daily life, unless coerced to change by some external stimulus. Lifestyle is thus mainly dependent on psycho-social and environmental factors and, to a smaller extent, on genetic influences. Lifestyle is developed in the form of a set pattern of behaviour, very gradually, over many years, in the way we eat, drink, exercise, use intoxicants, are predisposed to own health care and personal protection, sexual practices and so on. Since these behavioural patterns are acquired very gradually, changing them becomes a difficult proposition and needs a lot of persuasiveness as well as persistent approach on the part of the health care provider / health educator.

#### What are the major components of "Lifestyle"

As said earlier, lifestyle is more of attitudes and behaviours, about "predispositions". Thus, there would be a large number of components of "lifestyle" which affect health, from the way we exercise, to sexual mores to habitual hand washing before eating meals. However, from preventive point of view, the major facets of lifestyle are summarized in Box - 2, Box - 3 and Box - 4.

### National Scenario

India is experiencing large and rising burdens of chronic diseases, which are estimated to account for 53% of all deaths in 2005. Earlier estimates projected that the number of deaths attributable to chronic diseases would rise from 3·78 million in 1990 (40·4% of all deaths) to 7·63 million in 2020 (66·7% of all deaths). (1) Many of these deaths occur at relatively early ages. Compared with all other countries, India suffers the highest loss in potentially productive years of life, due to deaths from cardiovascular disease in people aged 35–64 years (9·2 million man years lost in 2000). By 2030, this loss is expected to rise to 17·9 million manyears (2). The estimated prevalence of coronary heart disease is around 3–4% in rural areas and 8–10% in urban areas among adults older than 20 years, representing a two-fold rise in rural areas and a six-fold rise in urban areas over the past four decades. About 29·8 million people were estimated to have coronary heart disease in India in 2003; 14·1 million in urban areas and 15·7 million in rural areas (3). The prevalence of stroke is thought to be 203 per 100000 population among people older than 20 years (4).

Data on cancer mortality are available from six centres across the country, which are part of the National Cancer Registry Programme of the Indian Council of Medical Research (ICMR). About 8 Lac new cases of cancer are estimated to occur every year. The age-adjusted incidence rates in men vary from 44 per 100000 in rural Maharashtra to 121 per 100000 in Delhi (5). The major cancers in men are mostly tobacco-related (lung, oral cavity, larynx, oesophagus, and pharynx). In women, the leading cancer sites include those related to tobacco (oral cavity, oesophagus, and lung), and cervix, breast, and ovary cancer. India has the largest number of oral cancers

**Box - 2 : The major components of unhealthy lifestyle**

- Lack of physical activity
- Faulty dietary habits
- Tobacco use
- Excessive alcohol intake
- Mental Stress
- Disregard to personal safety regarding
  - Accidents
  - Personal hygiene
  - Promiscuous Sex
  - Insect Vectors of Diseases

**Box - 3**

Lifestyle diseases or "Non-Communicable Diseases" have common risk factors as listed in the box above. Thus, by becoming physically active, eating a healthy diet, avoiding alcohol and tobacco and by managing mental stress, we will not only prevent IHD, but also diabetes, hypertension, cancers, road accidents, and stroke, since the determinants are common.

**Box - 4 : What socio-environmental changes have led to increasingly unhealthy lifestyles in populations ?**

- Rapid industrialisation / market economy
- Increased global earnings
- Materialism / consumerism
- Mechanisation
- Advertisement driven competitive food industry
- TV, Cables, VCDs
- Computers, Internet
- Increasing market of tobacco and alcohol, more so driven by advertisements
- Academic competitiveness among children
- Career competitiveness
- Migration towards urban areas
- Loss of "cushion" provided by traditional family life

in the world, due to the widespread habit of chewing tobacco.

India also has the largest number of people with diabetes in the world, with an estimated 19·3 million in 1995 and projected 57·2 million in 2025 (6). The prevalence of type 2 diabetes in urban Indian adults has been reported to have increased from less than 3·0% in 1970 to about 12·0% in 2000 (7). On the basis of recent surveys, the ICMR estimates the prevalence of diabetes in adults to be 3·8% in rural areas and 11·8% in urban areas. The prevalence of hypertension has been reported to range between 20–40% in urban adults and 12–17% among rural adults (8). The number of people with hypertension is expected to increase from 118·2 million in 2000 to 213·5 million in 2025, with nearly equal numbers of men and women (9).

With increasing life expectancy, the proportion of the population older than 35 years is expected to rise from 28% in 1981 to 42% in 2021 (10). During the decade 1991–2001, the population grew by 18% in the rural areas and 31% in urban regions (11). Urbanisation and industrialisation are changing the patterns of living in ways that increase behavioural and biological risk factor levels in the population.

An excess risk of death from coronary disease has been observed in men and women of south-Asian origin (12, 13). An increased risk of cardiovascular problems has been noted in Indian migrants to other countries.

A high frequency of metabolic syndrome (especially the characteristic dyslipidaemia of reduced HDL cholesterol and raised triglycerides) have been reported in Indian population groups (14, 15). The INTERHEART study (16) found that the clustering of coronary risk factors is quite common among indians.

Surveillance systems have been established to provide risk factor data from different parts of the country (17). The prevalence of tobacco use has been estimated in the National Sample Survey and the National Family Health Survey (18). In the Global Youth Tobacco Survey 25·1% of the students aged 13–15 years reported that they had ever used tobacco, whereas current use was reported by 17·5% (19). A national survey in 2002, reported that the overall prevalence of current tobacco use in men and boys aged 12–60 years was 55·8%, ranging from 21·6% in those aged 12–18 years to 71·5% in the 51–60 year age group (20). Many cross-sectional surveys have recorded a high urban prevalence of central obesity and overweight (especially when the lower thresholds recommended by WHO for Asian people are used). Women and men are equally affected (21, 22). Small birth size, with rebound obesity in early childhood, predicted diabetes and glucose intolerance in adulthood, in an Indian cohort, the so called "Barker's phenomena"(23).

Studies have revealed low levels of physical activity in urban areas and in the upper-income and middle-income groups. Low levels of physical activity have been reported in 61–66% of men and 51–75% of women, in urban surveys (22, 24). Most surveys have also shown higher mean concentrations of plasma cholesterol in urban population groups compared with rural groups, with a low mean concentration of HDL cholesterol (25). ICMR has observed that the prevalence of dyslipidaemia was 37·5% in individuals aged 15–64 years. Even in a relatively young industrial population (20–59 years), 62·0% had dyslipidaemia (26). Levels of awareness, treatment, and adequate control are low for hypertension, diabetes, and dyslipidaemia, especially in rural areas (26, 27).

With advancing health transition, the poor are increasingly affected by chronic diseases and their risk factors. (19, 28). Urban slums have high rates of diabetes and dyslipidaemia (29).

### World-wide Magnitude of the Problem

Chronic diseases represent a huge proportion of human illness. They include cardiovascular disease (30% of projected total worldwide deaths in 2005), cancer (13%), chronic respiratory diseases (7%), and diabetes (2%). Two risk factors underlying these conditions are key to any population-wide strategy of control - tobacco use and obesity. These risks and the diseases they engender are not the exclusive preserve of rich nations. An estimated total of 58 million deaths worldwide in a year, heart disease, stroke, cancer, and other chronic diseases will account for 35 million, more than 15 million of which will occur in people younger than 70 years. Approximately four out of five of all deaths from chronic disease now occur in low-income and middle-income countries, and the death rates are highest in middle-aged people in these countries (30).

### Magnitude in the Indian Armed Forces

Data among armed forces personnel due to major non-communicable diseases do indicate that we need to be vigilant and launch all out preventive health care programmes. The yearly hospital admission data (per

1000 personnel) for the period 2000 to 2005 for major

Table - 1 : Yearly hospital admissions (per 1000 personnel) due to major lifestyle diseases in Armed Forces (2000-2005)

| Year | Hypertensive Disease | | | Heart diseases | | | Diabetes Mellitus Type – 2 | | | Psychiatric Illnesses | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Army | Navy | Air Force | Army | Navy | Air Force | Army | Navy | Air Force | Army | Navy | Air Force |
| 2000 | 2.25 | 2.60 | 2.30 | 0.64 | 1.79 | 0.77 | 0.76 | 0.88 | 0.76 | 1.71 | 4.44 | 0.92 |
| 2001 | 2.08 | 2.77 | 2.30 | 0.65 | 1.76 | 0.72 | 0.73 | 0.99 | 0.80 | 1.84 | 3.15 | 1.32 |
| 2002 | 2.91 | 2.17 | 2.81 | 0.86 | 3.11 | 0.85 | 1.02 | 1.30 | 0.80 | 3.38 | 2.80 | 1.06 |
| 2003 | 2.93 | 3.46 | 3.79 | 0.92 | 0.35 | 0.63 | 1.09 | 1.64 | 1.00 | 3.11 | 3.16 | 1.13 |
| 2004 | 2.90 | 3.47 | 4.87 | 0.99 | 1.31 | 0.53 | 0.96 | 1.16 | 0.82 | 3.38 | 4.81 | 1.43 |
| | | | | | | | | | | | | |

non-communicable diseases are given in Table - 1.(31).

Surveys among apparently healthy army personnel have also revealed that obesity, raised blood pressure, impairment of glucose tolerance, metabolic syndrome and physical inactivity are likely to be an issue which needs to be addressed energetically (32).

We shall discuss the major components of healthy lifestyle and the methods of addressing them from the preventive angle.

## Lack of Physical Fitness and Physical Inactivity

Substantial progress has been made during the past two decades in scientifically substantiating the role of physical exercise and fitness in a number of human diseases and more recently, the role of physical exercise and fitness in positive lifestyle. Indeed, of all the lifestyle factors, physical exercise seems to be one of the most important in relation to health. It has been quiet aptly said that physical exercise in the nature's panacea for preventing ill health. 'Physical Activity' and 'Physical Fitness' are two distinct entities. One may be physically active but may still not achieve a high level of fitness. For instance, if a 70 Kg man walks slowly, covering 8 kilometers in 3 hours, he would burn off almost 550 kilocalories (kcal); however he may not achieve 'fitness' by such activity, since the 'Intensity' is quite low. On the other hand if the same person does a 'Walk and Jog' schedule, overcoming half the distance (4 km) in half an hour, he may burn off only half the numbers of calories, but will achieve a pretty good level of fitness. The point to be noted is that both are important – some work (activity / exercise) needs to be performed to burn off calories and, additionally, such activities / exercises should be undertaken with reasonable amount of intensity (vigorousness) so that, in addition to burning the calories, "fitness" is also achieved. The above point is important since recent research has pointed out that most of the health benefits of physical exercise (as brought out later in a separate section) are actually due to the "Fitness" that results from the exercise and not from simply burning off the calories during such activities. (33). For instance, a housewife, during the course of her daily chores, or a person playing golf without carrying the clubs and walking at a slow pace for 2 hours, may burn off substantial amount of calories but may not be able to reap the complete benefits of exercise.

However, for those who are not exercising at all or else cannot exercise at moderate intensity levels even mild exercises will help. For planning a physical exercise program, the dictum should be 'Any exercise is good; more the better' (34 - 37). In fact people who have not been exercising for a long time should be encouraged to start with low intensity exercises or even by bringing about simple "life style changes" so that they become more active. Coaxing then to undertake more strenuous exercises from the very outset could be counter-productive. Subsequently, as they progress, they may be encouraged to gradually increase the level of exercise intensity.

## Benefits of exercise and diseases due to physical inactivity

It is often thought that physical exercise is a very good way of reducing the body weight and that is all which is good about physical exercise. This notion is correct only to a very small extent which should be emphasised upon the individuals and communities so that they draw the maximum benefits of physical exercise. Alone and by itself physical exercise is not a very efficient method of reducing weight. The major emphasis, if weight reduction is the issue, should be control on diet. Physical exercise can only be a useful adjunct. For example, just one average sized slice of bread will give 65 to 70 Kilocalories (kcal), to burn off which, one would need to go running for a Kilometer. Just four innocuous looking slices or a small sized "Samosa" will push in 300 kcal, which would need 4 kilometers of running/ walking to burn off these calories. If one doesn't do that, these 300 additional kcal per day will finally result into an extra 1 kg every month or an additional dozen of Kgs at the end of a year. Thus, to reiterate, if the major objective is weight loss or weight maintenance, proper diet should be the mainstay; physical exercise can be used only as a supplementary

**Box-5 : Health benefits of physical exercise and fitness**

- Helps keeping body weight in check.
- Increases the action of insulin hormone, thereby increasing the insulin sensitivity and the peripheral utilization of glucose, thus protecting against Insulin Resistance Syndrome (Syndrome X; Metabolic Syndrome) and NIDDM (type-2 diabetes), both major risk factors for IHD.
- Has a preferential action in mobilizing the fat depots, particularly the "Visceral" (Intra abdominal, peritoneal ) fat. By preferentially mobilizing this dangerous type of accumulated fat, physical exercise protects against dyslipidemias, IHD & NIDDM.
- Has a specific role in altering the lipid profile in a healthy fashion. Various studies have shown that the HDL levels are much higher while the triglycerides, LDL and Total cholesterol levels are much lower, among those who exercise regularly.
- Is associated with lowered levels of systolic and diastolic blood pressure, thereby protecting against hypertension.
- Has cardio-protective effect. Besides the improvements in insulin sensitivity, blood pressure, lipid profile and visceral fat deposition, physical exercise exerts its cardio-protective role by opening up the collateral blood vessels; increases the stroke volume and maximal ventilatory capacity; reduces myocardial oxygen demand at a given level of work; reduces fibrinogen levels, platelet aggregation and tendency of thrombus formation.
- Brings about a reduction in the level of anxiety and stress and induces a sense of confidence and well-being. To some extent, this effect is believed to be brought about by the release of "beta endorphins " which are natural occurring, opiate like chemicals.
- Tones up muscles and increases flexibility, thus protecting form injuries and falls.
- Helps in maintaining adequate bone mass density thereby protecting from osteoporosis and its complications.

modality. Notwithstanding the above, there are large number of health benefits of physical exercise and fitness, which are over and above the issue of weight maintenance, as shown in Box - 5 (38 - 63).

### Epidemiological evidence

WHO estimates indicate that globally, physical inactivity accounts for more than one fifth of the IHD, one tenth each of stroke and breast cancer and one sixth of all colon cancers. Physically inactive lifestyle accounts in 3. 3% of all deaths (i. e. 1 death out of every 30 deaths in the world can be attributed to physical inactivity). Physical inactivity also accounts for almost 19 million disability adjusted life years (DALYs) world-wide. World wide estimates as per a recent WHO report indicate that, on a long term average, physical inactivity carries an increased risk (as measured in terms of RR) of 1. 05 to 2. 63 for IHD, 1. 2 to 2. 89 for hypertension and stroke, 1. 08 to 4. 31 times for diabetes type – 2, 1. 02 to 2. 5 for colonic cancer, 1. 02 to as much as 5 times for breast cancer and 1.02 to 1.37 for osteoporosis (64).

In the 1980s and 1990s, various epidemiological studies demonstrated that less intensive physical activity also provides considerable health benefits. The focus has therefore shifted now to advocate, for the general population at large, to take to moderate intensity exercise by all adults and children, as brisk walking (5 – 6. 5 Kmph), recreational cycling and recreational swimming. In addition, the focus has also shifted to inculcate healthy lifestyle, by increasing activity levels in all the four 'domains' of life viz. , at workplace, in transport, at home and during recreation time.

### Does past physical activity / fitness help?

This aspect needs to be clearly understood by all medical personnel and explained to the community members. There is enough evidence to indicate that the various health related benefits of physical exercise are always due to "current" physical activity and not "past" activity. Thus, for one to draw the benefits of exercise, one should continue to be active; the benefits will occur only as long as one continues to be active (36). Physical activity in the past does not seem to help – one may have been an international level athlete during one's heydays, but that does not protect if one becomes inactive later in life.

### Does "Spot – reduction – exercise" works ?

Often, obese people, especially those with abdominal obesity are led to believe that abdominal strengthening exercises (as 'sit ups' or equivalent gymnasium gadgets) will "burn off" the fat around the abdomen. It needs to be explained that for burning off the fat "around" (actually inside) the abdomen, one has to burn off overall calories and restrict the diet. Abdominal exercises may only slightly help by 'toning' up the abdominal muscles but the energy spent in such exercises will be too little to have any impact on overall weight loss. It needs to be emphasised that 'sit ups' do not, by any chance, push away the fat from the abdomen. Vibrator belts and massage systems used over the abdomen are equally unscientific. The best (and generally the only) way to lose fat from the tummy is to do brisk aerobic exercise and cut down on dietary calories.

## The Exercise Program

A physical exercise and fitness schedule should be incorporated into the daily lifestyle. It needs to be emphasized that such program does not include only walking or jogging or only weight- training. An optimum

physical fitness program should cater to three major facets of physical fitness, viz, Endurance (Stamina = Cardio-respiratory efficiency); Muscular Strength ; and, Flexibility.

**Endurance**

It is the capacity to undertake sustained aerobic physical exercise using a high proportion of maximal oxygen uptake. The ideal means of improving endurance is by undertaking sustained aerobic training at the near maximal level, which a person can tolerate. Gradually, with continued training, at near maximal level, the maximal aerobic capacity increases, i.e., the person increases the 'Stamina'. Concurrently, with increase in stamina, the level of physical fitness increases and the person starts reaping more and more health benefits of physical exercise, as have been cited earlier. Any Endurance training program has three distinct components, viz,

(a) Frequency

This is measured by the number of sessions per week that are devoted to endurance training. Ideally, there should be 4 to 5 session per week; the minimum recommended is 3 per week.

(b) Intensity

Intensity is measured by the 'strenuousness' of the exercise. We shall deliberate on the measures of strenuousness a little later in a separate section. In general, it is recommended that to achieve the maximum gains, the physical exercise should be of at least "moderate" intensity. As one becomes more and more fit, one could (and should) aim to undertake more strenuous (high intensity) exercises.

(c) Duration

This is the time spent on exercise, in a given session. In general, during a session, approximately 60 minutes should be devoted for mild intensity exercises, 40 to 45 minutes for moderate intensity activities, while 20 to 30 minutes and 10 to 15 minutes are adequate for high intensity and very high intensity exercises, respectively. It also needs to be emphasized that the above suggested plans are only recommendations based on overall consensus and evidence. Ultimately, the program has to be tailored to meet the individual / community needs.

**Measuring the level of intensity**

Out of the 3 components of endurance training, while measuring the duration and frequency is quite straightforward, measuring the various levels of intensity often gets shrouded with confusion, particularly at the level of the user. A summary of various available guidelines to measure intensity of exercises and the overall recommendations are given in the succeeding paragraphs.

**Measuring exercise intensity on the basis of heart rate**

One of the oldest and quite widely used measure of exercise intensity is based on "Maximum Permissible Heart Rate (MxPHR)". The MxPHR for any individual is calculated as 220 (-) Age in years. For example, for a person aged 50 years, the MxPHR will be 220 (-) 50 = 170 beats per minute. In general, during an exercise session, this limit should not be exceeded. If a person is exercising at 50% to 60% of his MxPHR, it is taken as Low intensity exercise, 60% to 70% is Mild intensity, 70% to 80% is Moderate intensity, while 80% to 90% and 90% to 100% are taken as Severe intensity & Very severe intensity exercises respectively.

For example, the MxPHR for a 50 years old person would be 170. If the heart rate achieved by the person during a session of exercise is 50 to 60% of 170 (i. e. 85 to 102 beats per minute) he is exercising at low intensity level. Accordingly, for this person heart rate levels from 103 to 119, 120 - 136, 137 – 153, and 154 to 170 or even more, would qualify for mild, moderate, severe intensity and very severe intensity exercise.

**How to measure the heart rate achieved during an exercise session**

A practical method is as follows : Immediately on completion of an exercise session and definitely within 5 seconds of completion the individual starts counting the radial pulse, for 10 seconds. The first beat is counted as zero. The number of beats so counted in 10 seconds is multiplied by '6' to obtain the heart rate achieved during exercise.

**Measuring Exercise intensity according to Borg's scale of "Rating of Perceived Exertion (RPE)"**

The scale has the advantage of simplicity and can be used by anyone in the general community. The scale rates the intensity of exercise, as perceived by the person himself, on a visual analogue scale of 0 to 20, as shown in the Table - 2.

To start with, the exercise should be at a level of '12'score, i. e. the subject feels that the exercise intensity is between "Light" and "Somewhat hard". This level, in most subjects, is approximately equal to 60% of MxPHR. As fitness improves, the subjects should increase the intensity of exercise so that they are finally working at a level of 16 i. e. the perception about the exercise they are undertaking is that it is more than 'hard' but less than 'Very hard'. This level usually represents approximately 85% of MxPHR in most subjects.

**Measuring exercise intensity using Metabolic Equivalents**

Table - 2 : Borg's scale of RPE

| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Nil | Almost Nil exercise | | | Very Very Light | | | Quite Light | | | Light | | | Somewhat Hard | | Hard | | Very Hard | | Excruciat-ingly Hard | |

**(METs).**

Recently the concept of METs is being increasingly used to prescribe the level of exercise for individual subjects. 1 MET is actually equal to a level at which a person will spend 1 kcal energy per kg body weight per hour and this level usually corresponds to the resting stage. This level also corresponds to an oxygen uptake level of 3. 5 ml / kg body weight per minute (65). As the level of MET increases, the intensity of exercise increases. Thus, a person weighting 70 kg at rest, i. e. at activity level of 1 MET will spend 70 K cal per hour while the same person exercising at the level of 6 MET will be spending 6x70 = 420 K cal in an hour. Moreover, the level of 6 MET will correspond to "moderate" level of exercise intensity. Thus, MET have dual advantage, in that in a single value they give an indication of both, the amount of energy expenditure as well as the intensity of exercise. According to general agreement, the MET levels corresponding to various intensity levels of exercise are shown in Box - 6 and the METs for common physical exercises are shown in Box - 7(65, 66).

Box - 6 : MET levels corresponding various intensity levels of exercise

| Level of exercise Intensity | Usual MET level | |
|---|---|---|
| | Men | Women |
| Rest | 1 | 1 |
| Very low intensity | 1 - 1.5 | 1 - 1.2 |
| Light | 1.6 - 3.9 | 1.2 - 2.7 |
| Low Moderate | 4 - 5.9 | 2.8 - 4.3 |
| High Moderate | 6 - 7.9 | 4.4 - 5.9 |
| Heavy Moderate | 8 - 9.9 | 6.0 - 7.5 |
| Unduly heavy | >10 | > 7.6 |

For example, let us say a subject weighing 70 kg is exercising by cycling at a speed of 16 km/h. He cycled for 8 km in half an hour. He will be exercising at 7 MET which is of 'moderate' intensity', rather almost touching the level of high moderate intensity exercise. During this half an hour, he will burn off (70 x 7 x ½) = 245 K cal of energy, this will be equivalent to burning off 30 grams of body fat.

## Recommendations for Physical Exercise

### Recommendations based on calorie expenditure

The minimum amount of calories to be expended in programmed physical exercise by the general population have been recently forwarded by CDC Atlanta and American College of Sports Medicine. These recommendations state that every adult should spend at least 200 kcal per day (i. e. 1400 k cal in a week) by physical exercise and this should be undertaken on "most days" (Preferably all days of a week) (67). This could be achieved by having a half – hourly session every day of brisk walking. The point to be noted is that these are the minimum recommendations and more exercise (in terms of more time or more intensity) is always better.

Box - 7 : MET levels for common physical exercises

| Activity | MET level |
|---|---|
| Walking 4.8 km/h (slow pace) | 3.0 |
| Badminton leisure | 3 - 6 |
| Walking 5.4 Km / h (slow pace) | 3.6 |
| Badminton match | 7 - 9 |
| Walking 6 km / h (brisk pace) | 4.3 |
| Dancing social | 3 - 7 |
| Walking 6.4 km/h (brisk pace) | 4.6 |
| Dancing aerobic | 6 - 9 |
| Walking 7 km / h (very fast pace) | 6.0 |
| Circuit weight training | 8 - 9 |
| Jogging 8 km/h | 8.7 |
| Roller skates | 5 - 8 |
| Running 9.6 km/h | 10.0 |
| Squash leisure | 8 - 10 |
| Running 12 km/h | 12.5 |
| Squash match | 11 - 12 |
| Bicycling 16 km/h | 7.0 |
| Tennis leisure | 6 - 8 |
| Swimming 20 mtr per minute | 6.0 |
| Tennis match | 9 - 10 |
| Swimming 40 mtr per minute | 12.0 |
| Volleyball | 3 - 6 |
| Golf, walking | 4.0 |
| Basket ball match | 7 - 12 |
| Golf, walking carrying bag | 5 - 6 |
| Basket ball non game | 3 - 9 |
| | |
| | |

More comprehensive recommendations on adequate calories to be spent have come from large scale studies among Harvard alumni and British civil servants. These recommendations in general suggest that to obtain the maximum health benefits of physical exercise, individuals should spend about 2500 k cal per week through regular and at least moderate intensity exercises. To spend these 2500 calories, an average person weighing about 65 kg

Table - 3 : Recommendations on exercise

| Intensity of Exercise | | | Target Heart | Duration | |
|---|---|---|---|---|---|
| Frequency By description | By MET level | By Borg's RPE scale | rate as % of MxPHR | (Mts per session) | sessions per week |
| Low Moderate | 4-5.9 | 13 | 70-80% | 60 - 75 | 5 - 6 |
| High Moderate | 6-7.9 | 16 | 80-90% | 45 - 60 | 4 - 5 |
| | | | | | |

will need to walk or jog about 35 kms in a week or roughly 5 kms every day.

**Comprehensive recommendations based on intensity, Duration & Frequency**

Besides the intensity of exercise and the calories to be burnt off, the duration (generally to indicate "how long during a given session") and frequency (to answer "how many times in a week?") are also equally important. The general guidelines are set out in Table - 3.

The good news is that the above mentioned exercise can be "accumulated" i. e. , it is not necessary to undertake a given session of exercise in 60 minutes at a stretch, Rather, 2 session of 30 mts each or even 3 session of 20 mts each over the day may also be good enough.

It is generally recommended that for achieving weight loss and subsequently maintaining it, people should accumulate 60 to 80 minutes of moderate intensity exercise every day. Although, to the general public, devoting 60 to 80 mts to exercise may sound a bit too much even impossible; however, once we emphasize on them that these 60 to 80 mts of exercise can be accumulated by undertaking frequent short sessions, things seem to become manageable for most individuals.

Most experts agree that the best schedule is to have 4 to 5 sessions per week, of moderate intensity exercises of 5 to 8 MET level, with each session lasting for 45 to 60 minutes. This will provide recesses for recovering, as also improve compliance, since the exercise-off days (2-3 per week) leave the participants with ample opportunities for other pursuits and social obligations. The optimum linear distance to be covered by brisk walking or jogging in a week is recommended to be about 35 km (20 miles).

**Resistance training**

Weight training and isometrics are often grouped under a general category of "resistance training". Current opinion is to encourage mild weight training as a part of exercise-fitness program. It is recommended that mild weights (20-30 pounds for men and 10-20 pounds for women) may be used, exercising all major muscle groups (chest, back, shoulders, arms, forearms, glutei, thighs and legs) keeping about 3 sets for each major muscle group and 10-15 repetitions in each set. Two or three weekly sessions of the above schedule are recommended. Care should be specifically taken not to indulge in "valsalva's maneuver" (breathing forcefully against closed glottis, as happens while straining at stools), while undertaking resistance training and even while undertaking aerobic exercises.

**Flexibility**

Gentle stretching exercises as forward bend, side bend and calf stretch are ideal. Yoga exercises are excellent for flexibility. It is best to incorporate flexibility exercises as part of overall exercise plan, during the initial "warming up" for 5 - 10 minutes & the final "Cool down" phase for another 5 - 10 mts.

**Progressing on the exercise program**

It is generally advisable to progress in three phases. In the first phase the subject starts at a low level of about 3 MET (as walking 4. 8 Kms in an hour) and over the next 4 - 6 weeks, gradually working up to a level of 4 - 5 MET (eg. , brisk walking at speed of 6. 5 to 7 km per hour) for 30 mts in a session, and having 4 - 5 such sessions per week. This level should be maintained for 4-6 weeks. Once the subject is comfortable at this level for 4-6 weeks (as evidenced by a reduction of about 5 beats per minute in the exercise heart rate at that intensity level of exercise or by a decreased feeling of exertion on the RPE scale or by ability to undertake higher level of MET exercises), the subject moves to phase – 2, wherein he/she undertakes exercises at MET level of 6 to 7 (see table of MET values, e. g. , brisk walk – jogging, covering 7 to 7. 5 km in an hour) for about 30 to 45 minutes every session, and maintaining at this level for 4 - 6 weeks. In the last phase, the subject again gradually works up, over 4 - 6 weeks to a level of 8 to 9 MET (Jogging, covering 7. 8 to 8. 5 km per hour).

**Bringing about "Physically Active" lifestyle changes**

"Structured Physical Activity" programmes, as have been discussed till now, are only one side of inculcating physical activity among individuals and communities. What is equally important is to educate and motivate persons and communities to inculcate a "physically active lifestyle" so that physical activity gets incorporated in each and every action of life. Emphasis should not only be towards incorporating "exercise sessions" in the daily time table or advising gymnasium activities. Equal emphasis should be placed on changing the overall lifestyle from one of luxury and sloth to one of physical activity at every possible moment, integrating physical activity into lifestyle with short, frequent bouts of moderate intensity exercise. This seems to provide the best answer and can be even better than structured exercise programmes. Some examples of positive lifestyle habits are shown in Box - 8.

**Box - 8 : Changing the daily lifestyle : Examples**

- Take stairs instead of the lift; make several trips.
- Put away the remote control of TV.
- Stand while answering the telephone.
- After every half an hour of office job, go out and walk in the corridor for 3 minutes.
- Park your car at the farthest possible point.
- Take a longer way around, to walk to the due destination.
- Don't use servants / children for "fetch-it' jobs; do them yourself.
- Go out for entertainment (eg, see a Movie in the theatre) rather than sitting before the TV.

The principal goal of active lifestyle is to increase energy expenditure without concern for the intensity of activity.

The basic principle is that very mild, even inapparent increases (as going out for shopping rather than ordering for grocery on telephone) may make much difference. In fact, emphasis should be on promoting low-intensity, leisure pursuits, which are seen as pleasurable (as walking a dog, gardening, etc. ) rather than simply stressing on occasional or periodic vigorous exercises. Similarly, "structured exercise" should also be encouraged but should not be presented as one which requires excessive physical effort; target should be on activities that can be easily incorporated in daily schedule.

### Practice Advocacy rather than Health Education

The effort of all health care professionals, whether in public health or in clinical domains, should be not simply to educate the community / individuals / patients, but rather to socially market the concept of physically active lifestyle. Such advocacy becomes especially important when dealing with high risk groups or with individual persons or patients.

**Box - 9 : Motivating the community members and subjects - Driving away any excuses for not exercising**

**Excuse : Lack of time**

- Take several spurts of 10 mts each, of exercise during lunch, tea time & dinner time.
- Park farthest away in the parking lot.
- Turn off TV/computer for at least 30 minutes and exercise instead.

**Excuse : Bad weather**

- Get a "treadmill" for home.
- Try an exercise video at home.
- Do stationary jogging / walking.

**Excuse : Holidays**

- Put a lot of effort into cleaning your house.
- Wash your car/two wheeler
- Go shopping and carry your packets of grocery.
- While going for shopping, park your vehicle far off, so that you walk for at least 2 to 3 Kms.

**Excuse : Feeling Fatigued**

- Remind yourself that exercise will give you more energy
- Try and "force" yourself for just 10 minutes of walk. Once you start off, chances are that you with

### Role of physicians in improving the lifestyle of subject / patient

Physicians may play a catalytic role in improving the lifestyle of people they come in contact with. An initial counselling session of 5 to 7 minutes by the physician followed by periodic telephone calls or personal interview sessions to keep up the motivation have been shown to be quite successful. Some motivatory examples to be conveyed to the community members are shown in Box - 9. The overall summary of key messages to be given to individuals are shown in Box - 10.

**Box - 10 : Key messages to be given to individuals and communities**

**There are two clear components** :-

Firstly, a formal, structured exercise and fitness programme;

Secondly, inculcating "physically active lifestyle" as a part of day to day life. Both are equally important.

**1. Structured Program:-**

Develop and meticulously follow a structured programme. Include all the three components (Endurance, Strength, Flexibility)

**Endurance**

- Most minimum : Brisk walking at least 2 miles (3.2 KM) every day or at least most days a week, covering 3.2 Km in 30 to 35 mts.
- Ideal :- Exercise at 6 to 8 MET (eg walking / jogging covering 7 to 8 Km in an hour), 45 to 60 mts per day, every day or at least 4 to 5 days a week.
- If you can exercise at even higher intensity or longer duration, the better it is.
- Instead of walking or jogging, substitute any other aerobic exercise (cycling, swimming, sports, etc.) which makes you happy.

**Strength :-**

Advisable to undertake resistance training with light weights (10 to 30 lbs) exercising all major muscle groups 2 or 3 times a week.

**Flexibility** :-

Undertake 5 to 10 mts of Yoga or other gentle stretching exercises before and after an exercise session.

**2. Physically Active Lifestyle :-**

Develop the attitude to be physically active always. Use stairs instead of lift, walk instead of driving, Remove the remote controls of TV, Fetch a glass of water yourself rather than asking your orderly, walk to you colleague's office and discuss rather than using the intercom, park your car at the farthest, and so on.

**3. Ensure Compliance :-**

Biggest hurdle in structured physical exercise or active lifestyle program is that you tend to lose out on compliance. Watch out.

### Diet and lifestyle

Proper diet is as important as physical exercise and fitness in context of lifestyle diseases. There is overriding evidence that various components of diet have strong association with IHD, Hypertension, Type – 2 Diabetes, Cancers, obesity and so on. The components of a healthy diet are shown in Box - 11. In brief, the individual components and recommendations given by WHO and various expert groups (68 – 71), are as follows :

Calories

Daily diet should provide calories which are actually

**Box - 11 : Principles of "healthy" diet**

- It should provide adequate amount of calories as required by the body, neither more nor less.
- Besides calories, it should provide all essential nutrients as protein, carbohydrates, fats, vitamins, minerals and water, as per need of the body.
- It should restrict the intake of fats, particularly saturated fats, dietary cholesterol, salt and refined sugars to within the recommended standards.
- It should promote the intake of complex carbohydrates, whole grains, fresh fruits and vegetables, while at the same time, discouraging the consumption of too much refining of grains.
- It should discourage consumption of "junk food", aerated drinks, and alcohol.

required by the body, depending on age, sex, existing body weight, amount of physical activity and other physiological requirements of growth, pregnancy, etc. In general, for a man weighing 55 Kg the daily requirements are 2400 kcal, 2800 kcal and 3900 kcal respectively if he is a sedentary worker (mostly chair bound jobs), moderately hard worker (sedentary jobs with 2 to 3 hours of brisk physical activity in a day) or hard worker (soldiers on active duties and training, agricultural & industrial labourers, etc). For a woman weighing 45 Kg the corresponding requirements are 1900, 2200 and 3000 kcal per day. Proportionately more calories will be required if body weight is higher. In context of armed forces and for purpose of planning healthy lifestyle diets, cadets / recruits or personnel on active duty involving exertional marches, climbs and training would come in the category of hard workers and may need even much more than 3900 calories. In peace time, personnel who are put to rigorous training schedules would also be considered as hard workers. Personnel who are generally performing chair bound duties but actively attending Physical training (PT) and games sessions could be taken as moderately hard working while personnel who are purely working on chair jobs and not regularly attending PT, games or any other structured exercise program could be taken as sedentary workers. Similarly, depending on the daily domestic tasks and exercise being undertaken, an officers wife may need 2200 to 2400 kcal while the wife of a PBOR may need 2400 to 2700 kcal.

### Dietary fats

The standard recommendations are that "energy from dietary fats should not be more than 30% of the total daily energy intake (preferably not more than 25% of the energy); within this limit, saturated fats should not provide more than 10% (preferably not more than 7%) of the total dietary energy". To practicalize this recommendation, let us say we have a JCO who, as per assessment, needs about 3000 kcal per day. A maximum of 30% of these 3000 kcal, i. e. , 900 kcal in a day could come from fats. Now, about 30% of this (i. e. 270 kcal) would, in any case, come from "invisible fats', which are present in the rice, wheat, legumes, nuts and condiments that we eat. Thus the remaining 630 kcal in this case could come from "open fat", i. e. , cooking oils, ghee, butter etc. Since conversion factor for fats is 9 kcal for each gram, 70 grams of open fats would be the requirement. Out of this, about 20 to 25 grams could be in form of saturated fats (butter, ghee) and about 50 gm in the form of vegetable oils. Thus, in a month, this person may consume 1. 5 Kg of vegetable oils and about half a Kg to 750 gm of butter / ghee. If this person has a family of 4 people (self, wife, two adult children) the total amount of fats consumed in such household could be about 5 to 6 Kg of vegetable oils and 2 to 2. 5 Kg of butter / ghee. Medical officers should give such practical, workable and easily understandable advise to personnel and families rather than giving technical jargon like "not more than 30% of energy should come from fats" which may not be understood by our clientele.

As regards which type of vegetable oil, one should advise that any oil which is culturally eaten and satisfies the taste is good enough, though coconut oil, hydrogenated oil and red-palm oil have a high percentage of saturated fat. It would be preferable if the cooking oils are "rotated" and a mix of oils as sunflower, safflower, rapeseed, soya bean, mustard or groundnut oil is used. What is more important is to strictly follow the guidelines for upper limit as suggested above.

### Dietary cholesterol

Recommendations are that dietary cholesterol should not exceed 300 mg (preferably not more than 200 mg) in a day. Egg yolk, Ghee, butter, high fat meat as undressed mutton /pork, thickened milk products are all rich sources of dietary cholesterol and need to be cautiously eaten.

### Dietary salt

Recommendations are that total salt intake should not exceed more than 6 grams a day, which works out to 180 grams a month. To ensure this, let us say a jawan has a family of total 4 adults. In such case he and his wife should be advised that the total salt consumed in his household in a month should not exceed 750 grams; that they may buy a one Kg pack at the beginning of the month and ensure that about one-fourth is still left at the end of the month. In addition, advise not to indulge in high salt foods (Common examples in Indian diets are pickels, chutneys, papads, sauces, soups, ketchups and tinned foods.) An additional healthy practice is to remove salt-sellers from the dining table.

### Refined sugars

As per guidelines, not more than 10% of daily dietary energy should be derived from refined sugars. For a person requiring 3000 kcal / day, this works out to 300 calories, i. e. , 75 grams sugar (conversion factor 4 kcal per gm). Thus in one month, the person should consume maximum of about 2 Kg sugar; for a family of 4 adults, the monthly purchase of sugar should thus not be more than 8 Kg.

### Fruits and Vegetables

These food items are rich source of Folic acid, and antioxidant vitamins and minerals, which are accepted to

be clearly protective against cardiovascular diseases and cancers. In one day, an adult should consume about 500 grams of fresh fruits and vegetables (not including potatoes). Thus, for a family of 4 adults, the weekly purchases should bring in almost 15 Kg of fruit and vegetables, concentrating on what is seasonally available and affordable.

Fibre

**Box-12 : Dietary guidelines for healthy lifestyle**

**Avoid eating food items which are :-**

- Fried (eg, Poori, Paratha, Samosa, Pakoda, etc)
- Creamed (eg, Custards, Ice cream, Thick creamy foods etc)
- Gravied (eg, gravied Matar Paneer, Butter Chicken, etc)
- Sweetened (eg, sweet-meats, chocolates, tinned milk, etc)
- Salt - Preserved or high in salt content (eg, papad, pickles, chutneys, sauces, etc
- Egg Yolk

**Prefer the following food items**

- Whole grains / split grains / coarsely refined flours
- Thin, watery, low energy items as thin soups
- Fresh fruits & vegetables
- Low fat dairy products as skimmed milk
- White meat (fish, skinned chicken)
- Baked, Steamed and grilled food items

**For a moderately hard working adult, the monthly consumption of following items should be NOT MORE than :-**

- 1.5 Kg of vegetable oil
- 0.5 Kg of Butter / Ghee
- 2 Kg of refined sugar
- 200 grams of salt

**An adult should eat 3 to 4 Kg fruits & vegetables in a week.**

Adequate consumption of dietary fibre has been shown to be protective against cardiovascular diseases, diabetes type-2, obesity, gall bladder disease and certain cancers particularly colonic cancers. Dietary consumption of fibre should be at least 30 grams per day (including both soluble polysacchrides as pectins and lignins found in fruits and vegetables as well as non-soloble polysacchrides (NSPs) found in grains and pulses. Adequate consumption of whole grain (sprouts, dalia, pulses, beans, etc) and fruits / vegetables as suggested above would ensure this consumption. A summary of dietary guidelines for healthy diet is given in Box -12.

### Tobacco & Lifestyle

Tobacco has been proven, beyond doubt, to be associated with a large number of serious diseases (see Box - 13). In fact, the single most important lifestyle factor as a risk for diseases is tobacco use. Globally, tobacco accounts for 27. 8% of all cardiovascular deaths, 13. 6% of all lung cancer deaths, 6. 6% of upper aerodigestive cancer

**Box -13 : Tobacco related diseases**

- IHD (RR 1.28 to 1.78)
- Stroke (RR 1.17)
- Lung cancer (RR 12 to 24)
- Oral cancer (RR 6.95 to 7.87)
- Liver Cancer (RR 1.40)
- Cancers of upper aerodigestive tract
- Peptic Ulcer
- COPD
- Buerger's Disease
- Hypertension
- Amblyopia

deaths, 6. 6% of other cancer deaths, 27. 2% of deaths due to COPD and 12. 8% of other respiratory deaths. Worldwide, tobacco use causes 4.83 million deaths, loss of 59 million DALYs and estimated economic loss of $200 billion per year. The medical recommendations regarding tobacco are very clear – individuals and communities should completely give up use of tobacco. In the armed forces, all medical functionaries should endeavour to educate and motivate troops and families regarding the adversities associated with tobacco use and to give up tobacco. In addition to educating and motivating, we must use all possible means to convince the Senior Commanders and ladies groups to exert influence in this regards, with a view to obtain the following ends :

(a) Make availability difficult (e.g. banning the sale of tobacco products in cantonment areas, near educational institutions, in messes and bars, in unit wet canteens, etc).

(b) Make the smokers feel that his smoking habit is "undesirable" (e. g. , ban smoking in auditoria, offices, meetings / gatherings, barakhanas, mess parties; create separate restricted areas as earmarked smokers rooms for people to smoke).

(c) Exerting influence through peer groups as ladies groups, religious teachers etc.

(d) Setting of personal example by influential persons as doctors, senior commanders, senior JCOs, etc.

### Alcohol

Habitual alcohol use is another major lifestyle factor associated with ill health and a large number of serious diseases, as depicted in Box - 14. Besides, it has additional social and emotional problems, and disrupts family and organizational health. A WHO report indicates that alcohol use accounts for 3. 2% of all global deaths and 4% of all global burden of diseases; it also accounts for 3.5% of all DALYs lost due to all causes. What is even more concerning is the recent trend wherein lay magazines tend to put across a conveniently distorted version of the medical research findings and tend to indicate that moderate drinking is good for health. This is, in fact, an issue which all medical persons would need to counter when talking to troops as well as commanders. While it is agreed that "moderate" alcohol intake may be associated

**Box - 14 : Alcohol related diseases**

- Hypertension & Stroke (RR 1.4 to 4.1, depending on intake)
- IHD (mild consumption may be protective (RR = 0.68); heavy consumption carries risk (RR = 1.33)
- Obesity
- Diabetes Mellitus type – 2
- Female Bresat Cancer (RR 1.14 to 1.62)
- Oral Cancer (RR 1.45 to 5.39)
- Road Accidents
- Other cancers (aerodigestive tract, stomach, pancreas, kidneys, bladder) (RR 1.8 to 4.93 depending on intake and site)
- Liver disease (RR 1.2 to 13 depending on intake) (cirrhosis, increased susceptibility to liver infections)
- Pancreatitis
- Degenerative neurological diseases
- Social and emotional problems
- Psychiatric problems and dependence
- Lack of efficiency and organizational issues.

with higher HDL-cholesterol levels and lower IHD mortality, the fact also remains that even continued moderate level alcohol intake is associated with a number of other diseases like road accidents, various cancers, obesity and hypertension. Secondly, it is quite difficult to maintain "moderation" - many of those who are initially moderate may become heavy drinkers gradually. Thirdly, there are various other more healthy methods (as brisk, regular physical exercise) rather than drinking, to increase the HDL levels. All these aspects should be emphasized on the clientele. The relationship between even mild drinking and obesity (with all the consequent ill health effects of obesity) is quite logical, as depicted in the

**Box -15 : Alcohol even in mild quantities, promotes obesity by :**

- Providing "blank" calories – each gram gives 7 kcal; I small peg gives 70 kcal, equal to running 1 Km !
- Promotes overeating
- Desire to eat rich, fattening food
- Reduces desire of physical activity

**Box - 16 : Defining "moderate" drinking**

- A "unit" of alcohol is defined as equivalent of 10 grams pure ethanol.
- This will be equal to 1 small peg of hard drink or 100 ml of Wine or half a bottle of Beer.
- Moderation means maximum of 3 units in a day for men ( and 2 units a day for women)

Box - 15. In addition, even two small pegs may raise the blood alcohol level beyond the legally acceptable limit (in India 30 mg %), and may interfere with the protective reflexes, causing road accidents. The hazards of alcohol use should be well communicated to our clientele and they should be motivated to give up alcohol. The recommendations should be

(a) There is nothing like medically prescribed or medically encouraged drinking to get good health; With all its well documented resultant diseases, alcohol should not be used.

(b) However, despite the above exhortation, if somebody still decides to drink, he or she may do so provided there is no other risk factor (Obesity, Diabetes, hypertension) and provided one drinks only in "moderation". The guidelines for "moderation" are in Box - 16.

(c) Besides restricting to moderation, adhere to the following principles : firstly, never drive after drinks (even after very mild drinking); secondly,

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# Mental Health and Stress Management

Mental health is an important component of the total positive health. Every physical ailment has a mental component and every mental illness has a physical component. The WHO expert committee defines mental health as 'the capacity in an individual to form harmonious relation with others and to participate in or contribute constructively to change in the social environment'. The comprehensive concept of mental health has thus a four-fold goal before it: to understand and cure the different types of mental disorders and defects; to detect the cases of incipient mental breakdown early; to prevent, or at least to minimize the occurrence of the disorders and defects and improve the mental health of the community (72).

**Box - 1 : Classification of psychiatric disorders (ICD - 10)**

- Organic :- Acute e.g. delirium and chronic e.g. dementia
- Substance misuse
- Schizophrenia and delusional disorders
- Affective (mood) disorders
- Depression
- Mania
- Recurrent affective disorders
- Neurotic, stress related and somatoform disorders: -
- Anxiety disorders including generalised anxiety , phobic anxiety and panic disorder
- Obsessive compulsive disorder
- Reaction to severe stress
- Acute stress disorder incl Post-traumatic stress disorder & ddjustment disorder
- Dissociative disorder
- Somatoform disorder
- Neurasthenia
- Behavioural disturbances :- Eating disorders, sleeping disorders, sexual dysfunction and puerperal mental disorders
- Personality disorders e.g. thumb sucking, bed wetting, juvenile delinquencies.

Classification of psychiatric disorders is shown in Box - 1.

### Magnitude of the problem

Worldwide, About 500 million people are believed to be suffering from neurotic, stress related and psychological (somatoform) problems. A further 400 million suffer from anxiety disorders, 340 millions from mood disorders, 60 million from mental retardation and 45 million from schizophrenia. It causes a heavy burden of suffering and economic loss (73). In India (74) surveys on mental morbidity in various parts of the country suggest a prevalance rate of 18-20 per 1000. In the armed forces there has been an increasing trend, during the period 2000-05, as shown in the introductory part of this section (31).

### Prevention of psychiatric diseases

As with all other diseases, prevention is the first line of defence against psychiatric illnesses (75-78).

#### Careful recruitment

This is the most important stage. An assessment of the potential recruit's mental capacity and strength of personality is essential. Individuals showing somatic symptoms of anxiety e.g. tachycardia, hyperhidrosis and tremors should be rejected. The motive for recruitment should be ascertained and any one with poor or negative motivation should be rejected. A history of mental illness in the family, of severe domestic problems and also of personal instability are indications for rejection. A detailed psychological assessment is not always possible, but every attempt should be made to eliminate individuals with low intelligence, emotional instability, weak personalities and history of gross maladjustment in civil life.

#### Screening at the training centers

It is possible to detect susceptible individuals during the training periods at the centres where the recruits are under constant observation of their instructors. Apart from homesickness, which usually passes off within 2-3 months, a recruit who does not show satisfactory adjustment at the end of 3 months should be discharged as unsuitable.

#### Training and selection for specialist trades

Many breakdowns are precipitated by unhappiness and discontentment with their trades. Every effort should be made to select men according to their individual aptitudes and capabilities. This is very important with regard to the highly skilled specialist trades like radar operators, signalmen, engineers and so on who may breakdown at critical moments and for whom replacements may not be readily available.

#### Maintenance of high morale

This is essential for a fighting unit and is more important than even superior equipment. The basic ingredients are leadership and good man-management. In addition to these, adequate training and battle indoctrination before action are essential to keep the men mentally fit, confident and eager to fight.

#### Elimination of precipitating factors

The stress of service in forward areas and of actual battle cannot be eliminated. But there are a number of factors, which aggravate this stress and precipitate breakdowns.

These may be domestic problems like marital disharmony, financial difficulties, illness of the wife and children, and other social and cultural difficulties. A man can fight and work better if his mind is free from these problems. Frequent letters from home, regular remittances of money to his people, leave when he needs it, promotion in due course, and well-organised welfare services reduce these stresses and hence minimize the chances of breakdown. Proper living conditions, adequate food water and sleep are also important factors. Human nature is such that a man will put up with physical hardships if he knows that these are inevitable. But if he suspects that these are due to the leader's carelessness, his morale is quickly lowered and this constitutes a dangerous precipitating factor. No one is prepared to suffer and die because of bad leadership.

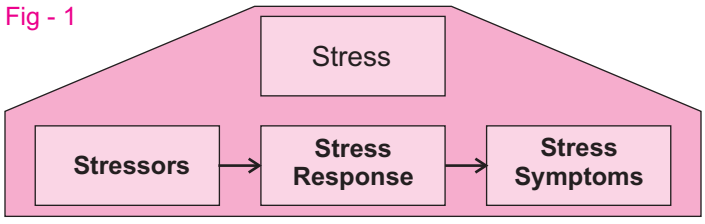
## Prevention and management of mental stress

There is a lot of talk going around these days about stress. Almost every week, some medical journal or lay magazine brings out an article on this issue. Most of the time, doctors also tell their patients to cut down on their stress. However, to the general public and patients, it is quite vague and confusing. What is stress? Why does it occur? Can we do away with it? Such questions can be quite intriguing. In contemporary times, any doctor engaged in health care of the community, especially from the armed forces, should be very well aware about all these aspects, so as to educate the clientele and be able to prescribe a road map for management of stress.

### What is a "stress response"

The term "Stress" is used as an umbrella term to cover all aspects associated with the phenomena. However, what really concerns us is the "Stress Response". This is the sum

Fig - 1




total of body reaction, both physiological and psychological, in response to a "stressor" i.e., an event occurring outside the body in the external environment. The stress response leads to various "Stress Symptoms" or "Stress diseases" (Fig - 1).

So, it is not really the "Stressor" (i.e the situation) that leads to stress but our perception of that event, the meaning we attach to it and the way we react or respond to it that leads to symptoms or diseases of stress.

To elaborate, stimuli from the environment or thoughts generated within the mind become amicable or inimical depending on whether they generate positive or negative effect. An inimical reaction brings on the fight stress response if one is angry and charged and the flight response if one is insecure or defeatist. Taking this argument forward will lead us to solutions for stress stimuli. We can alter our stress response from inimical to amicable and manage to cope with the stress stimulus. For example, let us say, to jump down to the ground from the roof, just 10 feet high, may be a tremendously stressful for most of us. Majority of us, on looking down at the ground, would feel "butterflies in the stomach". However, for a seasoned paratrooper, it would be fun. So, it is not the stressor (events, persons or environment) but our own interpretation and how we react that decides whether we will get "stressed" or not. As somebody has rightly said - it is not the "news" that stresses but rather the "editorial" that we ourselves write about the news (stressors) that leads to stress response.

### What is stress threshold?

Each of us respond to stress stimulus differently. In other words each of us has a different stress threshold. What determines this stress threshold? It is the training imparted to the paratrooper, in the example above, that makes him react differently. Other factors that influence the stress threshold are genetic make-up, family traits, cultivated habits, personality make-up and environmental factors.

### What is the biology of the stress response?

Nature has built the stress response into our biology and that of all animals for a protective and desirable reason, viz, to gear up the entire body to deal with acute physical emergencies. Just imagine our primitive ancestors, a few thousand of years ago. They were exposed to constant dangers- hunted down by tigers and bears, at the most unsuspected time. When a hungry tiger was about to take a leap on them, they had no time to contemplate sunset, so that they could hide in the darkness, even no time to objectively assess the approaching danger. To survive such flash emergencies, nature developed the instantaneous "stress response" or "fight or flight" response in our body (79 – 81). This quick response is mediated through the autonomic system (ANS), so named because it was presumed to be out of voluntary control. It has two divisions, the sympathetic and the parasympathetic. The sympathetic nerves tense up the body and set it aflame. The humors secreted by the sympathetic nerve endings are epinephrine and norepinephrine. Sympathetic stimulation is associated with increasing body temperature, speeding up the heart rate and respiration, burning up the food faster, increasing the glucose in the blood stream and raising the blood clottability all of which are required for the fight or flight response. In contrast the parasympathetic system cools the body and relaxes it so that it can recover after the fight or flight. The humor secreted by the parasympathetic nerves is acetylcholine. It is note worthy that the ANS contains components which not only bring about the stress response but also recovery from it.

The endocrine response mediated through the hypothalamus, pituitary and adrenal glands consists of a massive cascade of instantaneous physiological changes, mainly through hormones like noradrenaline and cortisol. Within milliseconds of their release, they would cause the heart to beat faster and more strongly and the blood

pressure to rise (so that more and more blood laden with oxygen and glucose could go to the muscles, to either fight it out or run away). The breathing would become deep and extra glucose would be pumped into the blood by the liver so that more of sugar and oxygen could be taken by the blood to the active muscles. Kidneys start saving water so that blood volume can increase, digestion reduces and blood from digestive organs is diverted to the active muscles. In addition, the blood clotting mechanism would increase so as to quickly seal off the wounds and minimize blood loss due to bleeding from injuries. All these massive physiological changes occur within the fraction of a second. Their purpose is to prepare us to take instant action against an acute physical stressor, by either fighting it or taking a flight.

The stress response is, in fact, protective for our body, rather life saving. So, where does it fit into the problems of stress that we are talking about? Well, the same stress response which was so useful and protective during the evolutionary stages of human race seems to have become a major hazard to our health. In our modern day life we seldom face the kind of physical danger for which nature had designed the stress response. The response was life saving for our ancestors when a hungry tiger suddenly pounced on them. Even today, we need it on some relatively uncommon occasions, as when a dacoit suddenly pops up from the bushes, while we are on a lonely track.

However, certainly we don't have to have your body and mind in such a state of alarm, and that too for prolonged periods of hours (may be, weeks or months), to negotiate modern day "stressors" or challenges like having a difficult boss, staying separate from the family, preparing for an important competition, difficulties in career, or lesser difficulties like having a flat tyre while driving on the highway. Unfortunately, even for these small hassles, the body's stress response remains massive or perpetual. The increase in blood pressure and heart rate, increase in blood sugar, increase in blood clotting mechanisms, taut muscles, lowering the immune defence of the body and reduction in the digestive process continue for long periods and lead to major diseases like hypertension, diabetes, peptic ulcer, infections due to reduced immune defence, muscular and joint pains, just to name a few. It is therefore essential for us to learn ways and means to calm down our reactions to the stressor, and to develop adequate "coping mechanisms" to tackle the stressors of day-to-day living.

### The adverse effects of stress

Stress affects our health in a wide variety of ways. The adverse effects are summarized below.

Psycho-somatic

These include IHD, hypertension, diabetes mellitus, peptic ulcers, predisposition to certain cancers, lowered immune functioning, arthralgias and myalgias, tension – headaches, etc.

Emotional

These include suppressed hostility (which in turn is a well documented risk factor for IHD), anger, panic, irritability, "burnout", fatigue, sleep disorders, anxiety, depression, and, suicide / attempted suicide.

## Roadmap to understanding stress and its management

### General overview

In today's world, especially from preventive point of view, stress is not something which happens to you. Rather, it is the "meaning" that you assign to the "events" that happen to you, i.e., how you "appraise" these events, that determines whether you will be affected by stress or not. It is, thus, your personal appraisal of the seriousness of the event and the adequacy of your coping resources, that determines whether you will or won't respond stressfully. The general map to understanding stress is as under.

Demands are those requirements placed on us, which are potential stressors. A demand can be something as minor as a wrong telephone call in the night, or as major as reporting of embezzlement of funds in your office. At this point, we are not calling a "demand" as a "stressor", because not every demand may end up becoming a stressor. Demands may be of four types.

Firstly, the most exacting demands are "self imposed". These often include perfectionist or highly ambitious expectations. The list of such demands may go on and on. Unfortunately, most of us have little tolerance for failing to meet them. Another set of very frequent demands that need to be coped up with are the "roles" that we are expected to play. i.e., those of husband / wife, father, subordinate, team-leader, and so on. As opposed to self-imposed requirements, role requirements come from other people (spouse, children, superiors, subordinates etc.) and are therefore much less under our control. Moreover, demands arising out of role-requirements can come up suddenly and unexpectedly, as the sudden requirement to care for a sick child.

The third type of demands are "significant life changes", such as coming down with a major, long term illness, moving on transfer to an uncongenial area which entails separation from near ones, loss of a loved one and so on. Finally, there is a fourth type of demand, viz., "daily hassles of life". In fact these can be more detrimental to your health than even major adverse events. These include a wide range of relatively minor events that plague your daily life, like an unexpected downpour, or your child's school suddenly deciding not to operate the school bus for the next one week, and so on.

### What happens once a "demand" is placed on us ?

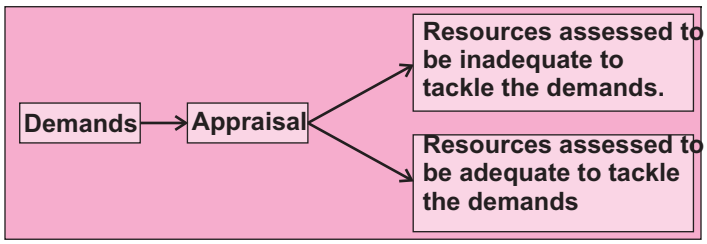
Once a demand is placed on us, it does not straightaway lead to stress. There are certain intermediary mechanisms that occur, before we experience stress. The awareness of "demand" is followed by our "appraisal" of the problem. This step is more important, since, as described earlier, the impact of a demand (stressor) is a function of, not only the event, but also the appraisal that we make of our own coping abilities to deal with it. The sequence of appraisal is as follows.

Firstly, the "primary appraisal", which involves evaluation

of the significance of the event. In fact, we ask ourselves "Am I in trouble?"

After the primary appraisal, comes the secondary appraisal. This involves the question "Can I handle it?"

Following the primary and secondary appraisal, if we feel that, firstly, we are in trouble, and secondly, we also feel that the demand (potential stressor situation) would outweigh our available coping resources, we are likely to experience the stress response, with many of its consequent "stress symptoms". On the other hand, if we appraise the demand as not being difficult, or else we see our "resources" as adequate to cope up with the demand, we experience a "challenge" and also the opportunity to increase our capability of 'coping". Thus, handling stress




may be a feast or famine situation. If we are able to cope up with the demands (stressors), we become energized; if not, we stand to be adversely affected by stress.

**Broad outline of the roadmap for preventing and managing stress**

The road map that we shall go through consists of the following sequential steps :

(a) Pre-emptive / preventive methods : The focus is to take prior steps to avoid difficult (stressor) situations and secondly, to ensure that difficult situations, if they occur, are seen as mild problems.

(b) Steps to develop adequate coping resources within the mind and body, which could be drawn upon, when faced with stressful situations.

(c) Developing the appraisal capabilities for analyzing, whether a given demanding situation does pose a threat and, secondly, if it does, to correctly appraise whether we have adequate coping resources to meet the demand. This step is quite important, because, depending upon the accuracy of our appraisal, we take either of the following two steps, as mentioned in paras (d) and (e) below.

(d) Problem focused coping : In case our appraisal indicates that our coping resources are adequate, we would take steps to combat the stressor.

(e) Emotion focused coping : If, on the other hand, the appraisal indicates that our resources are not enough to directly combat the stressor, we live with the stressor, but, at the same time, try to minimize the stress response.

Preventing / pre-empting stress & developing "coping resources"

This is quite pertinent as the better part of valour is to avoid unnecessary battles. This holds good for potential stressors too. To meet this end, we have two broad strategies, viz., firstly, by taking steps that difficult situations, even if they occur, will be seen as mild issues, and secondly, to avoid potentially stressful situations. The first of these pays us pretty well, though we have to start making efforts a long time before the appearance of potentially stressful situations. In addition, besides management of stress, these qualities, once developed, help us tremendously in improving our overall quality of life. Interestingly, these are not medical measures but managerial techniques which are given below.

**Learning and practicing decision - making techniques**

A number of decisions that we make about ourselves are much more important and have far reaching consequences than most of the other day-to-day decisions. For instance, choosing the wrong habit (drinking, gambling, etc.), the wrong occupation or friends, or making an unwise financial investment can create an endless string of future stressors. Consequently, learning and actually using proper decision making skills when faced with critical situations, can prevent much of stress later on. Wise decision making incorporates the sequential steps of firstly, defining the problem at hand, secondly, identifying the various alternative options at hand to tackle the problem, thirdly, deciding on the best option and finally, committing oneself to th selected course of action.

**Develop personal financial management skills**

Some of the major stressful situations in our lives result from financial crisis. These are often the result of poor financial management. Failure to take accurate stock of our existing income / projected income over the next one or two decades, reckless or impulsive spending, materialistic ambitions and a score of similar reasons, finally lead us into a situation when we don't have the finances at the time when they are most needed. While financial advisors and books on the subject are available and it may be worthwhile to take their advise, the minimum that everybody should do is to write down, on a paper, the income and expenditure. Having taken a written stock of the credits and potential expenses, one can sensibly match the resources. Whatever methodology you adopt to manage your finances, just remember that, firstly, improperly managed finances are one of the most important stressors of modern life. Secondly, one must avoid excessive desire that could fall in the category of "greed" (rather than essential or desirable for decent life), since, in our drive to fulfill such desire, we add further stress to our lives.

**Develop Time-management skills**

The work schedules as well as commitments in today's life, make time a premium entity. Managing available time in the most gainful and productive manner is a skill, which has to be learnt, practiced and sharpened over the years. Improper time management is an important cause of

getting stressed out.

**Make conscious and deliberate efforts to maintain good health.**

Even when one suffers from a disease as minor as common cold, one feels demoralized. Apparently, if one had to suffer from major diseases like heart disease, raised blood pressure and so on, the amount of stress that the person would be subjected to would be tremendous. One should therefore make conscious effort to maintain good health and prevent such diseases. Unfortunately, the value of prevention is often realized when one comes down with these diseases. In short, incorporating simple measures for a healthy lifestyle, like regular brisk exercise, giving up tobacco, avoidance of alcohol and eating a healthy diet would go a long way in prevention of some of the most dreaded diseases. One must remember that the boost that one gets from a state of good health is itself a tremendous stress-buster. On the same analogy, besides looking after one's own health, one should also deliberately and consciously look after the preventive health care of one's family members. Good health of your near one's prevents your stress.

**Undertake regular and brisk physical exercise** : By now, it has been clearly demonstrated by medical researchers that regular and brisk exercise is a major "stress-buster". In addition, the resulting physical fitness tends to shape up the psyche and physiology in such a way that we tend to become resistant to developing stress. With regular exercise, the body and mind get used to cope up with this adverse physiological challenge and the resulting high surge of stress hormones. In other words, the body and mind get acclimatized or "hardened" to stress in a very healthy manner. Secondly, it is also well known that brisk and regular exercise leads to release of beta-endorphins. These chemicals act on the brain and bring about a feeling of euphoria, well-being, confidence, alertness and decrease in pain sensations. It is almost like getting a kick after little dose of opium, though in a very healthy manner. This "high" state, caused by physical exercise due to endorphin release, persists for a few hours after exercise and has a very important role to play in both, reducing our threshold to stress as well as to subside the adverse effects, should a stressful situation occur.

**Train the family members for difficult situations** : Staying separated and fending for themselves is a task which many families have to undertake, when the head of family is away for prolonged periods, as a part of the service. An important reason for stress among the head of the family, when he is staying away, stems from the constant worries that occur about the family. It is therefore logical that people should visualize that occasions may come when the family has to stay separated. One should think of the problems that the family members would face during such situations and try to train the family members in dealing with the routine as well as the difficult situations. Once a person is confident that his family members would be able to fend for themselves during his absence, he will be much less stressed during the period of separation.

**Spend "Quality time" with your family**

Whenever one gets the opportunity, one should make sure that one spends at least a few hours of "QUALITY TIME" with the family members. By quality time we mean that you should get involved with them – play with them, teach them and so on, rather than simply sitting with them and surfing around the TV channels. From the psychological point of view, one of the major precursors of stress is the feeling of being "isolated" or "disconnected". On the other hand, when you spend quality time with your family members, you feel connected, without any feeling of isolation, which helps preventing stress.

**Develop Social Support Systems**

We, human beings, are social animals. At times of need, we should have social support. This is particularly true when we are faced with difficult and stressful situations. Therefore, it would be a very wise investment to put in some effort to develop some close friends towards whom we can look up for support during stressful situations.

**Avoid Ego struggles** : Many stressful encounters with others are, in fact, unnecessary ego struggles where the only prize is protection of your self-image, but the price is exposure to substantial stress, not only in the imminent future but also in the long run. We often argue with our colleagues, superiors, spouse and even children about trivial issues that really don't matter much. The point of argument in most of these situations is not really the subject of discussion but rather to decide who is to be declared "right" or the "winner". We sometimes act as if it is more important to be seen as "right" rather than be happy. It is best to avoid the tendency to forcefully convince others when it is not so critical to your own health and well-being. Doing so will help you escape a great deal of unnecessary stress. Try and seek "win – win" solutions to mutual problems and remember that 'compromise" is not as dirty a word as most of us think it to be.

**Adopt traditional cultures** : As Indians we have the advantage of a rich and ancient culture. Patanjali advocated Yoga as a means of attaining physical and psychological health 5000 years ago. Our culture has elaborated on the virtues of need based living, sharing, acceptance of good with the bad, and renunciation, which if combined with advantages of modern living will improve the quality of life many fold.

**Practice methods to get a good sleep**

Good sleep is very important for de-stressing us, as well as in assisting the repair of the physical and the mental breakdown that occurs during the whole day. Stress often interferes with our normal sleeping pattern. When we have anxiety or depression, we find it difficult to fall asleep, may wake up in the middle of the night and find it difficult to go back to sleep or get up too early feeling un-refreshed. Accordingly, practicing methods for getting a good sleep is likely to be of much help in both preventing stress as well as negating it's adverse effects. Some tips for getting good sleep are :

(a) Associate the bed with sleep only. Don't eat, read or watch TV while in bed.

(b) Avoid caffeine containing drinks (Tea, Coffee) or tobacco before retiring.

(c) Don't use alcohol to get sleep. Alcohol may make us drowsy and may initiate sleep, but interferes with the rhythm of normal sleep and causes rebound arousal of brain. The net effect is that it leads to more tiredness than relaxation.

(d) If you have difficulty in falling asleep or tend to have disturbed sleep in the night, then stop sleeping in the afternoons. This is believed to be a useful adjunct in managing stress (83).

(e) Undertake brisk exercise in the morning – you will have a nice sleep in the night. Schedule the brisk exercises for the morning (jogging, swimming, field games, cycling etc.) and light exercises (golf, light walking,) for the evening.

(f) Keep a regular sleep schedule – go to bed and get up roughly at the same time.

(g) If, on some odd occasion, despite all the above measures, you are still not able to get sleep, then do not try to "force" sleep by tossing and turning in the bed. Get up, sit down with a light reading and relax till the time you feel like dozing off.

**Practice "assertiveness" skills**

Assertiveness does not mean being aggressive. The former is a very good quality, while the latter damages the personality and the social support systems. Assertiveness is the honest expression of what you feel and want from others, without trying to force them to give it. Assertive behavior needs to be developed gradually and carefully. It is particularly useful when dealing with "difficult" people and the consequent stress.

Some of the characteristics of assertive behavior which need to be developed are :

(a) Speak up for yourself, for your needs and rights, while letting others to speak for themselves.

(b) Develop a sense of respect for yourself as well as for others.

(c) Protest, maybe politely but definitely, against unfair treatment or unjustified criticism.

(d) Take honest responsibility for your own wrongs / mistakes but, at the same time, do not take responsibility for someone else's lapses.

(e) Say "NO", maybe politely, when you feel that a particular task or favor being asked of you is unjustified or beyond your capabilities.

**Practice "Relaxation Techniques"**

There are certain proven techniques, which, if practiced for just 15 to 20 minutes a day, will help control stress related tension. These include Abdominal Breathing (Diaphragmatic breathing). To undertake abdominal breathing, sit comfortably, with your back upright. Place your left hand on the chest and right hand on the abdomen. Now, breathe in slowly, through the abdomen, so that the abdomen expands, but the chest should not expand. You can come to know of this by noticing your hands – if you are breathing through your abdomen, your right hand will rise but the left hand will move only very little. Now, gently exhale as much air as you can by slowly contracting your abdomen but not your chest. Once again, your left hand should move very little, while the right hand goes down perceptibly. Practice abdominal breathing for 4 to 5 minutes at any fixed time of the day. In addition, try breathing that way when faced with (or immediately after) a stressful situation.

**Progressive, Deep Muscular Relaxation**

For practicing this technique, you can either lie comfortably on your back, or else, sit in a chair. Begin by taking a slow and deep breath. At the same time, lift your heel a few inches off the ground and extend your legs, pointing your toes towards the knees, thereby tensing your thigh muscles and stretching your calf. Hold in this position for a count of seven. Now inhale deeply. Contract the muscles of your right arm and raise the arm by a few inches. Hold in this raised position for a count of seven, then let it fall down, limp. Relax for a few seconds, then repeat the same procedure with the right arm. Finally, gently roll your head from side to side and allow your neck to relax. Now inhale and tense up all the muscles of your face, including those of jaws, eyelids, cheeks, lips and forehead. Keep them squeezed for a count of seven, then let them go limp, let the jaw drop down and slowly exhale.

**Spiritual Practice and Meditation**

Engagement in spiritual practice in various forms has been shown to have a strong role in both, preventing the stress response, as well as for coping up with a deleterious stressful situation (82 - 85). Most of us tend to relate the word "spiritual" to organized religious activities. However, spirituality can also be practiced outside the formal / institutionalized religious environment. It needs to be noted that spiritual techniques cannot be a "one – time prescription" which one can indulge at week-ends. For optimum results, these techniques need to be adopted as part of daily lifestyle. The important methods of spiritual practice relevant to stress management are :

**Praying**

The power of praying has been of much interest to the medical fraternity in recent times. Praying, from the stress management point of view is like "connecting" us to a higher form. It reinforces our confidence and strengthens us with the feeling that we are not alone and that there is some higher power on which we can bank upon. This hope and confidence leads to release of certain hormones / chemicals in our body which strengthen the physiological functioning of various organ systems. It would be worthwhile devoting at least a few minutes once or twice a day for praying.

**Meditation**

The soothing physiological and psychological benefit of meditation is well known. Meditation does not belong to any particular religion and has a long history. Meditation essentially means "concentrating or focusing attention on an object and shutting off the mind to all other external

thoughts". With practice, one will realize that meditation is not something done once or twice a day for a few minutes. One can, in fact, bring that enhanced awareness to everything one does throughout the day.

Undertake meditation at a place that you have earmarked, so that you associate that place with meditation. Sit down in a comfortable position – in a chair, relaxed, hands on the lap or on the ground, cross-legged. Decide on the sound that pleases you which could be a verse or text from any religious book or a humming sound. Instead of a sound, the object of focus could be a light source or image, real or virtual, whichever suits you. Concentrate on the sound or image and remove any other thought that comes to the mind for the next few minutes that you are practicing meditation.

**Yoga**

There is enough evidence to indicate that Yoga is a powerful strategy for coping up with stress. An ancient Indian practice, Yoga is essentially a way of life. In general, try to practice Yoga daily or at least on 4 to 5 days in a week. It is not necessary to do complicated stretching exercises but even simple ones like a combination of sarpa-asana (Cobra posture), Dhanur-asana (Bow pose), Head rotation, shoulder rotation and shava –asana ( Corpse pose) can be reasonably good. Practice can be undertaken at any time but is usually best in the mornings. Ideal is a physical fitness schedule consisting of 10 to 15 minutes of Yoga, followed by 45 to 50 minutes of brisk exercise and lastly meditation and praying for 5 to 10 mts each.

Emotion focused coping

Our discussion so far has been directed at preventive measures and on development of coping resources. However, in anyone's life, there are some inevitable difficult situations. Growing old, suffering from chronic diseases, getting bypassed for promotion etc., are just a few examples of human predicaments that we must learn to live with. These are the situations where it would be wise for us to use the "Emotion Focused Coping" rather than the problem focused approach. The important components of emotion focused approach are listed below.

**Accepting the inevitable**

Once it appears that the problem is there to stay, it is best to accept the same. For those who have developed adequate coping resources, as faith in God, this becomes easier. One must draw lesson, in such times, from the prayer of St Assisi, which says "God, give me the courage to change what I can, the strength to accept what I can't and the wisdom to distinguish between the two".

**Don't discount the importance of hope**

Hope is a powerful ally in dealing with stress. The hope that things will improve goes a long way in reducing stress.

**Suppress the distressing thoughts** : If you have done what all can be done, then further mental processing of the problem can only make matters worse. This is because the body's physiology and hormonal system does not distinguish between fact and fantasy. The continuous mental processing creates a state of despondency. In such situations it is better to suppress our thoughts to control the resultant emotional responses.

**Reframing**

As stated before, stress response is not triggered by the problem but by the meaning attached to it. Thus, if we change the "meaning" attached to the situation, we can change the emotional response. This strategy is "reframing", in which we start looking differently at a situation, and, while accepting the problem, we look out for positive elements that might make the experience less stressful, by questioning "What could be good in this situation? There has to be something good! Or what can I learn from this situation?

**Discharging painful emotions**

We often become unhappy or even sick, due to bottled up emotions. Disclosing our feelings to a near one, or to a Doctor, often provides much relief. Another method is to write a personal diary, often referred to as "therapeutic writing". Maintaining a stiff upper lip may be a part of the self created "strong personality" for most of us, but it does not seem wise from what we know of the human emotions.

**Stress prevention in the armed forces : A check-list**

Armed Forces have peculiar types of stresses, like being faced very often with life and death situations, uncertainties about future and compounded by staying alone, away from near and dear ones. The guidelines given in the preceding paragraphs would be of considerable use in preventing and effectively tackling mental stress among industrial workers and armed forces. It is suggested that armed forces Doctors educate the commanders, personnel and families in these various steps as have been outlined above. Some additional tips for the military commanders are given below.

(a) Educate your subordinates on the various preventive / pre-emptive as well as stress – coping methods, as explained in detail in this chapter.

(b) Stay "connected" with your subordinates. This may take the form of physical contact like hugging or shaking hands or maintaining touch through playing together.

(c) Talk a lot to your subordinates and encourage them to talk about themselves, their families and their problems. This greatly helps in "opening up" and reduces stress.

(d) Allow, rather promote, humor and laughter. Make sure people speak out their painful experiences. This helps in "discharging" painful feelings and combats stress.

(e) As a leader, develop the art of "listening" to your subordinates. Send messages that you are listening to them carefully, as by giving head-nods or saying "yes" in between, or by repeating the last few words of what they have spoken.

(f) Encourage regular and brisk physical exercise in the form of organized physical training and sports. Besides having tremendous stress busting ability, physical exercise also promotes "togetherness" and combats loneliness and isolation.

(g) Keep everybody informed about your plans and job expectations (of course on a need – to – know – basis). One of the causes of stress in workplaces is the "lack of control on circumstances". By letting everybody know about the tasks to be performed and the reasons for the same, you would let the subordinates have a feeling that they are "in control" of the situation.

(h) Promote spirituality and meditation. Regular partaking in worshiping in an organized manner and organizing sessions on meditation / Yoga can reduce stress among employees. Discourage alcohol and tobacco. Restrict occasions where moderate alcohol consumption is permitted. Never let people drink alone in their bunkers / rooms.

(j) Encourage subordinates to write. A good method is to encourage them to frequently write letters to near and dear.

(k) Show your subordinates that you are fair and impartial. Convince them by talking to them frequently that the physical / mental difficulties faced by them are for the combined good of the team and are only for a temporary period only.

(l) Leave is an important aspect in Armed Forces as personnel stay away from near ones for prolonged periods. Such break from routine and meeting family disrupts the vicious circle of isolation and stress. Hence, leave should be provided regularly to the extent possible, subject to exigencies of service.

(m) Never discount the value of hope. Keep optimism alive in yourself and your subordinates.

(n) Establish a "buddy" system wherein each member of the pair is responsible for taking care of his buddy and keep vigil for early signs of stress. The early signs of stress are described below.

What are the early signs of stress ?

Early recognition of stress is important. The first step is be alert to the signals of stress emanating from our body and mind. Quite often your near and dear ones or the "buddies" notice them and it would be worthwhile to occasionally ask them if they have noticed such signs in you. The signs of stress are listed below.

(a) Headache, pain in neck, backache, aches in muscles and joints, fatigue and exhaustion, vague symptoms of indigestion, sleep problems (either difficulty falling asleep or getting up in between sleep)

(b) Feeling of being distressed / harassed, decreased interest in life and decline in cheerfulness.

(c) Deterioration of inter-personal relationships, whether at home, workplace or in social circles, increased "tiffs", frequent bouts of irritability and social withdrawal.

(d) Deterioration of performance, difficulty in concentration, forgetfulness, increased errors, reduced efficiency and decreased motivation.

(e) Initiation or increase of substance abuse (alcohol, tobacco etc.).

(f) Excessive and frequent eating of food / snacks or avoidance of food and gain or loss of body weight in a short span of time.

Medical Officers should emphasize on the clientele that these warning signs are subtle and may be easily missed, unless one is very observant. For noticing them, one will have to search for these signs and deliberately listen to one's mind and body. One may have to ask your near ones if they noticed these signs in him. If such signals are noticed, they should not be dismissed lightly. Serious action should be taken by bringing all the coping resources (as discussed earlier) into play. Secondly, the clientele should be assured to consider the Doctor as their best friend; to talk to him about their problem. One must realize that stress can occur to anybody . It is no disease to be shy about. It is just a reaction of one'sbody to the adversity in the environment. So, even if there is a slight doubt, one should talk to the family members, friends and with the Doctor.

Col RajVir Bhalwar

# Ischaemic Heart Disease (IHD); Syn: Coronary Heart Disease (CHD); Coronary Artery Disease (CAD)

IHD is the prototype example of lifestyle diseases. In affluent countries, it is the most devastating disease, often accounting for almost a quarter of all deaths. It has also been the most researched disease in modern times regarding it's epidemiology, risk factors, management and prevention. The term Cardiovascular Diseases (CVD) encompasses a wider spectrum of diseases which include IHD, heart diseases other than IHD, Systemic arterial hypertension, Stroke and, Peripheral vascular disease (PVD). Within the gamut of the term IHD, we have a wide spectrum of conditions, starting from asymptomatic coronary insufficiency at the mildest end and sudden death at the other, in between we have typical angina, atypical angina and acute Myocardial Infarction, representing increasing severity along the spectrum.

### Definition

IHD is defined as a state of lack of supply of oxygen to the myocardium vis a vis the demands, due to narrowing of the coronary arteries as a result of the atherosclerotic process.

### Magnitude of the problem and frequency

IHD places a mammoth load of disease and ill health on humanity. In developed countries, half of all deaths are due to CVD and a quarter due to IHD. In developing countries, the problem is no less; as economic development will occur, IHD may, by the year 2025, become a leading cause of death and disability in our country.

IHD derives its importance for a variety of medical and socio-economic reasons, as follows :

(a) The magnitude of problem in terms of sheer numbers is very high

(b) The disease has a very high "killing power" - even in developed countries with well established treatment and ambulance services, 25% of those who suffer from acute MI would die within one hour and would never reach the hospital; another 8 to 10% would die in the next 24 hours in the hospital and another 10% would die in the next one year.

(c) Even for those who survive, the quality of life in terms of physical capabilities is compromised, alongwith constant apprehension about the future.

(d) The treatment is quite costly and available at few selected centres.

(e) Most of the persons affected with clinical disease are in their middle age, and are in the maximal productive pahase of their life; they also have the maximum family and social obligations to fulfill at this age. Getting affected by the disease at this age therefore leads to tremendous loss to the organization and much suffering for the family.

The silver lining is that a large number of factors which place an individual at high risk of getting affected with IHD (called "coronary Risk factors") are well known to the medical world and potentially amenable to preventive efforts. IHD thus is very much a preventable issue.

The magnitude of problem has been brought out in chapter - 1 of this section (1 - 30). Some important findings are as follows :

### Global Problem

Of an estimated 58 million deaths globally from all causes in 2005, cardiovascular disease (CVD) accounted for 30%. This proportion is equal to that due to infectious diseases, nutritional deficiencies, and maternal and perinatal conditions combined (86). It is important to recognize that a substantial proportion of these deaths (46%) were of people under 70 years of age, in the more productive period of life; in addition, 79% of the disease burden was attributed to cardiovascular disease is in this age group (87). Between 2006 and 2015, deaths due to noncommunicable diseases (half of which will be due to cardiovascular disease) are expected to increase by 17%, while deaths from infectious diseases, nutritional deficiencies, and maternal and perinatal conditions combined are projected to decline by 3% (86). Almost half the disease burden in low and middle-income countries is already due to noncommunicable diseases (88).

### Indian scenario

The figures have been recently summarized by Reddy et al (89). Over the past 4 decades, the prevalence of IHD has risen two fold in rural and six fold in urban areas. At present, an estimated 3 to 4% of rural and 8 to 10% of urban adults are likely to be affected by IHD, thus putting the estimated IHD cases in India at 30 million (15 million each in rural and urban areas). In the armed forces also there is a disturbing, rising trend as has been described in chapter - 1 of this section.

## The determinants (Coronary risk factors)

With large scale, world-wide research over the past 60 years, both epidemiological as well as clinical, we are now well aware of various coronary risk factors, which place an individual at high risk of getting affected with IHD (90). These are listed in the Table 1. It needs to be noted that the search for coronary risk factors is an ongoing one and every year a few more are likely to be added to the list. Broadly, these may be classified as "modifiable" and non-modifiable" risk factors.

### Non-modifiable

As the name suggests, we can not "change" these factors; only thing is that if a person has any of them, he / she needs to be even more careful as regards modifiable factors. The non-modifiable risk factors are :

Age

Age > 45 years for males and > 55 years for females increases the risk.

Sex

Male sex is at a higher risk. However, after menopause, the risk for females increases and equalizes that of males by the age of 50 to 55 years.

Family history

History of definite MI or sudden death in father or 1st degree male relative before 45 years age or in mother or 1st degree female relative before 55 years age indicates high risk.

Race

Some races may be more predisposed. For example, South Asian populations are said to be at higher risk, possibly because of "thrifty gene"; the Finnish population are at a high risk while Japanese are at lower risk. The extent to which these differences are because of genetic factors that differ between races or else due to lifestyle factors peculiar to different races, is still not clear.

**Modifiable coronary risk factors**

These are summarized in the Table - 1

A discussion on the major risk factors emphasizing on the benefit achieved by controlling them is reviewed in the subsequent paragraphs.

Dyslipidaemia

Over the past two decades, the focus has shifted from "hypercholesterolaemia" to "dyslipipidaemia", giving due consideration to various other fractions of lipid profile. Of course, total serum cholesterol (TC) remains the single most important predictor of CHD risk both on individual as well as population level. The incidence of IHD is high among populations with mean serum TC > 200 mg / dl and low in populations with mean TC levels < 150 mg / dl. It is desirable that on individual level, the TC level should be kept below 200 mg / dl, while on population level, we should strive to keep the mean level below 160 mg / dl. Besides TC, LDL-Cholesterol levels have assumed importance. The ATP-3 recommends that on individual level, the LDL levels should ideally be < 100mg / dl; since this may be difficult for most people, levels of < 130mg / dl are considered as "near optimal". Levels of > 160 indicate high risk, while between 130 to 159 mg / dl indicate moderately increased risk.

HDL has been acknowledged to be the protective component. HDL levels > 40 mg / dl for males and > 50 mg / dl for females should be aimed. In addition to simply going by TC or HDL levels, the ratio of TC : HDL has been increasingly advocated. Ideally, this ratio should be maintained at < 3; ratio of > 4. 5 indicates high risk.

Finally, the role of raised triglycerides (TG) as CHD risk

Table - 1 : Modifiable Coronary Risk factors

| Well Established | | Emerging / Being researched | |
|---|---|---|---|
| **Lipid** | | ✎Mental stress (depression, low job control, suppressed hostility) and personality (type 'A') | calculated as TC – HDL) |
| ✎Raised Total Cholesterol (< 200 mg / dl : desirable; 200 – 239 : Borderline high; >= 240 : High) | **Non Lipid** | **Lipid** | **Non Lipid** |
| ✎Raised LDL – C ( < 100 mg/dl : optimal; 100 – 129 : near optimal; 130-159 : Borderline high; >= 160 : High) | ✎Tobacco use (even small amount of tobacco use increases risk) | ✎Raised TC : HDL-C ratio (> 4.5) | **Inflammatory markers** |
| ✎Raised triglycerides (<150 mg/dl : normal; 150 – 199 : Borderline High; >= 200 : High) | ✎Raised Blood Pressure | ✎"Lipid Triad"(concomitant presence of raised triglycerides, small dense LDL particles and low HDL | ✎Raised Total WBC count |
| ✎Low HDL-C ( < 40 mg/dl in men or < 50 in women) | ✎Diabetes Mellitus – type 2 or Impaired Glucose Tolerance | ✎Lipoprotein (a) | ✎Raised C-reactive Protein |
| ✎Metabolic Syndrome (Syndrome 'X') – a clustering of low HDL, raised triglycerides, hypertension, impaired glucose tolerance and obesity | ✎Obesity (either generalized or central) | ✎Raised Apolipoprotein – B | **Prothrombotic factors** |
| | ✎Physical Inactivity | ✎Low Apolipoprotein A-1 | ✎Platele-Hyperaggregability |
| | ✎Atherogenic diet (high in total calories, Total fat, saturated fats, cholesterol, salt and refined sugar; low in whole grains, cereals, legumes, fruits, vegetables, antioxidant vitamins, folic acid, fibre, and Omega-3 fatty acids | ✎Small, dense LDL particles | ✎Raised Fibrinogen |
| | | ✎Raised Non-HDL Cholesterol (this is VLDL + LDL and is routinely | ✎Raised Plasminogen Activator Inhibitor (PAI-1) |
| | | | ✎Tissue Plasminogen Activator (tPa) |

factor has been assuming increasing importance, especially in case of south-asian populations and in the context of metabolic syndrome (see later). Ideally TG levels should be maintained at < 150 mg/dl; levels of 200 mg / dl and above indicate high risk. Needless to say, from the preventive action point of view, dyslipidaemia is only an indicator. It results due to a wide variety of other risk factors especially atherogenic diet, smoking, obesity, and physical inactivity and hence, focus should be control of these risk factors for effectively addressing dyslipidaemia.

### Tobacco

There is a large body of evidence from prospective cohort studies regarding the beneficial effect of smoking cessation on coronary heart disease mortality (91). Some studies suggest that, about 10 years after stopping smoking, coronary heart disease mortality risk is reduced to that of people who have never smoked (92,93). Other reports suggest that a much longer time is required (94). A 50-year follow-up of British doctors demonstrated that, among ex-smokers, the age of quitting has a major impact on survival prospects; those who quit between 35 and 44 years of age had the same survival rates as those who had never smoked (95). The benefits of giving up other forms of tobacco use (as chewed tobacco) are also established (96-99). Recent evidence from the Interheart study (100) has highlighted the adverse effects of use of any tobacco product and, importantly, the harm caused by even very low consumption (1-5 cigarettes a day). The benefits of stopping smoking are evident; however, the most effective strategy to encourage smoking cessation is not clearly established. All patients should be asked about their tobacco use and, where relevant, given advice and counselling on quitting, as well as reinforcement at follow-up. There is evidence that advice and counselling on smoking cessation, delivered by health professionals (such as physicians, nurses, psychologists, and health counsellors) are benefi cial and effective (101 - 106). Several systematic reviews have shown that one-time advice from physicians during routine consultation results in 2% of smokers quitting for at least one year (103, 107). Data from observational studies suggest that passive cigarette smoking also produces a small increase in cardio vascular risk (108-110).

## Dietary risk factors

### Dietary fat and cholesterol

The relationship between dietary fat and coronary heart disease has been extensively investigated. Saturated fats as a whole have been shown to raise LDL-cholesterol levels (111-115). However, individual fatty acids within the group have different effects, with myristic and palmitic acids having the greatest effect on LDL-cholesterol (116, 117). Saturated fatty acids are not all equally hypercholesterolaemic. When substituted for saturated fatty acids in metabolic studies, n-6 polyunsaturated fatty acids (which are abundant in soybean and sunflower oil) and monounsaturated fatty acids (which are abundant in olive oil) lower total cholesterol, LDL cholesterol and triglyceride concentrations (115, 118). Trans-fatty acids come from both animal and vegetable sources and are produced by partial hydrogenation of unsaturated oils. Dietary intake of trans-fatty acids increases LDL-cholesterol and, at high intakes, lowers HDL cholesterol (113-115, 119-121). Metabolic and epidemiological studies have indicated that trans-fatty acids increase the risk of coronary heart disease (115, 122, 123).

A high intake of fat (more than 30% of total calories) generally increases intake of saturated fat and is associated with consumption of excess calories and weight gain. On the other low intake of fats and oils (less than 20% of total calories) increases the risk of inadequate intakes of vitamin E and essential fatty acids, and may contribute to unfavourable changes in HDL-cholesterol and triglycerides (124). It has also been demonstrated that replacing saturated and trans-unsaturated fats with monounsaturated and polyunsaturated fats is more effective in preventing coronary heart disease events than reducing overall fat intake (115, 123, 125). Current guidelines recommend a diet that provides less than 30% of calories from dietary fat, less than 10% of calories from saturated fats, up to 10% from polyunsaturated fats, and about 15% from monounsaturated fats (118). Metabolic studies have shown that dietary cholesterol is a determinant of serum cholesterol concentration (126-128).

### Omega-3 fatty acids, fish and cardiovascular risk

The main dietary sources of omega-3 fatty acids are fish and fish oils (which contain eicosapentaenoic acid and docosahexaenoic acid), and certain nut and plant oils, such as canola, soybean, flaxseed and walnut (which contain alpha-linoleic acid). Epidemiological studies and clinical trials suggest that people at risk of coronary heart disease benefit from consuming omega-3 fatty acids (129, 130, 131). The proposed mechanisms for a cardioprotective role include altered lipid profile, reduced thrombotic tendency, and antihypertensive, anti-inflammatory and antiarrhythmic effects (132-135).

### Dietary salt

Population studies have demonstrated that high salt intake is associated with an increased risk of high blood pressure (136). Several observational studies have linked baseline sodium intake, estimated from either 24-hour urinary sodium excretion or dietary intake, to morbidity and mortality. In a Finnish study, the hazard ratios for coronary heart disease, cardiovascular disease, and all-cause mortality, associated with a 100 mmol increase in 24-h urinary sodium excretion in men and women, were estimated as 1. 51 (95% CI 1. 14 to 2. 00), 1. 45 ((95% CI 1. 14 to 1. 84), and 1. 26 (95% CI 1. 06 to 1. 50), respectively (137). A prospective study in a Japanese cohort also showed that high dietary salt intake increased the risk of death from stroke (138). The efficacy of reduced sodium intake in lowering blood pressure is well established (139, 140). An average reduction of 77 mmol/day in dietary intake of sodium has been shown to reduce systolic blood pressure by 1. 9 mmHg (95% CI, 1. 2 to 2. 6 mmHg) and diastolic blood pressure by 1. 1 mmHg (95% CI, 0. 6 to 1. 6 mmHg) (138). Phase 2 of the Trials of Hypertension

Prevention studies has also documented that a reduced sodium intake can prevent hypertension (141). In a meta-analysis of dietary interventions to alter salt intake, a reduction of 100 mmol (6 g) per day in salt intake was associated with a fall in blood pressure of 7.11 mmHg (systolic) and 3.88 mmHg (diastolic) This information strongly supports other evidence that a modest, long-term reduction in population salt intake would immediately reduce stroke deaths by about 14% and coronary deaths by about 9% in people with hypertension, and by approximately 6% and 4% in those with normal blood pressure. (142). It is clear that intensive interventions, in particular the Dietary Approaches to Stop Hypertension (DASH) (143), are capable of reducing salt intake and lowering blood pressure. On the basis of the above, current recommendations on salt intake (< 5 g (90 mmol) per day) are appropriate (144).

### Fruits and vegetables

Fruits and vegetables may promote cardiovascular health through a variety of micronutrients, antioxidants, phytochemicals, flavonoids, fibre and potassium. The evidence on the role of the individual constituents is so far inconclusive. Ness & Powles (145) reviewed ecological, case-control and cohort studies examining the association of dietary fruits and vegetables with cardiovascular disease. For coronary heart disease, they found a significant protective association with consumption of fruits and vegetables or surrogate nutrients. Overall, the results support a protective effect of fruits and vegetables on stroke and coronary heart disease (146, 147). Joshipura et al. (146) evaluated the association between consumption of fruits and vegetables and risk of coronary heart disease in the Nurses' Health Study and the Health Professionals' Follow-Up Study. After adjustment for standard cardiovascular risk factors, people with fruit and vegetable intake in the highest quintile had a relative risk for coronary heart disease of 0. 80 (95% CI 0. 69 to 0. 93) compared with those with intake in the lowest quintile. Each increase of one serving per day in intake of fruits or vegetables was associated with a 4% lower risk of coronary heart disease (relative risk 0. 96; 95% CI 0. 94 to 0. 99). The relationships between intake of whole grains, refined grains, fruits, vegetables and total mortality risk / incidence of coronary artery disease and ischaemic stroke, were also evaluated in the Atherosclerosis Risk in Communities (ARIC) cohort (n = 15 792) (148). Over an 11-year follow-up period, whole-grain intake was inversely associated with total mortality and incidence of coronary artery disease. A recent meta-analysis of 10 prospective cohort studies (149) has also shown that the consumption of fibre from cereals and fruits is inversely associated with risk of coronary heart disease. On the basis of the available evidence, a daily intake of at least 400 g of fruit and vegetables is recommended (150).

### Physical inactivity

It has been estimated that inadequate physical activity is responsible for about one-third of deaths due to coronary heart disease and type 2 diabetes (151). There is evidence from observational studies that leisure-time physical activity is associated with reduced cardiovascular risk and cardiovascular mortality in both men and women (152-154) and in middle-aged and older individuals (155, 156). Several meta-analyses have examined the association between physical activity and cardiovascular disease (157-162). Berlin & Colditz (160) found a summary relative risk of death from coronary heart disease of 1. 9 (95% CI 1. 6 to 2. 2) for people with sedentary occupations compared with those with active occupations. A meta-analysis of studies in women showed that physical activity was associated with a reduced risk of overall cardiovascular disease, coronary heart disease and stroke, in a dose-response fashion (157). Physical activity improves endothelial function, which enhances vasodilatation and vasomotor function in the blood vessels (159). In addition, physical activity contributes to weight loss, glycaemic control (163, 164), improved blood pressure (165), lipid profile (166-168) and insulin sensitivity (169). The possible beneficial effects of physical activity on cardiovascular risk may be mediated, at least in part, through these effects on intermediate risk factors. Physical inactivity and low physical fitness are independent predictors of mortality in people with type 2 diabetes, which in turn is a strong risk factor for CHD (170). Overall, the evidence points to the benefit of continued regular moderate physical activity, which does not need to be strenuous or prolonged, and can include daily leisure activities, such as walking or gardening (157). Taking up regular light or moderate physical activity in middle or older age significantly reduces CVD and all-cause mortality, and improves the quality of life (156-158, 171, 172).

### Overweight

Prospective epidemiological studies have shown a relationship between overweight or obesity and cardiovascular morbidity, CVD mortality and total mortality (173-179). Obesity is strongly related to major cardiovascular risk factors, such as raised blood pressure, glucose intolerance, type 2 diabetes, and dyslipidaemia (173, 176, 178, 180). Meta-analyses of RCTs have shown that a weight-reducing diet, combined with exercise, produces significant weight loss, reduces total cholesterol and LDL-cholesterol, increases HDL-cholesterol, and improves control of blood pressure and diabetes (181 - 183). A meta-analysis of randomized controlled trials (184) found that a net weight reduction of 5. 1 kg (95% CI 4. 25 to 6. 03 kg), reduced systolic blood pressure by 4. 44 mmHg (95% CI 2. 95 to 5. 93 mmHg) and diastolic blood pressure by 3. 57 mmHg (95% CI 2. 25 to 4. 88 mmHg). The long-term benefit of weight reduction on blood pressure control has been confirmed in several studies, including Phase II of the Trials of Hypertension Prevention Collaborative Research Group (185, 186). Evidence also suggests that physical exercise and fitness is equally and independently important. In a review of data from 24 prospective observational studies, Blair & Brodney (187) found that regular physical activity attenuated many of the health risks associated with overweight and obesity. Physically active obese

individuals have lower morbidity and mortality than individuals of normal weight who are sedentary; physical inactivity and low cardiorespiratory fitness are as important as overweight and obesity as predictors of mortality. The appropriate upper limits of measures of overweight and obesity have been recently defined by various expert bodies. For South Asian populations, including Indians, the upper limits are (188 - 190)

**Waist Circumference** : 90 cms for males and 80 cms for females

**Waist** : Hip ratio (WHR) 0. 90 for males and 0. 80 for females

**Body Mass Index (BMI)** : 25 and above as overweight and 30 and above as obese. However, recent WHO recommendations tend to recommend an even lower cut-off for Asian populations as 23 and above as overweight and 27. 5 and above as obese.

### Alcohol

Many studies have shown a U or J- shaped association between mortality and alcohol consumption, in which people who drink light or moderate amounts have a lower death rate than nondrinkers, while those who drink large amounts have a higher death rate (191 - 199). People who drink heavily have a high mortality from all causes and cardiovascular disease. In addition, they may suffer from psychological, social and other medical problems related to high alcohol consumption (196 - 199). A meta-analysis of 28 cohort studies of alcohol consumption and CHD showed that risk decreased as consumption increased from 0 to 20 g/day (RR = 0. 80); there was evidence of increased risk at higher consumption. Smaller protective associations and more harmful effects were found in women. The amount of alcohol associated with the lowest mortality rates was between 10 and 30 g (1-3 units) per day for men and half these quantities for women (1 unit has already been defined in the earlier chapter). Various mechanisms have been proposed for the protective effect of modest alcohol consumption, including the demonstrated beneficial effects of alcohol on lipid profile, particularly an increase in HDL-cholesterol level, thrombolytic profile, and platelet aggregation (196, 199 - 201). The benefits of alcohol in light to moderate drinkers may be overestimated in observational studies, as a result of confounding because it is primarily the non-drinking group that causes the U-shaped relationship, and this may contain both life-long abstainers and people who stopped drinking because of ill-health; this could result in a spurious association suggesting that there is a safe level of alcohol intake. This would imply that there is no level of alcohol consumption that is beneficial with respect to coronary heart disease; rather, risk increases with increasing consumption in a linear fashion. Interestingly, earlier, the beneficial effect of hormone replacement therapy (HRT) on HDL-cholesterol convinced many that cohort studies showing a protective effect of HRT on coronary heart disease risk were valid. However, subsequent randomized controlled trials have found either no benefit or a harmful association; the earlier beneficial results were likely to be due to uncontrolled confounding. On the same analogy, it is possible that the protective association between light-to-moderate alcohol consumption and coronary heart disease is also an artefact caused by confounding. Light-to-moderate drinkers may be “light-to-moderate” in other behaviours, such as tobacco use which could be responsible for their lower risk of CHD (203). It is also important to note that alcohol consumption is associated with a wide range of medical and social problems, including road traffic injuries. Some individuals are also at risk of progression to problem drinking. Other risks associated with moderate drinking include fetal alcohol syndrome, obesity, haemorrhagic stroke, large bowel cancer, and female breast cancer (196, 204). Consequently, from both the public health and clinical viewpoints, there is no merit in promoting alcohol consumption as a preventive strategy.

### Psychosocial factors

Observational studies have indicated that some psychosocial factors, such as depression and anxiety, lack of social support, social isolation, and stressful conditions at work, independently influence the occurrence of major risk factors and the course of coronary heart disease, even after adjusting for confounding factors (205-207). Other psychosocial factors, such as hostility and type A behaviour patterns, and anxiety or panic disorders, show an inconsistent association (208, 209). Rugulies (205), in a meta-analysis of studies of depression as a predictor for coronary heart disease, reported an overall relative risk for the development of coronary heart disease in depressed subjects of 1. 64. Other studies have also found a strong association between depression and CHD (209-211). Depression was shown to be a predictor for risk of myocardial infarction in the Interheart case-control study (odds ratio 1·55). This finding was consistent across regions, in different ethnic groups, and in men and women (206). More recent trials have cast doubt on the causal nature of the association between depression and CHD. In a large randomized trial of psychological intervention after myocardial infarction, no impact on recurrence or mortality was found (212). Another large trial that provided social support and treatment for depression also found no impact (213). Kivimäki et al. (214), in a 25. 6-year prospective cohort study in Finland, found that metal industry employees with high job strain (a combination of high demands at work and low job control) had a cardiovascular mortality risk 2. 2 times that of their colleagues with low job strain. This association between stressful conditions at work and CHD is supported by other studies (209, 215). There is also some evidence that social isolation and lack of quality social support are independent risk factors for CHD onset and prognosis: the risks are increased 2-3-fold and 3-5-fold, respectively, in both men and women (216). The association has been demonstrated in subjects in different countries, and in various age groups (209, 216-219). While these findings provide some support for a causal association. Well planned trials of interventions are required to elucidate whether there is a true cause-effect relationship and, more importantly, whether intervention

reduces cardiovascular risk.

### Raised Blood Pressure

Raised blood pressure is estimated to cause about 7 million premature deaths throughout the world, and 4. 5% of the disease burden (64 million disability-adjusted life years (DALYs)) (86 - 88). It is a major risk factor for cerebrovascular disease, coronary heart disease, and cardiac and renal failure. Treating raised blood pressure has been associated with a 35-40% reduction in the risk of stroke and at least a 16% reduction in the risk of myocardial infarction (220). Raised blood pressure often coexists with other cardiovascular risk factors, such as tobacco use, overweight or obesity, dyslipidaemia and dysglycaemia, which increase the cardiovascular risk attributable to any level of blood pressure. Worldwide, these coexisting risk factors are often inadequately addressed in patients with raised blood pressure, with the result that, even if their blood pressure is lowered, these people still have high cardiovascular morbidity and mortality rates (221-223). Almost all clinical trials have confirmed the benefits of antihypertensive treatment at blood pressure levels of 160 mmHg (systolic) and 100 mmHg (diastolic) and above, regardless of the presence of other cardiovascular risk factors (220, 224). Observational data support lowering of these systolic and diastolic thresholds (225, 226). Several trials in patients at high cardiovascular risk (227-229) have confirmed these observational data, showing reductions in cardiovascular morbidity and mortality in people whose blood pressure is reduced to levels significantly below 160 mmHg systolic and 90 mmHg diastolic. These trials support the view that, in patients at high cardiovascular risk, with blood pressures in the range 140-160 mmHg (systolic) and 90-100 mmHg (diastolic), the treatment for such high-risk patients should begin at the lower blood pressure thresholds of even lesser than 160 mm systolic or 90 mm diastolic. There is also enough evidence that it is not only the diastolic level but that systolic BP level is also independently related to cardiovascular risk; in fact, as age advances, the level of systolic BP may be more important for CV risk than diastolic level. More details regarding the epidemiology, risk factors and prevention of hypertension are addressed in a subsequent chapter.

### Diabetes and Impaired Glucose Tolerance (IGT) / Impaired Fasting Glucose (IFG)

Cardiovascular disease accounts for about 60% of all mortality in people with diabetes. The risk of cardiovascular events is 2-3 times higher in people with type 1 or type 2 diabetes (230, 231) and the risk is disproportionately higher in women (230, 232). Patients with diabetes also have a poorer prognosis after cardiovascular events compared with non-diabetics (233, 234). Epidemiological evidence also suggests that the association between blood glucose and cardiovascular disease begins before diabetes manifests itself (233 - 237). The cardiovascular risk increases as glucose tolerance becomes impaired and then progresses to diabetes (338). Further, abnormal glucose regulation tends to occur together with other known cardiovascular risk factors, such as central obesity, elevated blood pressure, low HDL-cholesterol and high triglyceride level (239, 240). The Diabetes Control and Complications Trial (DCCT) (241) demonstrated that intensive treatment to ensure good glycaemic control substantially reduced the risks of cardiovascular events, neuropathy, nephropathy and retinopathy (242). The United Kingdom Prospective Diabetes Study (UKPDS) found that glycaemic control in people with type 2 diabetes reduced the frequency of microvascular complications, such as blindness, amputation, and end-stage renal disease (243). Each 1% increase in HbA1c level was associated with a 14% increase in the incidence of fatal or nonfatal myocardial infarction (244). A later study suggested that stringent blood sugar control in people with type 2 diabetes, combined with targeted reductions in blood lipids and blood pressure, reduced macrovascular events in diabetic patients with microalbuminuria (245). Good glycaemic control should be a key goal of treatment of diabetes, to delay the onset and progression of microvascular and macrovascular disease. The first approach to controlling glycaemia should be through diet alone, combined with physical exercise; if this is not sufficient, oral medication should be given, followed by insulin if necessary. Treatment should aim to achieve a fasting blood glucose level of 4-7 mmol/l (72-126 mg/dl); and an HbA1c level of 6. 5% or less. More details regarding the epidemiology, risk factors and prevention of diabetes type - 2 are addressed in a subsequent chapter.

### The Metabolic Syndrome (Syndrome 'X')

In 1988, The noted Diabetologist, Gerald Reaven had postulated that resistance to insulin action would occur mainly due to obesity, central obesity, physical inactivity, and possibly certain genetic reasons. Once insulin resistance developes, the body, in an effort to compensate, releases more and more insulin, resulting into fasting hyperinsulinaemia. Under the influence of this hyperinsulinaemia, there occurs a very unique and specific "clustering" of certain specific cardiovascular risk factors, namely, raised blood pressure, impaired glucose tolerance, and a unique dyslipidaemia manifesting with low HDL and raised triglycerides. This clustering was referred to as "Syndrome X" by Reaven (246) and it was postulated that once such clustering occurs, it is likely to be a major risk factor for development of IHD and Diabetes type -2. Large number of cinical and epidemiological studies over the past 2 decades have confirmed that the metabolic syndrome is, indeed, a reality. In fact, scientific evidence suggests that south Asians, especially Indians are likely to be at a high risk of developing this syndrome. Surveys among apparently healthy armed forces personnel have also revealed a substantial prevalence of almost 8% of this syndrome (32).

There are various defining criteria of this syndrome, of which the WHO criteria and ATP-3 criteria are the most widely used. The WHO criteria are (247) :

(a) Diabetes or IFG or IGT or evidence of insulin resistance (either of hyperinsulinaemia or

euglycaemic clamp glucose uptake in lowest 25%)

(b) **PLUS any two** of the following :

(i) Obesity as defined BMI > 30 or WHR > 0. 9 for males or > 0. 85 for females (>0. 80 for Indian females)

(ii) Hypertension as defined as blood pressure > 140 systolic or > 90 diastolic

(iii) Dyslipidaemia as manifested by triglycerides > 150 mg / dl or HDL < 35 mg / dl for males or < 40 mg / dl for females

(iv) Microalbuminuria defined as albumin excretion > 20 microgram albumin excretion / mt.

Hormone replacement therapy (HRT)

On the basis of data from observational studies (248), hormone therapy has been used for prevention of cardiovascular disease, osteoporosis and dementia. This practice has been called into question following publication of the results of several randomized clinical trials, which showed no coronary protection, and the Women's Health Initiative (249), which indicated that long-term use of estrogen plus progestin was associated with increased risks of cancer and cardiovascular disease. A Cochrane systematic review (250) of 15 randomized double-blind trials showed that the only statistically significant benefits of hormone therapy were decreased incidences of fractures and colon cancer with long-term use. In relatively healthy women, combined continuous hormone therapy significantly increased the risk of coronary events and venous thromboembolism (after one year's use), stroke (after 3 years), breast cancer (after 5 years) and gallbladder disease. Long-term estrogen-only hormone therapy also significantly increased the risk of stroke and gallbladder disease. In relatively healthy women over 65 years taking continuous combined hormone therapy, there was an increase in the incidence of dementia. Thus, HRT is not recommended as a preventive step against IHD, from public health point of view.

### The Effect of Multiple Risk Factors

All the leading CHD risk factors described above tend to act in a multiplicative mode when two or more are present (which, quite often, they are). This means that when multiple risk factors are present, their effect on increasing the coronary risk is not simply additive but rather "multiplicative" (in simple corollary, it is not 2+2+2 =6 but rather 2X2X2 = 8). Another aspect which must be kept in mind is that multiple risk factors, even if present in "moderate" quantum, tend to increase the coronary risk quite substantially, compared to when only one factor is present in high quantum. For instance, a person who is marginally obese (eg, BMI 25. 5), smokes 2 or 3 cigarettes a day, has a WHR which is marginally raised (e. g. , 0. 93), goes for brisk exercise only once a week, and has mild elevation of BP (eg, 150 / 96) would be having much higher overall risk than a person who smokes 10 cigarettes per day but has no other risk factor. This issue is important since we often tend to "condone" those who have mild elevations of multiple risk factors thinking that "moderation" is not bad !

**Box - 1 : Preventive strategies for IHD**

- Primordial Prevention
- Primary prevention
  - Population Strategy
    - ~ Mass Approach
    - ~ Targeted Group approach
  - Targeted High Risk Individual Strategy
- Secondary Prevention
- Tertiary Prevention

## Prevention and control of IHD

As said earlier, IHD is the prototype example of a serious, lifestyle disease. It needs to be addressed in a very concerted manner, by both, the medical functionaries as well as by Commanders / Administrators. The preventive strategies are summarized in Box - 1.

### Primordial prevention

The concept may sound "Utopian" to many, but it is a fact that certain countries / communities have been successfully adopting this strategy. The strategy can be used by those countries / communities where lifestyle has not, as yet, acquired the pattern associated with high CHD incidence and where the average level of critical risk factors is still favourable; however, economic advancements and changing life styles threaten to undermine this favourable situation and in these situations, we could take action to "prevent the very emergence of predisposing conditions, in countries and communities in which they have not yet appeared". This, in essence, is primordial prevention.

### Primary prevention

Primary prevention focuses on measures so that the pathological processes of IHD are either not initiated or else do not progress to develop into the disease. There are two mainstays of this approach : firstly, educating & motivating the individuals and communities with a view to achieve positive life style behaviour changes, and, secondly, supplementing these IEC (Information, Education and Communication) efforts by suitable socio-political, legislative and administrative steps. The ultimate objective is that individuals and communities live a healthy lifestyle, free of cornary risk factors. Primary preventive steps can be undertaken through two broad strategies, viz. , the "population approach" which focuses on large population groups, even the entire states or countries, and the "Targeted, individual, high risk strategy" which focuses on individuals who have a high probability of developing IHD, due to the presence of certain risk factors. The population approach can be of further two types, as follows :

"Mass Strategy"

Box-2 Key messages for I.E.C. : Primary prevention of IHD

- Eat a diet -
  - Just sufficient in calories
  - Total fats provide < 30% of calorie need
  - Saturated fats provide < 10% of calorie need
  - Trans-fatty acids to be eliminated from diet
  - Most dietary fat should be polyunsaturated (up to 10% of calories) or monounsaturated (10–15% of calories).
  - Refined sugars provide < 10% of calorie need
  - Salt consumtion (all sources) < 5 gm / day
  - Cholesterol < 200 mg / day
  - Low in gravied, fried, creamed and sugared food stuffs
  - Plenty of whole grains, cereals, legumes, beans & pulses
  - 400 to 500 grams fresh fruits / vegetables
  - Low fat dairy produce
- Undertake brisk walk every day, covering 2 miles (3.2 Km) in 30 to 35 mts daily; if you can exercise longer or at higher intensity, the better it is
- Supplement aerobic exercises (walking, running, cycling, sports) with light weught training and stretching exercises as yoga
- NO TOBACCO. If you don't use tobacco, don't start; if you do, stop.
- Avoid alcohol. If you must drink, not more than 3 small drinks s day for men (not more than 2 small a day for women); don't drive even after mild drinks; try not to drink daily.
- Regularly check your body weught and measure your waist and hip circumference; BMI should be kept at < 25 (preferably < 23) and waist < 90 cm or WHR < 0.90 for males (for females, < 80 cm or WHR < 0.80)
- Control and manage mental stress:-
  - Pray, meditate
  - Spend Quality time with family
  - Yoga
  - Manage your finances well
  - Exercise regularly
  - Look after health of yourself and family members
- Undergo periodic / annual medical examinations seriously; take precautions as told by your doctor
- If you have any symptoms of chest pain, fatiguability. Palpitation or breathlessness, seek medical attention.

**See further details in the chapter on healthy lifestyle in this section**

This focuses on large sections of populations, may be the entire District, state or even the country; in context of armed forces, IEC methods directed to the entire armed forces or a complete Division or Brigade would be an equivalent example. The strategy adopts a two pronged approach as follows :

(a) Education and Motivation by various IEC techniques, with a view to informing the community / population and to secure a healthy lifestyle change. The key issues of IEC are summarized in box - 2.

(b) Socio-political, administrative and legal actions to supplement the IEC steps, eg. , legislation and coercive steps against tobacco and alcohol; provision of gymnasia, playgrounds & walkways; encouragement for production of fruits and vegetables; subsidy on fruits and vegetables; administrative disincentives for obese persons; and so on.

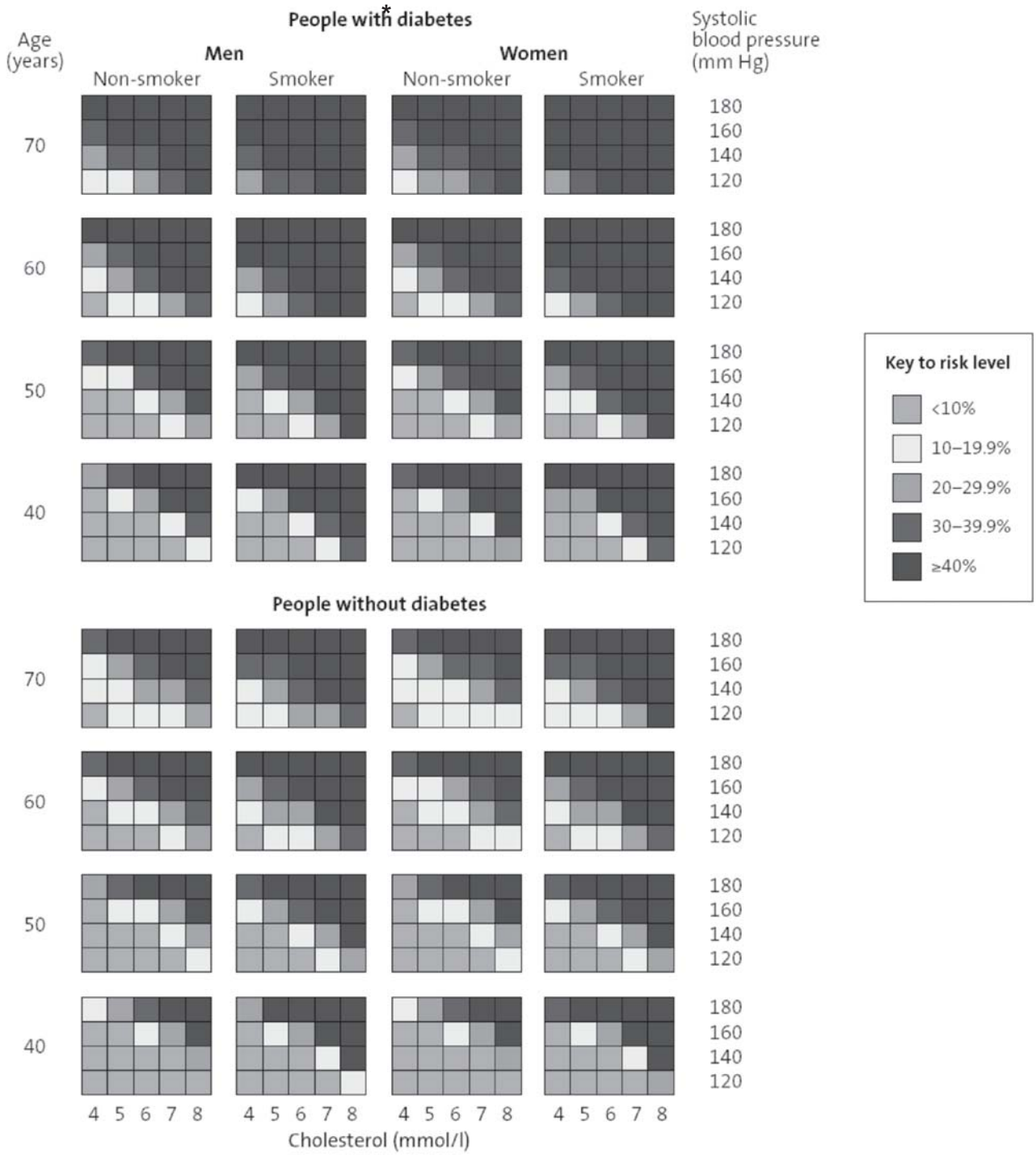
Targeted, "Group" strategy

This strategy focuses on the educational and motivational efforts, not on entire population or community, but rather on certain selected groups of persons who, due to certain characteristics, are at high risk of developing the coronary risk factors (e. g. , "newly rich" persons, executives, bureaucrats, businessmen; in the context of armed forces, JCOs / senior NCOs are an example), or people who can be of help in implementing the preventive programmes (e. g. , local leaders, policy makers, influential politicians and bureaucrats; in context of armed forces, senior commanders and senior functionaries of Wives Welfare Associations, Army School-Teachers), or, those groups who are in a "formative" stage and may develop healthy lifestyle if properly informed / motivated at this stage (e. g. , school & college children; in context of armed forces, Recruits, Cadets and school children of Army schools, Sainik Schools, and KVs).

Individual, high risk strategy

While population strategy is very effective in gradually bringing down the incidence of IHD in the total population, the process may be slow; secondly it relies on behavioural and lifestyle change by individuals which often may not easily happen, especially permanently. Therefore, the population strategy should be supplemented by the Individual High risk strategy, which aims at identifying those individuals, who have a higher probability of developing IHD, because of presence of certain major risk factors, so that concerted preventive as well as treatment efforts may be directed to these individuals. In the simplest form, when a doctor checks the age, sex, family history of IHD, BP and body weight of each of his adult patient, and educates / treats those who have a few of these risk factors, she is actually practicing the Individual High Risk Strategy.

Box - 3 : WHO Risk prediction chart for cardiovascular disease




* A person who has diabetes is defined as someone taking insulin or oral hypoglycaemic drugs, or with a fasting plasma glucose concentration above 7.0 mmol/l (126 mg/dl) or a postprandial (approximately 2 hours after a main meal) plasma glucose concentration above 11.0 mmol/l (200 mg/l) on two separate occasions).

Conversion factor for total Cholesterol is 1 mmol / l = 37.5 mg / dl

The recent advancement in this strategy in the development of "Individual Risk Prediction Charts" by the WHO for various regions of the world. (The chart applicable to Indian region is given on Box 3). Use of risk prediction charts to estimate total cardiovascular risk is a major advance on the older practice of identifying and treating individual risk factors, such as raised blood pressure (hypertension) and raised blood cholesterol (hypercholesterolemia). The total risk approach acknowledges that many cardiovascular risk factors tend to appear in clusters; combining risk factors to predict total cardiovascular risk is consequently a logical approach to deciding who should receive treatment. Risk scoring moves the focus of treatment from the management of individual risk factors to the best means of reducing an individual's overall risk of disease.

In the charts, the subjects are first of all divided into diabetic or non-diabetic. Within each of this category, the subjects are divided according to tobacco use (users or non users), age and sex. Thereafter, the subject is evaluated as per his / her Systolic BP and Total Cholesterol level, and the level of CHD risk is directly read from the chart. The risk, technically, indicates the probability that the given individual is likely to develop IHD in the next 10 years. In general, < 10% risk is equivalent of low risk (low risk does not mean "NO RISK"); 10 - 20% : modearte risk, 20-30% high risk; and > 30% very high risk.

It may be mentioned that if a person has clear history of having suffered from IHD or has clear family history then the person is to be taken as "high risk" irrespective of the score obtained in this chart. Once the person has been evaluated on the chart, the action to be taken is as per guidelines given in Box - 4

**Secondary Prevention**

Early detection of CHD at the incipient stage is quite relevant. The available tools are firstly, resting ECG using Minnesota code criteria for coronary insufficiency, a method which has been used in epidemiological surveys, but has low sensitivity and specificity for individual prediction. Secondly, a combination of Rose questionnaire which taps symptoms of angina on effort and resting ECG can be used. Better predictive values are obtained with exercise ECG, either alone or in conjunction with echocardiography. Exercise ECG however carries some risk and should be undertaken in presence of a physician. All these screening procedures will give better predictive value if used in high risk populations, as middle aged, obese, having hypertension or impaired glucose tolerance or dyslipidaemia. The most important practical aspect is to keep a high index of diagnostic suspicion and

**Box - 4 Actions to be taken after evaluation of the person on the risk chart**

- All persons, irrespective of risk category should be educated and motivated for healthy lifestyle change, as per box given above.
- Antihypertensive treatment : indvls with sustained BP readings > 140 / 90 mmHg : if risk category 1 or 2, continue lifestyle changes; if category – 3 give lifestyle changes but if despite lifestyle changes for 4 to 6 months BP is > 140 / 90mmHg, give treatment starting with a thiazide like diuretic or ACE inhibitor or calcium channel blocker or beta blocker. Indvls in risk category – 4 with BP > 130 / 90mmHg - start drug treatment alongwith lifestyle changes. All individuals with blood pressure at or above 160/100 mmHg, or lesser degree of raised blood pressure with target organ damage, irrespective of risk category, should definitely have drug treatment and specific lifestyle advice.
- Anti-diabetic drugs : Individuals with persistent hyperglycaemia of fasting > 6 mmol / l (110 mg / dl) should be given hypoglycaemic drugs irrespective of risk category
- Lipid lowering treatment (use statin) : Risk category 1 and 2, advise healthy lifestyle; category 3 : If despite lipid lowering diet, TC > 200 mg/dl or LDL > 120 mg/dl consider a statin alongwith lifestyle advise; category – 4 along with lipid lowering diet, give statin to lower TC to < 200 mg/dl and LDL to < 120 mg/dl. If TC > 320mg/dl, give statin irrespective of risk category.
- Antiplatelet drugs : consider low dose aspirin only in case of category – 4.

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# Diabetes Mellitus

**Definition / Identification**

Diabetes Mellitus is defined as a metabolic abnormality characterized by hyperglycaemia and disturbances of carbohydrate, fat and protein metabolism that are associated with absolute or relative deficiency in insulin secretion and / or insulin action (251). When fully evolved, it is characterized by fasting hyperglycaemia but it can also be characterized in the less overt stages and before fasting hyperglycaemia appears, most usually by the appearance of glucose intolerance. Most often, it tends to be asymptomatic ("silent killer") in which case the diagnosis depends on biochemical investigations. (252).

**Classification**

Diabetes mellitus consists of a group of metabolic disorders which have been classified by a WHO expert group as given in Table - 1 (251)

IDDM (now called Type -1 Diabetes or T1D)

IDDM comprises 5 to 10% of all diabetes. It is due to absolute insulin deficiency as a result of pancreatic beta cell destruction. It is characterized by abrupt onset of severe symptoms, proneness to ketosis and presence of one or more of the classical symptoms (polyuria, polydypsia and polyphagia). The age at clinical onset or diagnosis is usually below 30 years. All patients of this type need exogenous insulin for survival. Blood glucose levels are unequivocally elevated and glucose and ketones are usually present in urine.

NIDDM (now called Type – 2 Diabetes or T2D)

NIDDM forms the majority of the problem from lifestyle and non-communicable diseases point of view, comprising 85 to 90% of all diabetes cases. For the purpose of this chapter, the focus will be on T2D. The disease takes a very silent course and is quite often detected on a routine urine or blood screening test, with diagnosis being often made after 40 years age. It has a strong genetic (family history) component. In addition, obesity is frequently associated with T2D, though in developing countries, many of the subjects with T2D may not be obese if we go simply by weight for height standards.

IGT and IFG are progressive stages of the same disease of which T2D represents to most severe form. Both IGT and IFG are themselves a strong risk factor for future occurrence of diabetes. Proper lifestyle management (Diet, Exercise and Weight reduction) prevents progression to the later stage. In the natural course, about one-thirds each of IGT subjects will develop diabetes, or remain as IGT or revert back to normal. The microangiopathic complications (Retinal and Renal) which are characteristic of diabetes are rare in IGT; however, there is increased occurrence of atherosclerosis in IGT as compared to normal people.

MRD (Malnutrition Related Diabetes)

In developing countries in the tropics, young people with diabetes may present with a constellation of clinical features including onset usually below 30 years age, average or low body weight (BMI < 30) moderate to severe hyperglycaemia, usually non-proneness to ketoacidosis unless there are precipitating conditions as infections, the requirements of large dose of insulin for metabolic control and frequently a history of malnutrition in infancy and early childhood. The term "MRD" has been assigned to this syndrome.

**Diagnostic Criteria**

The diagnostic criteria, as enunciated by the American Diabetic association (ADA) and duly agreed by the WHO

Table 1 : Classification of Diabetes Mellitus

<table>
<tr><th colspan="8">A.Clinical cases</th><th rowspan="2" colspan="2">B. Statistical Risk classes<br>(Subjects with normal glucose tolerance but substantially increased risk of developing Diabetes)</th></tr>
<tr><td colspan="5">(i) Diabetes mellitus</td><td colspan="3">(ii) Impaired glucose tolerance (IGT) and impaired fasting glucose</td><td>(iii) Gestational diabetes mellitus (GDM)</td></tr>
<tr><td rowspan="2">Insulin Dependant Diabetes Mellitus (IDDM, Type - 1)</td><td colspan="2">Non Insulin Dependant Diabetes Mellitus (NIDDM, Type- 2)</td><td rowspan="2">Malnutrition Related Diabetes (MRD)</td><td rowspan="2">Other Types of Diabetes (associated with certain diseases as pancreatic disease, hormonal, drug induced etc.</td><td rowspan="2">Non - Obese</td><td rowspan="2">Obese</td><td rowspan="2">Associated with certain diseases</td><td rowspan="2"></td><td>Previous abnormality of glucose tolerance</td><td>Potential abnormality of glucose tolerance</td></tr>
<tr><td>Non – Obese</td><td>Obese</td><td></td><td></td></tr>
</table>

Table - 2 : Diagnostic criteria for Diabetes Mellities, IGT& IFG

| Diabetes Mellitus | | IGT | IFG | |
|---|---|---|---|---|
| Plasma | Whole blood | Plasma | Plasma | Whole blood |
| Fasting >= 126 OR 2 hrs PP >= 200 | Fasting >= 110 OR 2 hrs PP >= 180 | Fasting < 126 AND 2 hrs PP >= 140 but < 200 | Fasting >= 110 but < 126 | Fasting >= 100 but < 110 |

**Notes :-**

- All value shown above indicate glucose levels in mg / dl
- 2 hrs PP value are after 2 hrs of 75 gms glucose orally in 250 – 300 ml water
- ADA has recently recommended downgrading the criteria of IFG to 100 mg / dl from above mentioned 110 mg. The

are as given in Table - 2 (253, 254).

### Complications of Diabetes

Diabetes owes it's importance to the fact that it is a silent killer. It leads to a large number of serious sequelae which are disabling, besides drastically reducing the quality of life. The complications / sequelae are listed in Box - 1.

Box - 1 : Sequelae / Complications of diabetes

**Acute**

- Hypoglycaemia
- Hyperglycaemia and Ketoacidosis
- Infections (especially fungal infections of skin and mucous membranes, urinary infections, anaerobic infections of deep tissues, mybacterial infections).

**Chronic**

- Atherosclerosis, manifesting in cerebrovascular and coronary artery disease.
- Diabetic eye disease (Retinopathy, cataract)
- Diabetic Kidney Disease
- Diabetic Neuropathy (peripheral as well as autonomic neuropathies)
- Foot Ulceration and infections

It needs to be noted that presence of diabetes carries a very high risk for IHD (RR of 3. 5 to 4 times). In addition, diabetes frequently co-exists with other coronary risk factors as hypertension, dyslipidaemia, obesity & metabolic syndrome.

### Magnitude of the problem

As per estimates of WHO, the number of people affected worldwide with diabetes were approximately 125 million which are expected to be almost 300 million by 2025. (255). The incidence is peculiarly high among populations living in Nauru islands and among Pima Indians of USA where the prevalence may be as high as 40 to 50%. In developed, induatrialized countries, prevalence rates of as high as 10 to 20% may occur(251). India has the unfortunate privilege of being the "Diabetes capital" of the world. The prevalence rates have been estimated to be 12% in urban areas and 4% in rural areas. More concerning is the fact that diabetes prevalence over the past 4 decades has increased fourfold (89). Another interesting phenomena is that Indians who migrate to affluent countries develop very high prevalence rates of 10 to 20%, indicating the high racial predisposition that Indians and other south asian populations have for diabetes, and which gets expressed whenever we get affluent conditions (251).

### Determinants

### Risk Factors for Diabetes

The two most important determinants of diabetes are firstly, genetic background (family history) and secondly, obesity. It has been very aptly said that for diabetes, "genetics loads the cannon and obesity finally fires it". As for IHD, the risk factors may be grouped as "Non-Modifiable" (Age, Sex, Genetic and Racial factors) and "Modifiable" (Obesity, physical activity, nutritional factors, stress, drugs, infections and chemical toxins, etc).

Genetic factors

NIDDM shows strong family aggregation. Twin studies and familial studies have provided firm evidence that the role of genetic factors is relatively high. Till now, no specific genetic marker has been identified, though some have been proposed. With the current status of knowledge, it seems that diabetes is a "polygenic" disease and not possibly due to defect in a single gene. History of diabetes among parents, grandparents and first degree relatives predisposes a person to high risk of developing diabetes.

Age

Increasing age increases the risk. Most cases are detected during the middle age.

Sex

There is no clear difference between sexes as regards the risk of diabetes.

Race

Some races are known to be at high risk as Polynesians, Eskimos, Pima Indians, etc. The possibility is also strong that south asian populations including Indians may be at high risk. One hypothesis is that this may be due to the effect of "thrifty genes". These genes developed as a part of nature's protective mechanisms, among populations who were, for many centuries, exposed to starvation, famines and lack of food. The thrifty gene developed to conserve whatever small amount of energy, which was available to such populations, in the form of body fat

stores. However, with economic improvements in such populations, the food supply improves greatly but the protective effect of thrifty gene also continues resulting into excessive levels of obesity and consequent diabetes.

Obesity

Obesity has been proven to be a very strong risk factor for diabetes type 2. the estimates of risk vary from RR of 1. 8 to 3. 2 in different populations. The role of obesity is independent of racial factors. In addition, central distribution of body fat (referred to as central, abdominal, visceral, apple-shaped or android type of fat distribution and measured in terms of waist circumference or Waist hip ratio) is upheld to be an important risk factor, independent of total body weight.

Physical inactivity

It has been clearly demonstrated that physical inactivity decreases insulin sensitivity. The risk of diabetes due to physical inactivity has been estimated to be as high an RR of 4. 31 in some large scale studies. The protective effect of physical activity is independent of obesity; this means that an obese person who is physically active and fit would have lower risk of diabetes (as well as lower risk of other life style diseases) than a normal weight person who is physically inactive and unfit. In addition, physical activity will also assist in keeping the body weight under control.

Nutritional factors

There is increasing evidence form both epidemiological as well as laboratory studies that increased dietary intake of saturated fat and decreased intake of fibre can result in lowered insulin sensitivity and impairment of glucose tolerance. In general, reduction in the overall calories, reduced intake of saturated fats & refined sugars and increased intake of grains, fruits and vegetables would be of utility in preventing diabetes.

Foetal and early childhood Influences

There has been increasing evidence (Barker's Hypothesis) that poor maternal nutrition during pregnancy and malnutrition during early infancy may be associated with insulin resistance, obesity, impaired glucose tolerance, raised blood pressure and occurrence of metabolic syndrome in the same person during his / her adult life. This underlines the value of ensuring adequate nutrition during pregnancy and during early childhood.

Stress

Several states of physical stress and trauma can lead to glucose intolerance through altered hormonal mechanisms but whether they can permanently lead to diabetes is not established. Similarly, the role of mental and social stress as contributory factor in diabetes mellitus has been suggested but remains unproven.

Drugs and Hormones

Phenytoin, diuretics (especially thiazides), beta blockers, corticosteroids and certain contraceptive steroids may, in susceptible persons induce glucose intolerance or even diabetes, but this usually resolves after withdrawl of the drug.

## Prevention and control

The broad strategy for prevention and control of diabetes will remain the same as that outlined for IHD earlier, including primary, secondary and tertiary levels of prevention.

### Primary prevention

Primary prevention would basically utilize the Information, education and Communication (IEC) strategy to educate and motivate the community and individuals. The key messages for IEC will remain the same as have been outlined for prevention of IHD in the earlier chapter. Primary prevention will, as for IHD, include the population strategy, educating both, the general community (mass approach) and specific groups (group approach) as outlined for prevention of IHD. Similarly, the primary prevention steps would also include the "individual high risk strategy", focusing on individuals who have strong family history of diabetes mellitus, who are changing from active to more leisurely lifestyle (as the JCOs / NCOs), are obese, have evidence of IFG or IGT, have other cardiovascular risk factors as hypertension and dyslipidaemia, and women who have history of Gestational DM or history of giving birth to babies weighing > 4kg.

### Secondary Prevention

This would be through early diagnosis and prompt treatment, mainly by way of screening programmes. The strategies could be either "population screening" by screening the entire population or a selected random sample, which is fruitful only if the prevalence of diabetes is very high or else for research or health planning purposes. Secondly, it could be a "selective screening" undertaken in groups of people known to be at high risk, as those with family history, obese persons (BMI > 25), aged more than 40 years in high prevalence populations, women giving history of GDM, those with history of IGT / IFG, or those with hypertension or dyslipidaemia. Thirdly, it could be an "Opportunistic Screening" employed when high risk individuals come in contact with the Doctor, eg obese person, hypertensive, having IHD, having family history, etc, once such a person reports sick.

### Tertiary Prevention

The role of Doctors as well as paramedical personel assumes importance in context of tertiary prevention – to follow up the patient, to advocate continuous treatment, to educate the patient about importance of treatment and the various precautions to be taken by them. The key issue to be kept in mind are outlined in Box - 2.

**Box - 2 : Key issues for tertiary prevention**

- Keep a follow up of the patient of diabetes
- Reassure about the possibility of leading a near normal life, with proper treatment and precautions
- Educate about
  - Do not miss the antidiabetic medicines
  - Do not miss the meals
  - Diabetic identification card
  - Carry some sugar or lozenges for any hypoglycaemic emergency
  - Foot care, footwear and daily inspection
  - Early identification of complications
  - Regular physical exercise, diet, no tobacco, avoid

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# Systemic Arterial Hypertension and Stroke

### Definition / Identification

Systemic arterial hypertension is defined as a state of chronically elevated arterial blood pressure, as compared to what is normally expected in context of the age of an individual.

### Levels

It needs to be noted that blood pressure is a "continuous" variable and hence it may be scientifically difficult to draw a arbitrary cut-off line to delineate normal from raised blood pressure; e. g. , blood pressure level of 130 / 86 would carry a higher risk for cardiovascular and other morbidity as compared to 120 / 80, though both would fall in the category of "normotensive". However, for the purpose of epidemiological, clinical and public health needs, the following is the categorization of hypertension, based on systolic and diastolic levels. This classification is based on the recent guidelines of WHO & ISH and from JNC - VII (256, 257) (Table - 1):

Table - 1 : Classification of Hypertension

| Grade | Systolic level (mm Hg) | | Diastolic level (mm Hg) |
|---|---|---|---|
| Normal | < 120 | AND | < 80 |
| Pre-hypertension | 120 to 139 | OR | 80 to 89 |
| Hypertension Grade - I | 140 to 159 | OR | 90 to 99 |
| Hypertension Grade – II | 160 to 179 | OR | 100 to 109 |

The above classification is a clear departure form the earlier WHO classification in which Blood pressure levels of 140/90 mmHg and above were taken to qualify as hypertension (258), since in this report even those with levels between 120 to 139 mmHg systolic and 80 to 89 mmHg diastolic have also been classified as "prehypertensive" thereby emphasizing the importance of concerted "lifestyle" modification and public education efforts for this group also.

### Classification

Hypertension can be classified in 3 different ways, as follows :

(a) **According to the level of blood pressure** : this has been described in the above table.

(b) **According to identifiable cause, if any**

About 5 to 10% of the cases of hypertension will have some identifiable cause for the raised BP. This is called as "Secondary" hypertension. Important causes of secondary hypertension are given in Box - 1.However, 90 to 95% cases will not have any identifiable cause; these are called as "primary" of "essential" hypertension. Certainly, the word "essential" gives an impression that these persons have to have raised BP, which is not correct; there is nothing like "essential" and most of these cases will also become normotensive with proper lifestyle changes.

(c) **According to the extent of target organ damage.** The various types of target organ damage that can be caused by raised BP are as given in Box - 1 (258, 259).

Box 1

**Causes of secondary hypertension**

- Induced by exogenous substances or drugs (Hormonal contraceptives, corticosteroids, sympathomimetics, cocaine, Tyramine containing foods & MAO Inhibitors, NSAIDS)
- Secondary to Renal Disease (Renal parenchymatous disease, Renovascular hypertension, Renin producing tumours)
- Associated with endoctine disorders (Acromegaly, thyroid disease, adrenocortical diseases, carcinoid tumours)
- Pregnancy Induced
- Coarctation of Aorta

**Target organ damage due to hypertension**

- Heart : IHD, LVH, Heart Failure
- Brain : Stroke, TIC
- Chronic kidney disease
- Peripheral arterial disease

### Hypertension as a risk factor for diseases

For purposes of public health and preventive medicine, hypertension and stroke are considered together since at the large population level, the major cause of stroke is raised blood pressure and efforts to prevent hypertension will pay a rich dividend for prevention of stroke. At the individualized clinical level, of course, there would be other causes of stroke that naturally, would need consideration.

Hypertension, like diabetes, is often referred to as "silent killer". For most of it's course, it produces hardly any signs / symptoms by itself; however, it damages the end organs substantially (cardiovascular system, Kidneys and Retina). Epidemiological estimates from large scale studies indicate that subjects with DBP of 105 mmHg have a ten times increased risk of stroke and five times more risk of IHD compared to subjects having DBP< 80 mmHg. Prolonged reductions in DBP by 5, 7.5 and 10 mmHg are respectively associated with at least 34%, 46% and 56% reduction in risk of stroke and at least 21%, 29% and 37% reduction in risk of coronary events (260).

It also needs to be clearly noted that both systolic as well as diastolic BP are important from the morbidity and mortality point of view. In fact, after 55 years age, SBP may become even more important than DBP from preventive point of view. Raised SBP has been associated with a higher RR of CHD, stroke, CCF, Renal disease and overall mortality. In the follow up of MRFIT trial, as compared to subjects with SBP < 120mmHg and DBP < 80mmHg, the RR of coronary events was 3.23 times higher for those with isolated diastolic hypertension (DBP > 100 mmHg with normal systolic, i. e. , < 140mmHg); the RR was 4.19 times for those with isolated systolic hypertension (SBP > 160 mmHg with DBP < 90 mmHg); and 4.57 times among those who had both, i. e. , SBP > 160mmHg and DBP > 100mmHg (261). Besides stroke and IHD, hypertension also substantially increases the risk of Congestive cardiac failure (CCF) by 2 to 4 times, and of end stage renal disease by 1.65 times (261, 262). Another important aspect to be remembered is that although raised blood pressure is independently associated with an increased risk of cardiovascular events, the risk is substantially increased by the presence of other risk factors namely smoking, dyslipidaemia and diabetes. Thus, equal blood pressure levels would carry different risks when associated with different combinations of risk factors and that too, at different levels. Therefore, raised blood pressure should not be seen in isolation but as a part of the overall, total cardiovascular risk assessment for the individual (263).

### Magnitude of the problem

#### World-wide

Hypertension affects approximately 50 million individuals in the United States and approximately 1 billion worldwide. As the population ages, the prevalence of hypertension will increase even further unless broad and effective preventive measures are implemented. Recent data from the Framingham Heart Study suggest that individuals who are normotensive at age 55 have a 90 percent lifetime risk for developing hypertension (264). The crux of the issue is that hypertension is now a major public health problem in all parts of the world (265 – 272). When cut-off values of 160 mmHg SBP and 95 mmHg DBP are taken, in most of the adult populations in the world, the prevalence comes to 10% to 20%. If cut off levels are lowered to the standard values of 140 mmHg SBP and 90 mmHg DBP, the prevalence would go up further, possibly to 25% to 30% of adult population (258).

#### Indian situation

In our country, prevalence of hypertension has been estimated to be between 20% to 40% in urban adults and 12% to 17% in rural adults. The estimated number of Indians with hypertension was 120 million in year 2000, which is likely to expand to 200 million by 2025, with equal numbers among men and women. (89).

#### Armed forces

Hypertension has been showing a gradual but consistently increasing trend, which needs to be adequately tackled. The data has been presented in the first chapter of this section.

### Determinants (Risk factors)

As for other lifestyle diseases, the risk factors for hypertension can be grouped as modifiable and non-modifiable.

### Non-Modifiable risk factors

#### Age

All studies have demonstrated a positive association between age and blood pressure (273). SBP increases consistently till almost the seventh or eighth decade, while DBP increases till fifth decade, becoming stationary thereafter, leading to an increase of pulse pressure and increased incidence of systolic hypertension in the elderly. However, the age related rise in blood pressure is not an inevitable phenomena of nature since in some isolated populations with very low habitual salt intake, the blood pressure does not increase with age, indicating that with controlled salt intake, the rise of blood pressure can be checked, despite ageing.

#### Sex

In childhood there is no difference in BP, between sexes; from adolescence onwards, the average BP is higher in males. However, this difference narrows down after women attain the age of 50 years, and thereafter, may even get reversed (273).

#### Heredity

Family history of elevated blood pressure is a strong risk factor for future development of hypertension.

#### Genetic factors

The genetic basis of high blood pressure has been well supported by experimental research, and while some monogenic hypertensive disorders in humans have been described (eg, ACE-II and angiotensinogen gene polymorphism), for the most part, hypertension is currently regarded to be a “polygenic” condition.

#### Ethnicity

Black races have been described to be having higher risk of hypertension; whether this is due to certain racial factors or else due to socio-cultural differences between black and white races is not clear. More recent research indicates that south asian populations including Indians, may be more predisposed to developing hypertension and metabolic syndrome.

### Modifiable risk factors

#### Dietary salt

There is substantially convincing evidence that dietary salt intake over and above the physiological requirements, is a strong risk factor for hypertension. It has been estimated that a 100 mmol per day lower intake of sodium over the lifetime would result in 9 mm smaller rise in SBP between 25 to 55 years of age; this would translate to a reduction in mortality by 16% in IHD, 23% for stroke and 13% deaths from all causes. Well established public health recommendations indicate that dietary salt

consumption, from all sources should not exceed 5 to 6 grams a day for an adult (274, 275).

### Dietary Potassium

In contrast to sodium, dietary potassium is protective. More precisely, it is the ratio of sodium to potassium which is more relevant. Thus, at a given level of dietary salt intake, blood pressure could be lowered by increasing the potassium intake. The case is therefore quite strong to encourage consumption of fresh fruits and vegetables (400 to 500 grams per day for an adult), which are rich sources of potassium (275, 276).

### Other macro and micro-nutrients

The role of saturated fats, dietary cholesterol, fibre (protective), antioxidant vitamins (protective), dietary calcium (increased intakes are protective) have all been postulated, though there is still no convincing evidence. However, keeping in view the fact that these nutrients have been shown to have a role in other lifestyle disease as IHD and diabetes, it would be desirable to adhere to the healthy lifestyle recommendations, in totality.

### Overweight

There is strong and consistent evidence that overweight / obesity is associated with hypertension, with the RR being 2 to as much as 6 times. The proportion of hypertension attributable to obesity has been estimated to be 30 to 65% in western countries. It is also estimated that for 10 Kg increase in weight (with all other risk factors held constant) the SBP would increase by 2 to 3 mm and DBP by 1 to 3 mm (277). Besides obesity, central obesity due to excessive intra abdominal (visceral) fat, as measured by waist circumference or WHR has been clearly shown to be a risk factor for hypertension, independent of whether generalized obesity is present or not. Hypertension and obesity / central obesity, in addition, are factors which cluster together in metabolic syndrome.

### Lack of physical activity

It has also been convincingly demonstrated by epidemiological and clinical data that physical inactivity is an important risk factor for hypertension. Sedentary and unfit normotensive individuals have 20% to 50% increased risk of developing hypertension in the next few years as compared to their fit and more active peers (278). WHO estimates indicate that the RR for developing hypertension due to physical inactivity is between 1.2 to 2.9, in different research studies.

### Alcohol

Alcohol consumption has been consistently related to blood pressure in different epidemiological studies. The risk effects are independent of obesity, central obesity, physical inactivity, age, sex and smoking. The RR of alcohol for causing hypertension has been estimated to be 1.4 to as high as 4.1, depending on the quantity and regularity of alcohol consumption (WHO global estimates). When 2 or more drinks are consumed daily, SBP increases by 1 mm and DBP by 0.5 mm on an average; daily drinkers have SBP and DBP levels which are higher by 6.6 mm and 4.7 mm respectively compared to those who drink only once a week (275, 279).

### Tobacco use

Tobacco use and hypertension, when present together, interact and greatly increase the cardiovascular risk compared to when either of them would have been alone. The direct risk of tobacco in causing rise in blood pressure is not very clear. However, WHO global risk estimates indicate that the RR of hypertension due to tobacco use is 1.17 times higher.

### Psychosocial stress

There is evidence that acute mental stress causes an increase in blood pressure. There is, however, not enough evidence to prove that long term stress causes chronic increase in blood pressure. Overall, the available evidence is insufficient to allow for definite conclusions of causality; methodologically sound research is required in this area. Nonetheless, stress management techniques would be of help in controlling acute stress and acute increases in blood pressures.

### Early childhood experiences

The “Barkers Research Group” has undertaken a large amount of research in various settings and strongly hypothesized that foetal malnutrition (as evidenced in form of low birth weight) and malnutrition during infancy and early childhood may be a strong risk factor for subsequent development of hypertension, diabetes, obesity, dyslipidaemia and metabolic syndrome in later adult life (280). These observations raise interesting possibilities of ”foetal programming”. The findings need to be substantiated by prospective studies.

### Tracking

The phenomena of “tracking” means that the level of risk factors during childhood and adolescence tends to track into the youth and late adulthood also. Thus, children who have higher levels of body weight, blood pressure, blood glucose and cholesterol, will tend to have the same level of these parameters during adulthood also. For example, in one of the large epidemiological studies, people in their 40’s with elevated BP as a group, had higher blood pressure readings than normal at the age of 7 years (281).

### Other environmental factors

Exposure to noise, air pollution and water pollution have all been implicated as a risk factor for hypertension, but no concrete epidemiological evidence is still available. Protection of public against environmental hazards is, in any case, a worthwhile public health measure.

### Increased heart rate

It has been noted in studies that resting heart rate of hypertensives is higher than normotensives. Whether hypertension leads to raised heart rate, due to haemodynamic adjustments or else, whether increased heart rate is a marker for prediction of hypertension, is not still clear.

### Low socio-economic status

In a number of populations in developed countries,

consistently higher levels of BP and a higher prevalence of hypertension have been noted in lower socio-economic groups. Contrarily, in those countries whose economies are improving, higher prevalence is seen in higher socio-economic groups. Thus, in developing countries, the higher prevalence in higher socioeconomic strata probably represents the initial stages of the epidemic of cardiovascular diseases; as the epidemic advances in these countries, there is likely to be a reversal of the social groups affected.

White coat hypertension

Measurement of BP by a doctor, may raise the concern and lead to a rise in BP in the subject, a phenomena called as white coat hypertension. It is therefore important to reassure the subject, and take the blood pressure in a relaxed state.

## Prevention and control of hypertension

Prevention and control of hypertension is addressed as per the same strategies, as has been discussed for IHD and diabetes.

### Primary Prevention

This would be by utilizing the mass approach or the group approach. The strategy utilizes the IEC approach to educate the community (mass approach) of the dangers of hypertension and the fact that it is a silent killer and most of the times the patient may not have any outward symptoms but the disease may progress. Education should be provided as regards the risk factors and adoption of healthy lifestyle to prevent the onset or progress of the disease. Education would also be directed towards specific groups (group approach) as outlined for prevention of IHD. Similarly, the primary prevention steps would also include the "individual high risk strategy", focusing on individuals who have strong family history of hypertension, who are changing from active to more leisurely lifestyle (as the JCOs / NCOs), are obese, or are likely to be physically inactive (as office workers).

### Secondary Prevention

This would be through early diagnosis and prompt treatment, mainly by way of screening programmes. The strategies could be either "population screening" by screening the entire population or a selected random sample, which is fruitful only if the prevalence of hypertension is very high or else for research or health planning purposes. Secondly, it could be a "selective screening" undertaken in groups of people known to be at high risk, as those with family history, obese persons (BMI > 25), aged more than 40 years in high prevalence populations, or those with diabetes or dyslipidaemia. Thirdly, it could be an "Opportunistic Screening" employed when high risk individuals come in contact with the Doctor, eg obese persons, diabetics, having IHD, having family history, etc, once such a person reports sick. Since measurement of blood pressure is a very simple, inexpensive and non-invasive procedures, it would be a very fruitful step if all medical persons make it a point to measure the blood pressure of all adult patients who come to them, irrespective of the presenting symptoms.

### Tertiary Prevention

The role of doctors as well as paramedical personel assumes importance in context of tertiary prevention – to follow up the patient, to advocate continuous treatment, to educate the patient about importance of treatment and

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# Cancers

### Definition / Identification

The term cancer encompasses a very wide variety of heterogenous disorders occurring in different parts of the body, with very different clinical manifestations. However, there is a special reason for grouping such diverse diseases under a single heading. The reason is that cancers, as they are defined, are "Group of heterogenous disorders characterized by Clonality (arise from a single stem cell that clones into carcinomatous cells), Autonomy (the cell division and growth is uncontrolled), Anaplasia (lack of cell differentiation) and Metastasis (distant spread)". It is these common features that bind cancers into a single entity for the purpose of description. Secondly, various cancers, despite their diversity in clinico-pathological manifestations, have some risk factors in common, a phenomena that again binds them together and can be fruitfully utilized for the purpose of prevention. As we shall see in the course of this chapter, these common risk factors are primarily a reflection of unhealthy lifestyle and hence, the contemporary saying is that cancers are, by and large, diseases of unhealthy lifestyle and are potentially preventable.

### Magnitude of the problem

Cancers reflect a major load on human health by way of morbidity, mortality and, above all, human suffering.

**Worldwide,** approximately 10 million new cases and more than 6 million deaths (12% of all deaths) occur due to cancers every year, as per estimates for the year 2000.It is estimated that more than 22 million people would be living with cancers, worldwide at any given point of time (282). These figures represent an increase of around 19% in incidence and 18% in mortality since 1990.In terms of incidence, the most common cancers worldwide are lung (12.3% of all cancers), breast (10.4%) and colorectum (9.4%). Lung cancer is the largest single cancer in the world (1.1 million annually). The top three causes of death from cancer are those of the lung (17.8% of all cancer deaths), stomach (10.4%) and liver (8.8%). Developing countries contribute to more than half of the total cancer cases worldwide. By 2020, the new cases are expected to reach at least 15 million a year and deaths 10 million. The projection of new cases of cancer per year, for 2020, is 6 million and 9.3 million respectively from developed and developing countries.

**In India,** approximately 8 lakh new cases of cancers are expected to occur every year (89). Large majority of these are tobacco related and hence potentially preventable. It has been estimated that 48% of cancers among men and 20% in women are due to tobacco. Cancer incidence in India is estimated to be around 70 – 90 per 100, 000 populations with 700, 000 – 900, 000 new cases of cancer every year. If survival is taken as three years on an average, at any given time there will be about 2, 500, 000 cancer patients in the country, In 2000, five and a half lakh deaths in the country were due to cancer. The commonest cancers in men are those of lungs, stomach, oral cavity and oesophagus, while in women, those of cervix uteri, breast, oral cavity, ovary, oesophagus and stomach are the commonest.

In India, a network of cancer registries was started across the country under the National Cancer Registry Programme (NCRP). There are at present six population based cancer registries(PBCRs) (five urban and one rural) and five hospital based registries (HBCRs) generating data on cancer in the country under NCRP. The details of national cancer registries are given in the section on national health programmes.

### Problem in Armed Forces

The hospital admission rates due to cancers per 1000 serving personnel from 2000 onwards are given in Table - 1. However, the data needs to be interpreted with caution since armed forces reflect a "young" population, with large majority of the personnel retiring before 50 years age; hence hospital admission rates due to cancer among serving personnel may not correctly reflect the magnitude. Hence, what is very important for the armed forces medical officers is to impress on the commanders and personnel, the need to follow "healthy lifestyle" which will go a long way in preventing not only cancers, but also other serious problems as IHD, diabetes and hypertension also.

Table - 1 : Hospital admissions / 1000: Neoplasms

| Year | Army | Navy | Air force |
|---|---|---|---|
| 2000 | 0.43 | 0.56 | 0.24 |
| 2001 | 0.64 | 0.72 | 0.17 |
| 2002 | 0.94 | 1.82 | 0.32 |
| 2003 | 0.85 | 0.51 | 0.30 |
| 2004 | 0.92 | 0.77 | 0.39 |
| 2005 | 1.06 | 0.78 | 0.35 |
| 2006 | 0.95 | 1.00 | 0.31 |

### The major risk factors for Cancers

Tobacco

Tobacco smoking is the main known cause of human cancer-related deaths worldwide. An increase in risk of lung cancer (relative to a non-smoker) is consistently evident at the lowest level of daily consumption, and is also proportional to the duration of smoking. In general the relative risk (RR) of lung cancer due to smoking is of the order of 10 to as high as 20 times. Smoking of black tobacco cigarettes represents a greater risk for most tobacco-related cancers than smoking of blonde cigarettes; similarly smoking filtered cigarettes entails a lower risk for most tobacco-related cancers than unfiltered and high-tar cigarettes. However, it needs to be noted and emphasized that a "safe" cigarette does not

exist; all smoking tobacco products entail a carcinogenic risk. In addition to lung, tobacco also causes cancers of the larynx, oral cavity, pharynx, oesophagus, pancreas, kidney and bladder (283). In non-alcohol drinking male smokers, risk of developing cancer of the oral cavity is about double that for non-drinking non-smokers. Elevations of ten-fold or more are evident for cancer of the larynx and five-fold or more for oesophageal cancer. A common feature of lung and other smoking-induced cancers is the decreased risk which follows smoking cassation ("quitting") relative to continuing smoking (283). The relative risk of cancer at most sites is markedly lower than that of current smokers after five years' cessation, although risks for bladder cancer and Adeno-carcinoma of the kidney appear to persist for longer before falling. Despite the clearly established benefit of cessation, the risk for ex-smokers does not decrease to that for "never smokers".

Other cancer types may be a consequence of smoking. These include cancer of the stomach, liver, nose and myeloid leukemia. Exposure to environmental smoke (passive smoking) is a definite risk for lung cancer and possibly laryngeal cancer; the relative risk has been estimated at about 1.15-1.20 times.

Smokeless tobacco use (the commonest being tobacco chewing as "quid") has been associated with increased risk of head and neck cancer, particularly oral cancer. Since chewing of tobacco-containing products is particularly prevalent in southern Asia, especially India, it represents a major carcinogenic hazard in this region.

Alcohol consumption, exposure to asbestos and exposure to ionizing radiations interact with smoking in increasing the risk of cancers. For alcohol drinking and smoking, risk for cancer of the larynx, oesophagus and oral cavity increase multiplicatively.

### Alcohol drinking

Causal association of drinking alcohol has been definitely established in respect of oral, oesophageal and liver cancers (284). A causal association is also established in the case of breast cancer and is probable for colon and rectal cancer (284, 285). There have been suggestions of a possible carcinogenic effect of alcohol drinking on other organs, such as the lung, but the evidence is still inconclusive (286). For all cancers caused by drinking alcohol, the risk of cancer increases with the level of consumption, up to an intake of about 80 g of ethanol / day (equal to 8 small pegs of hard drinks as Rum or whisky). The risk of head and neck cancer is 5-10 times higher in heavy drinkers than in abstainers, the carcinogenic effect of alcohol appearing to be more potent in the oral cavity, pharynx and oesophagus and weaker in the larynx. The relative risk of breast cancer in women with a high consumption of alcohol is approximately two-fold. Alcohol drinking and tobacco smoking show a synergistic interaction in the etiology of cancers of the oral cavity, pharynx, larynx and oesophagus.

Alcohol drinking is estimated to be involved in the etiology of 3% of all cancers (that is, 4% in men, 2% in women). In women, approximately half of the neoplasms attributed to alcohol drinking are breast cancers.

### Occupational exposures

The first reports of associations between risk of cancer and employment in particular occupations appeared during the 18th century (287) and 19th century (bladder cancer in workers exposed to dyes (288)). However, the majority of studies establishing a link between an increased risk of cancer and a particular working environment were published between 1950 and 1975 (289). At present, 25 chemicals or mixtures, for which exposures are mostly occupational, have been established as human carcinogens, the important ones being asbestos, crystalline silica and heavy metals. Aromatic amines have been shown to increase the risk of bladder cancer; benzene that of leukemias and that of myelogenous leukaemia in particular (290); Asbestos and other fibers have been associated with lung cancer and mesothelioma. Cancer of the lung can be caused by exposure to inorganic arsenic in mining and copper smelting and among workers in chromium plants and chromium alloy workers. Nickel refining also carries a carcinogenic risk.

Coal tar, coal gas production and iron founding are associated with cancers of the skin and of other sites, including the urinary and respiratory systems. Work in iron and steel founding is also associated with an elevated risk of lung cancer. Nasal adenocarcinomas are caused by exposures in the furniture and cabinet making industry, mainly among people exposed to wood dust. Similarly, among painters, 40% excess risk of lung cancer has been consistently recorded.

### Environmental pollution

In the present context, "environmental pollution" refers to a specific subset of cancer-causing environmental factors, namely, contaminants of air, water and soil. The carcinogenic pollutants for which most information is available include asbestos (referring here to non-occupational exposure), toxic agents in urban air pollutants and chlorination by-products and other contaminants of drinking water. Various studies suggest that environmental pollution accounts of 1-4% of the total burden of cancer in developed countries (291, 292). Non-occupational exposure to asbestos may occur domestically and as a consequence of localized pollution. Cohabitants of asbestos workers may be exposed to dust brought home on clothes. Non-occupational exposure to asbestos may cause lung cancer, particularly among smokers (293). Ambient air pollution has been implicated as a cause of lung cancer. It is possible to attribute some carcinogenic risk to particular atmospheric pollutants, including benzo(a)pyrene, benzene, some metals, particulate matter (especially fine particles), and possibly ozone.

Drinking water may contain a variety of potentially carcinogenic agents, including chlorination by products and arsenic. Chlorination by products results from the

interaction of chlorine with organic chemicals. Among the many halogenated compounds that may be formed, trihalomethanes and chloroform are those commonly found. Studies on bladder cancer have suggested an increased risk associated with consumption of chlorinated drinking water (294). Doubts remain as to whether such associations are causal because of the way in which the studies measured exposure.

Arsenic causes cancer in the skin, lung and other organs. The main source of environmental exposure to arsenic for the general population is through ingestion of contaminated water. High exposure to arsenic from drinking water is found in several areas of Alaska, Argentina, Bangladesh, Chile, India, Mexico, Mongolia, Taiwan and the USA. There is strong evidence of an increased risk of bladder, skin and lung cancers following consumption of water with high arsenic contamination (295, 296).

Food contaminants

Food may be contaminated by mycotoxin – producing fungi. The most studied are Aflatoxins, which occur as food contaminants in hot, humid parts of the world, with diets based upon maize and groundnuts (peanuts). Aflatoxins are products of the aspergillus fungi and particularly accumulate during storage of grains. Together, aflatoxin exposure and HBV infection are the main risk factors according for the high incidence of hepatocellular carcinoma in some regions of Africa, Asia and South America (297). Incidence of oesophageal cancer has been related to the occurrence of another fungus, viz. , F. verticillioides or its toxins in maize. Similarly, Ochratoxin A, also a fungal metabolite may contaminate grain and pork and pork products and lead to urothelial urinary tract tumors.

Certain organochlorines, including DDT and other pesticides, are bioconcentrated in the human food chain. DDT in particular has been associated with increased risk of pancreatic cancer, breast cancer, lymphoma and leukaemia in humans.

Certain heterocyclic amines are formed during cooking of meat and fish at high temperature. Heterocyclic amines are carcinogenic in various organs of mice, although their carcinogenic potential in humans has not yet been established (298). Another group of chemicals, the Polycyclic aromatic hydrocarbons are generated in meat when it is fried, roasted or cooked over an open flame, and many members of this chemical class are carcinogenic.

**Radiation**

Ionizing radiations are one of the most intensively studied carcinogens (299-301). Exposure to ionizing radiations from natural as well as from industrial, medical and other sources, can cause a variety of neoplasms, including leukaemia, breast cancer and thyroid cancer

Sunlight is by far the most significant source of ultraviolet irradiation and causes several types of skin cancers, particularly in highly-exposed populations with fair skin. Extremely low frequency electromagnetic fields generated by electrical power transmission have been associated with an increased risk of childhood leukaemia, but the findings are not conclusive. (302).

Mobile telephones are the greatest source of radio frequency exposure for the general public. The evidence of the carcinogenicity of radio frequency fields is not clear. The experimental evidence is also limited, but suggests that radio frequency fields cannot cause DNA mutations.

Chronic infections

Infectious agents are one of the main causes of cancer, accounting for 18% of cases worldwide, and the majority occurring in developing countries. The most frequently affected organ sites are liver (hepatitis B and C, liver flukes), cervix uteri (human papilloma viruses), lymphoid tissues (Epstein-Barr virus), stomach (Helicobacter pylori) and the urinary system (Schistosoma haematobium). The mechanism of carcinogenicity by infectious agents may be direct, e. g. , mediated by oncogenic proteins produced by the agent (e. g. , human papilloma virus) or indirect, through causation of chronic inflammation with tissue necrosis and regeneration. Strategies for prevention include vaccination (hepatitis B virus), early detection (cervical cancer) and eradication of the infectious agent (Helicobacter pylori).

Chronic carriers of HBV, have around 20 times higher risk of developing liver cancer than non-carriers (303). It has been estimated that 60% of cases of primary liver cancer worldwide and 67% of cases in developing countries can be attributed to chronic persistent infection with HBV. About 20% of cases of liver cancer in the world are attributed to HCV.

Many molecular epidemiological studies (304 - 306) have consistently shown higher relative risks for invasive cervical cancer due to HPV. In fact, HPV DNA is found in virtually all invasive cervical cancers, indicating that HPV is a necessary cause (307). Moreover, about 80% of anal cancers and 30% of cancers of the vulva, vagina, penis and oro-pharynx can be attributed to HPV. HIV infection enhances the risk of Kaposi sarcoma by approximately 1, 000-fold, of non-Hodgkin lymphoma by 100-fold, and of Hodgkin disease by 10-fold. Infection with Helicobacter pylori is one of the most common bacterial infections worldwide. In developing countries, the prevalence of H. pylori among adults ranges from 80 to 90% whilst in developed areas it is around 50%. It is clear that H. pylori plays a role in gastric cancer, but other cofactors (e. g. , diet) are also contributory (308).

Diet and nutrition

A principal environmental factor, now generally recognized as major determinant of cancer incidence, is diet. It is estimated that up to 30% of human cancers are probably related to diet and nutrition. The western diet and lifestyle are generally associated with high incidence of cancers of the colorectum, breast, prostate and endometrium. Based on available evidence, the major factors in diet related to cancers are :

**Vegetables and fruits**

The most consistent finding on diet as a determinant of

cancer risk is the association between high consumption of vegetables and fruits and reduced risk of several cancers. Adequate consumption of vegetables and fruits is associated with reduced risk of cancers of the pharynx, larynx, lung, oesophagus, stomach and cervix uteri, while only vegetables, but not fruits, seem to protect against cancers of the colon and rectum. Large scale studies confirm these observations, suggesting, for example, that a daily consumption of 500g of fruits and vegetables can decrease incidence of cancer of the digestive tract by as much as 25% (309).

**Salt and salt-preserved foods**

Several studies have reported increased relative risks of stomach cancer in relation to the increased consumption of salt and salt-preserved foods. Salted, smoked, pickled and preserved foods (rich in salt, nitrite and preformed N-nitroso compounds) are associated with increased risk of gastric cancer. Such high salt intake, together with Helicobacter pylori infection, may contribute to the development of atrophic gastric and hence gastric cancer. Consumption of Chinese-style salted fish has been specially associated with increased risk of nasopharyngeal cancer in South-East Asia (310).

**Meat**

Epidemiologic studies on meat consumption and cancer risk supports the existence of a specific association with colorectal cancer risk. This association seems to have been found more consistently for consumption of red meat (beef, lamb and pork) and processed meat (ham, salami, bacon, etc. ) for which consumption of 80 g per day may increase colorectal cancer risk by 25 and 67% respectively (311).

**Refined sugars**

Increased consumption of simple sugars (mono-and disaccharides) may be associated with increased colorectal cancer risk, while consumption of complex polysaccharides, non-starch polysaccharides and/or fiber is associated with lower risk.

**High overall fat / saturated fat intake**

The hypothesis that high fat intake is a major cancer risk factor in the Western style diet has been at the centre of most epidemiological and laboratory experimental studies. The results are, however far from clear and definitive. The only moderately consistent result seems to be the positive association between consumption of fats of animal origin (except for fish) and risk of colorectal cancer.

**Food additives**

Although some animal bioassays have revealed an increased incidence of urinary bladder cancer, there is inadequate evidence for carcinogenicity of saccharin in humans (312). The proportion of dietary- related cancers considered attributable to food additives is very low (313).

**Micronutrients**

Research on vitamin and cancer in humans has focused mainly on carotenoids and vitamin A (retinol), vitamin E, vitamin C and some of the group of B vitamins (folic acid, B6). The biological basis of the interest in these vitamins is their involvement in either of two metabolic mechanisms commonly called the antioxidant effect (carotenoids, vitamins C and E) and methyl donation (folic acid, B6). Studies have shown quite consistently that individuals with lower carotenoid levels have increased lung cancer risk. Less consistent and weaker protective effects of carotenoids have also been reported for cancer of the oesophagus, stomach, colorectum, breast and cervix. Low dietary intake of vitamin C has been found to be associated with increased risk of cancers of the stomach, mouth, pharynx, oesophagus and, less consistently, with cancers of the lung, pancreas and cervix. Although results on vitamin E and cancer are less strong and consistent than those on carotenoids and vitamin C, several studies have suggested that low vitamin E intake is related to increased risk of cancers of the lung, cervix and colorectum. There is rising interest in the possible cancer-preventive effect of folic acid; some prospective studies have shown that high dietary intakes and higher blood levels may be associated with reduced risk of cancers and adenomatous polyps of the colorectum. Folate deficiency leads to an accumulation of homocysteine. High homocysteine level have recently been found to be strongly associated with death from myocardial infarction, total mortality and colon cancer risk (314). Among other micronutrients, zinc and selenium deficiency may increase cancer risk (315).

Overweight, obesity and reduced Physical Activity

Western type of diet (characterized by highly caloric food rich in animal fat and protein), often combined with a sedentary lifestyle and hence energy imbalance and obesity, increases the risk of colon, breast, prostate and endometrial cancers. The strongest and most consistent association with body mass has so far been seen for endometrial cancer, the risk of which is increased two-to six-fold in obese compared to lean women, both before and after menopause. Majority of case control and prospective studies have also found that Obesity is a strong risk factor for endometrial cancer, as well as or breast cancer in postmenopausal women.

Genetic susceptibility

Inherited cancer syndromes (e. g., retinoblastoma, neurofibromatosis, etc. ), usually involving germline mutation may account for up to 4% of all cancers. Inherited mutations of the BRCA 1 gene account for a small proportion of all breast cancers. Environmental factors may modify the cancer risk of individuals affected by inherited cancer syndromes.

Reproductive factors and hormones

Female sex hormone metabolism, reproductive factors and menopausal status affects the development of endometrial, ovarian and breast cancer. Use of combined oral contraceptives accounts for a slight increase in risk of breast cancer, but is protective against ovarian and endometrial cancers. Hormone replacement therapy is associated with increases in risk of breast and endometrial cancers. For breast cancer, incidence rates rise more steeply with age before menopause than after.

Furthermore, breast cancer risk is increased in women who have early menarche, or who have late menopause, whereas an early age at first full-term pregnancy and high parity are associated with reduced risk of cancers of breast, ovary and endometrium (316). Ovarian cancer risk does not show strong relationship with menstrual history, but is clearly and inversely related to parity (317).

## Epidemiology of common cancers

### Lung Cancer

Lung cancer is the most common tumour worldwide, with 900, 000 new cases each year in men and 330, 000 in women. It is leading causes of death from cancer. In men more then 80% of lung cancer cases are caused by smoking; in women the attributed risk is less (about 70% in Northern Europe; 45 worldwide). In India also, it is the commonest form of cancer among males. Some occupational exposures and air pollution (including passive tobacco smoke) make a minor contribution to incidence. No population-based screening procedures have been established. No effective treatment is available; the five-year survival rate for lung cancer patients is less than 15%.

### Breast Cancer

Breast cancer is the most common malignancy affecting women, with more than one million cases occurring worldwide annually. Affluent societies carry the greatest risk, with incidence rates of >80 per 100, 000 population per year. In India, it is the second commonest cancer among females. Though it can be detected early and treated with effective measures like self / clinical breast examination or mammography. In our country only 15% patients present in the localized stage; in 75% regional lymph nodes are already involved while 10% have distant spread at the time of reporting.

The worldwide breast cancer epidemic has many etiological factors, including diet and diet related lifestyle factors, obesity (for post-menopausal breast cancer), high caloric diet, low intake of dietary fibre, physical inactivity, low intake of fruits and vegetables and alcohol use; hormone related and reproductive factors (early menarche, late or no pregnancy, late menopause, use of oral contraceptives, regular ovular menstrual cycle and lack of breast feeding); previous history (family history of breast cancer; history of benign breast disease); and, exposure to ionizing radiations at the time of development of breasts. The positive aspect of breast cancer is that it is possible to detect it at an early stage and treat it effectively. In some regions of the world, including North America, Western Europe and Australia, breast cancer mortality rates have started to decline, mainly due to improvements in early detection and treatment (chemotherapy and tamoxifen). Five-year survival rates are higher than 70% in most developed countries. Breast cancer screening trials of mammography have also shown that mortality can be reduced by up to 30%.

### Cancers of the female reproductive tract

Cervical cancer is the second most common cancer of women worldwide with more than 470, 000 new cases per year and about 230, 000 deaths every year. More than 80% occur in developing countries. In India, it is the commonest cancer among females, with more than a lakh new cases being detected and 75000 deaths every year. Sexually transmitted infection with human papillomavirus is fundamental to development of carcinoma of the cervix. HPV prevalence increases with multiple sexual partners and poor genital hygiene. Early age at first sexual contact and multiparity are other risk factors.

Population based screening with pap smear has improved early detection and survival. Five-year survival rates are up to 70%. In our country, it is recommended that ideal age at screening should be 35 to 50 years, as chances of detecting pre-cancerous lesions are maximum in this group. Other screening methods being studied for their efficacy in population screening include Unaided Visual Inspection (UVI), Visual inspection using 4% acetic acid (VIA) and visual inspection using Lugol's Iodine.

Endometrial cancer mainly affects postmenopausal women in developed countries; worldwide, 188, 000 new cases are diagnosed annually and obesity is a major risk factor. About 190, 000 cases of ovarian cancer occur each year, predominantly among postmenopausal women in developed countries; five-year survival rates are about 40%.

### Oral and other head and neck cancers

The most common cancer in the head and neck, namely oral cancer, ranks eleventh worldwide (390, 000 new cases per year), while cancers of the pharynx (65, 000 cases) and larynx (160, 000 cases) are less common. In India, oral cancer is one of the commonest cancers among males, mainly due to smokeless tobacco (tobacco chewing), which is the single most important risk for oral cancer. Other risk factors include alcohol use, betel nut chewing, and chronic trauma to oral mucosa by sharp tooth or ill-fitting dentures. Multiple primary carcinomas are not uncommon. Oral cancer is eminently suited to early detection and treatment by regularly inspection of oral cavity for leukoplakia / erythroplakia or ulcers. Early-stage tumours can be surgically resected, However in developing countries like ours, many patients present late in the disease. Overall, oral cancer patients have a five-year survival rate of less than 50%.

### Stomach Cancer

Cancer of the stomach is among the most common malignancies worldwide, with some 870, 000 new cases every year. Mortality from stomach cancer is second only to lung cancer. In India also it is one of the commonest cancers among males, alongwith cancers of lung and oral cavity. Patients are often diagnosed with advanced disease and five-year survival rates are poor, usually less than 30%. Infection with Helicobacter pylori is considered as an important risk factor in the development of stomach cancer.

Incidence is declining worldwide. In most European countries it has fallen by more than 60% during the past 50 years. This trend is mainly due to markedly decreased consumption of salt-preserved food, increasing avoidance

of a high-salt diet and availability, in many countries, of fresh fruits and vegetables throughout the year.

### Oesophageal Cancer

Cancer of the esophagus is the sixth most common cancer worldwide (more than 400, 000 cases per year). Incidence varies markedly, and is highest in western and south-central Asia. The major risk factors are tobacco and alcohol abuse. Other risk factors include consumption of very hot beverages and malnutrition. Most cancers of the oesophagus are detected at an advanced stage; five-year survival rates are less than 15%.

### Colorectal Cancer

Cancers of the colon and rectum are rare in developing countries, but are the second most frequent malignancy in affluent societies; over 940, 000 cases occur annually worldwide. An important etiological factor is unhealthy lifestyle involving a diet rich in fat, refined carbohydrates and animal protein, combined with low physical activity. Studies suggest that risk can be reduced by decreasing meat consumption and increasing intake of vegetables and fruit. Colonoscopy is the most reliable means for early detection. Progressively improved treatment has resulted in a five-year survival rate of about 50%.

### Liver Cancer

About 560, 000 new cases of liver cancer, usually hepatocellular carcinoma, occur annually, and contribute significantly to cancer mortality worldwide. More than 80% of cases occur in Asia and Africa. The incidence rate is more than twice as high in men as in women. In Africa and Asia, hepatocellular carcinoma is most frequently caused by hepatitis B virus infection; concomitant dietary exposure to aflatoxin multiplies the risk. In Japan, this cancer is predominantly caused by hepatitis C virus infection. In western countries, liver cirrhosis due to chronic alcohol abuse is the major etiological factor. Hepatocellular carcinoma has very poor prognosis, survival from time of diagnosis often being less than six months; only 10% of patients survive five years or more.

### Cancers Of The Male Reproductive Tract

Prostate cancer accounts for about 200, 000 deaths annually worldwide, predominantly afflicting older men in developed countries. Risk factors include high caloric intake and low physical activity. Black men have the highest, white men intermediate and Asian men a lower risk. Recorded incidence is increasing in many countries, partly as a result of screening for elevated serum levels of prostate-specific antigen. Testicular cancer mainly affects young men, with close to 50, 000 new cases each year worldwide. Incidence is increasing in many developed countries; its etiology is largely unknown. The mean five-year survival rate is higher than 95% mainly due to the efficiency of chemotherapy using cisplatin; long-term disease-free survival can even be achieved in cases of metastatic testicular cancer.

### Bladder Cancer

Bladder cancer is the ninth most common cancer worldwide, with 330, 000 new cases and more than 130, 000 deaths per year. Bladder cancer is primarily attributable to smoking, which accounts for 65% of male and 30% of female cases in some developed countries. Other important causes include analgesic abuse (phenacetin), some types of cancer chemotherapy and historically, occupational exposure to chemicals such as 2-naphthylamine. In Egypt and some Asian regions, chronic cystitis caused by Schistosoma haematobium infection is a major risk factor. Treatment based on endoscopy, surgery, radiotherapy and cytotoxic drugs often permits long-term survival in developed countries, where 65% of patients live for at least five years after diagnosis.

### Leukaemia

Leukaemia is the eleventh most common cancer worldwide with more than 250, 000 new cases each year. The etiology of leukemia is largely unknown, although a small proportion of cases is attributed to treatment with anticancer drugs or exposure to ionizing radiations. The genetic characteristics of many leukaemias are being elucidated. Treatment of acute leukemia has made much progress and helped to establish general principles of cancer chemotherapy and management. Survival varies greatly according to type, with acute lymphoblastic leukemia patients having a five-year survival rate of up to 70%, whilst for those with acute myeloid leukemia it is only 20-30%.

### Lymphoma

Malignant lymphomas are classified as either Hodgkin's disease or non-Hodgkin's disease or non-Hodgkin lymphoma. Hodgkin's disease affects mainly children's and the elderly in developing countries and young adults in more developed countries; 62, 000 new cases are diagnosed annually. The incidence of malignant Non-Hodgkin lymphomas is increasing worldwide; more than 280, 000 new cases occur annually, predominantly in more developed countries. Advances in chemotherapy have led to a five-year survival rate for Hodgkin disease of more than 70% and that for non-Hodgkin lymphomas has increased to 60-70%.

### Pancreatic Cancer

Pancreatic cancer is the 14th most common cancer worldwide, with approximately 216, 000 new cases per year. Highest incidence rates occur in more developed countries. In countries with high smoking prevalence, more than 40% of cases are attributable to tobacco consumption. Familial risk, often involving hereditary pancreatitis, is evident in up to 10% cases. No effective early diagnostic test or population-based screening procedure is available. Five-year survival rates are poor (less than 5%) and the vast majority of pancreatic cancer patients die within a year of clinical diagnosis.

### Renal Cancer

Cancer of the Kidney is the 15th most common cancer in the world and quite prevalent in developed countries. Close to 190, 000 cases are diagnosed each year worldwide and men are generally affected more frequently than women. Tobacco smoking is an

established cause. Excess body weight (obesity) has also been identified as a risk factor, particularly in women. Patients with late stage diagnosis face a poor prognosis. Recent advances in imaging allow the early detection of asymptomatic tumours. The five-year survival rate is approximately 50%.

## Prevention and control of cancers

Cancers represent serious maladies which have great potential for prevention, as well as early diagnosis and effective treatment. Prevention of Cancers should be a totalistic approach, targeting all levels of prevention, viz. , primary, secondary as well as tertiary levels.

### Primary prevention

Community education and motivation

As is evident from the foregoing discussions, the commonest (as also serious) cancers, viz;, lung, oral cavity, breast, cervix uteri, stomach, upper aerodigestive tract and colorectum, are greatly related to "unhealthy lifestyle" which has been the discussion of this entire section. Education and motivation of the community to adopt simple healthy lifestyle steps, as depicted in Box - 1.will go a long way in preventing not only various serious and common cancers but various other serious diseases also.

**Box - 1 : Key message**
**Community education for cancer control**

- Stop Tobacco in any form today itself ; do not start if you are non-user.
- Stop alcohol; if you cannot stop, drink in moderation.
- Eat at least half a Kg of fresh, seasonal fruits and vegetables every day.
- Eat plenty of whole grains, pulses, beans and legumes in diet.
- Keep salt consumption to < 5 grams a day; avoid food items which are salt-preserved, smoked or cooked in re-heated oils
- Exercise briskly : at least 2 miles (3.2 Kms) of brisk walk in 30 minutes every day.
- Avoid Ghee, butter, deep fried, thick-gravied, creamed and sugary foods.
- Avoid "Red Meat" (lamb, beef, pork).
- Maintain your body weight with proper combination of diet and exercise (BMI at < 25; waist at < 90 for males & < 80 for females)
- Avoid sexual promiscuity.
- Maintain hygiene of genital organs.
- Take vaccination against hepatitis - B.
- Do a self examination of oral cavity and breast (females) once a month, as described.
- Report to the doctor if you have any "warning signs" (described later)
- Proper protection in occupational settings.

Tobacco Control

Comprehensive tobacco control, including implementation of regulatory measurements and encouraging personal commitment, require coordinated involvement of government, professionals and planners. Tobacco control involves health promotion and education, advocacy, support for cessation, community mobilization, taxation and other fiscal measures, livelihood alternatives, regulation, legislation and enforcement. Policy level interventions would include levy of taxes (to raise cost of tobacco products and act as a disincentive for purchase), regulation of tobacco products (for constituents, emissions, health warnings, and misleading health claims) and measures to reduce supply (ban on sale to youth, curbs on smuggling, and programmes to aid tobacco farmers and workers to switch over to alternative livelihoods). There is a tobacco control legislation titled "The Cigarettes and Other Tobacco Products (Prohibition of Advertisement and Regulation of Trade and Commerce, Production, Supply and Distribution) Act 2003". This comprehensive piece of legislation, intended to protect and improve public health, encompasses a wide array of evidence-based strategies to reduce tobacco consumption. This includes provisions for prohibition on direct and indirect advertisements on tobacco products, prohibition on smoking in public places, prohibition on sale of tobacco products to persons less than 18 years age or within 100 yards of an educational institution, and display of statutory health warnings in a conspicuous and legible manner on tobacco products. Each of these provisions is accompanied with corresponding penalties that can be imposed.

Alcohol

Control of alcohol requires actions similar to those for tobacco control. The action should be targeted towards individual and community and include taxation, general public education and motivating highly vulnerable groups like young people to avoid starting consumption.

Sexual and reproductive factors

Sexual and Reproductive Factors are associated with cancer of the uterine cervix and breast, as explained in forgoing paragraphs. Human Papilloma Virus (HPV) has now been identified as the etiological agent responsible for cervical cancer. HPV prevalence increases with high risk sexual behavior and poor sexual hygiene. Education regarding sexual hygiene and safe sexual behavior should be provided for prevention of cancer cervix. Safe sexual behavior protects women from the risk of cancer by preventing infection with HPV. Breast cancer is not much amenable to primary prevention, to any large extent. Early detection is the main strategy for improving survival in breast cancer.

Diet, physical exercise and avoidance of obesity

Proper diet, regular moderate intensity physical exercise and avoidance of obesity are important for prevention of breast, upper aerodigestive tract and intestinal cancers,

as has been described in detail earlier.

**Certain lifestyle measures may help in reducing risk of cancer**

(a) Avoid being underweight or overweight.
(b) Engage in regular, brisk physical activity.
(c) Consumption of alcohol and tobacco should be stopped.
(d) Limit consumption of salted, deep fried foods.
(e) Choose predominantly plant based diets rich in grains, legumes and fruits and vegetables.
(f) Restrict the intake of red-meat (beef, pork, lamb) and preserved meat.

Occupation

Occupational cancers constitute 5 – 10% of all cancers. Limiting exposure to potentially carcinogenic substances through personal protective gear, rotation of workers, mechanized handling of such chemicals may help reduce cancers from occupational exposures.

Environmental pollution

Maintaining proper vehicle emission standards, promoting alternative sources of energy instead of biomass fuel, taking measures to reduce the emissions of CFCs and anti-tobacco measures in home / public places will be of help.

Radiation protection

Personal protective devises and dosimeters by personnel engaged in radiological procedures, avoidance of exposing patients to unnecessary X-rays and adequate safeguards in nuclear facilities should be ensured.

Infection

The important infections in relation to cancer prevention, in Indian context, are HBV and HBC, HPV, and H pylori. Vaccination against HBV, use of universal precautions in health care settings, proper sterilization of syringes, needles and other medical equipment, blood safety, safe sexual practices, avoidance of sexual promiscuity, maintenance of genital hygiene, and treating the patients with symptomatic infections of H pylori are the mainstays in this regards.

Reduction of exposure to ultraviolet radiation

Encouragement of sun-protective behavior is the most effective public health measure to reduce incidence of skin cancer in populations, and especially in children. Available options include sun avoidance by using shade, wearing protective clothing and using sunscreens. Efficacy is expressed through the "sunscreen protection factor" (SPF). Most commercial preparations are presented as having SPF values of up to 15-20.

Chemoprevention

Chemoprevention is defined as reduction of the risk of cancer development through the use of pharmaceuticals or micronutrients. The breast cancer drug tamoxifen reduces the risk of developing a second cancer in the other breast. A lower risk of colon cancer has been observed following regular use of aspirin and related non-steroidal anti-inflammatory drugs which reduce the risk of recurrence of adenomas. Trials to establish chemo-preventive activity by micronutrients, including carotenoids and retinoids, among people at high risk, have been inconclusive. At present, tamoxifen is the only cancer prophylactic drug being used in medical care, under close supervision of a specialist.

### Secondary prevention

Secondary prevention aims at diagnosing the condition at a very early, preferably asymptomatic stage and effectively treating it. In context of cancer prevention, it takes two forms : firstly by educating the community at large regarding "early danger signs" so that they could report to medical facility for further evaluation, should these signs appear. Secondly, secondary prevention uses certain well established screening procedures for early detection.

Early warning signs

Community should be educated regarding the following signs / symptoms and report to the medical facility should they occur These include

(a) Unexplained change in bowel or bladder habit.
(b) A white patch or ulcer in the mouth that does not heal.
(c) Obvious change in a mole or wart, like rapid increase in size, bleeding or ulceration.
(d) Bleeding form body's orifices eg – haematuria, bleeding in stools, bleeding PV etc.
(e) Persistent indigestion / difficulty in swallowing / difficulty in breathing.
(f) Persistent fever unresponsive to treatment.
(g) Unexplained loss of weight.
(h) Chronic cough or hoarseness of voice especially in a smoker.

## Screening for common & important Cancers

### Screening For Breast Cancer

Early diagnosis of breast cancer, by promoting breast awareness among all women and clinical breast examinations for women, preferably in the age group 40-69 years, should be encouraged. Women should be educated and encouraged to inspect and manually examine all quadrants of the breasts with the flat of hand, and the axillae, once a month, ten days after the menstrual period. Every women should also be made aware of the following signs

(a) A change in size
(b) A nipple that is pulled in or changed in position or shape
(c) A rash on or around the nipple.
(d) Discharge from one or both nipples
(e) Puckering or dimpling of skin
(f) Lump or thickening in the breast
(g) Constant pain in the breast or armpit

Breast Examination by a health professional

With the flat of the hand, both the breasts are palpated in a circular manner starting from the nipple and areolae in a clockwise manner towards the periphery and the axillary tail of the breast in sitting and lying down positions. Then the axillary, supraclavicular region and liver are also examined.

Mammography

The epidemic increase in breast cancer incidence has led to the introduction of population-based mammography screening. The analysis of large randomized trials has shown that in women aged 50 to 69 years, mammography screening can reduce mortality from breast cancer by 25-30%. For women in the age group 40-49 years the screening efficacy is significantly less.

### Screeining for Cervical Cancer

In most developed countries, cytological screening (Pap test) has led to significant reduction in the incidence of and mortality from cervical cancer. Screening should preferably begin at 35 years of age, as at younger ages, dysplasia detected through screening rarely progresses to cancer, but adds to programme cost in treatment. Alternative strategies such as visual inspection are being tested for use in low-resource settings where laboratory facilities for cervical cytology are inadequate. Test performance of visual inspection with Acetic Acid (VIA) suggests that it has similar sensitivity to that of cervical cytology in detecting cervical intraepithelial neoplasia, but has lower specificity. Further studies are underway to judge how appropriate and feasible it will be to introduce VIA-based cervical cancer screening programmes on a population-wide basis. There is increasing interest in the use of HPV DNA testing for screening. The test, however, requires financial and sophisticated technical resources. A very important aspect of cervical cancer screening which should be noted by all medical functionaries is to ensure proper response rates, especially from those who are 'disadvantaged", since they are the ones who are expected to have a higher prevalence. Secondly, it is also equally important to ensure final confirmatory tests and aqdequate treatment if required, among those who test positive on screening tests.

### Screening for oral Cancer

Oral cancer and its precancerous lesions, including leukoplakia, can be readily detected by visual inspection of the oral cavity not only by trained health workers and doctors, but to a large extent by the subject himself.

**Self Examination of oral cavity** : This is important for detecting oral lesions at an early stage. All habitual tobacco users should do it once a month. The following procedure should be followed : Rinse the mouth with water and stand before a mirror in adequate light. Look in the mirror for any abnormal white or red patch, ulcer or roughened area, or granular area or swelling in the mouth. If any such area is seen, the suspicious area should be felt with the fingers (normal oral mucosal is soft and pink). Consult a doctor if any abnormal area is found

**Examination by a health professional** : Utilize every opportunity to examine the oral cavities of tobacco users. All parts of the oral cavity should be examined; oral cavity includes lip, anterior 2/3 of tongue, floor of mouth, buccal mucosa, gingival mucosa, hard palate and retromolar area. Population screening for oral cancer results in the diagnosis of large numbers of oral pre-cancers and early stage tumours. However, a reduction in incidence of, and mortality from, oral cancer resulting from such interventions remains to be demonstrated.

### Screening for other Cancers

Prostatic Cancer

Prostate-specific antigen (PSA) testing is now being widely used in developed countries, for the early detection of prostate cancer. Elevated levels of PSA are closely, but not definitely, associated with prostate cancer. False positive results may lead to unnecessary treatment. PSA analysis should be combined with a digital rectal examination, the latter providing an assessment of the volume of the gland, since PSA is also released into the bloodstream of patients with benign prostate hyperplasia and other prostatic diseases.

Colorectal Cancer

Faecal occult blood test (FOBT) is a very cost-effective screening method available, but its specificity and sensitivity are limited. Endoscopy provides the definitive method for detecting colorectal cancer and its precursor lesions, e. g. , polyps. However, its application to population-based screening is limited by cost and availability of qualified specialists.

### Tumour markers

Certain cancers release biological products into the circulation, which can be measured for increasing the level of diagnostic suspicion. The common ones are :

Alpha feto protein (AFP)

This is increased in Liver cancer and certain tumours of testis and ovary. It is also increased in cirrhosis and hepatitis.

Beta human Chorionic Gonadotrophin (B-hCG)

Increased in choriocarcinoma and testicular tumours. Also increased in hypogonadism and hydatiform mole.

Carcino Embroyonic Antigen (CEA)

Increased in colorectal, breast and stomach cancers and Cholangiocarcinoma. Also raised in liver disease and among smokers.

CA-125

Raised in epithelial ovarian cancers. Also raised during pregnancy, menstruation, endometriosis, ascites and pleural effusion.

Prostate Specific Antigen (PSA)

Raised in prostatic cancer as also in prostatitis and BHP.

### Tertiary prevention

Tertiary prevention is also quite important in cancers. It consists of proper treatment of disease, especially advanced disease. The available options are Surgery, Radiotherapy and Chemotherapy. It also involves

Col RajVir Bhalwar

# Injuries and Accidents (Non-Enemy Action)

Non-enemy action injuries constitute the leading cause of sickness in the Armed Forces. These injuries vary to a great extent in degree of severity and may be trivial requiring only outpatient treatment or may be serious necessitating prolonged hospitalization. The latter group may remove the individual from work for a considerable time before his injury reaches finalization. Proper rehabilitation of such a long term injury also poses a great problem. As has been very aptly stated, care in injuries and trauma is quite a prolonged process, which often begins in the field by emergency medical services (EMS) and is finally completed by rehabilitation specialists (318).

### Trends in Armed Forces

The trend in hospital admissions for Injuries Non Enemy Action (NEA) (All forms) has been on the increase over the decade especially in Army and Navy where it ranks first among the causes of morbidity. However in Air Force, injuries NEA rank second, next to respiratory diseases. The trends is depicted in Table-1.

Table-1 : Hospital admissions / 1000 : Injuries NEA

| Year | Army | Navy | Air force |
|---|---|---|---|
| 2000 | 18.95 | 32.40 | 22.50 |
| 2001 | 20.24 | 22.34 | 19.04 |
| 2002 | 21.16 | 20.53 | 15.94 |
| 2003 | 23.17 | 9.50 | 15.54 |
| 2004 | 22.38 | 13.50 | 16.37 |
| 2005 | 23.44 | 19.63 | 16.07 |
| 2006 | 18.41 | 24.16 | 16.29 |

## Epidemiology

Injuries non-enemy action, result from the interaction of various agent, host and environmental factors. The relative importance of these factors varies in different types of accidents. Among the various groups within the broad category of Injuries NEA, the two major categories are Road Traffic Accidents (RTAs) and Training Injuries. The epidemiology of trauma and its related mortality has been discussed in detail by various workers (319, 320). The important epidemiological variables, according to the triad of agent, host and environmental factors are as follows :

### Agent Factors

The important agent factors are as follows :

Goods and Equipment

The troops handle complex arms and equipment and this may expose them to injury e. g. operating or lifting heavy equipment, use of tools such as hammer, chisel and cutting instruments may involve some individuals in injuries.

Vehicles

A poorly maintained vehicle may be the cause of accident e. g.

(a) Improper working of brakes and lights.
(b) Machinery without guards or with inadequate guards.
(c) Poor maintenance of machinery and equipment.
(d) Uneven and poorly maintained playgrounds, tracks, paths and so on.
(e) Faulty design and poor maintenance of buildings.
(f) Faulty electric connections and fittings and poorly maintained electric gadgets.

### Host Factors

The host factors, directly or indirectly, play an important role in the causation of injuries. The important host factors are as follows :

(a) Improperly trained worker is more liable to injuries.
(b) Lack of interest in training /work
(c) Physical disabilities such as vision, poor agility, etc. , predispose to injuries.
(d) Carelessness and willful negligence while working
(e) Faulty work methods
(f) Use of loose fitting and unsafe clothing.
(g) Mishandling of goods, tools and equipments.
(h) Consumption of alcohol while driving or working.
(j) Tiredness due to long working hours

Psychological Factors

Psychological Factors as persons improperly selected for the job, boredom / fatigue of job, lack of basic amenities and welfare measures.

Injury Proneness

Some individuals may be naturally injury prone and inspite of all efforts they will show a higher incidence of injuries than others under the similar circumstances. It has been estimated by epidemiological surveys in certain industries that between 10-25 percent of the workers are accident-prone. This accident proneness is attributed to defective neuro-muscular control in these persons. In case of RTAs, the thrill associated with over-speeding, sudden application of brakes, and general disregard of traffic / safety rules seem to characterize the drivers often involved in vehicular accidents (321).

### Environmental Factors

Terrain

When troops are deployed in difficult terrain like high mountains, jungles and marshy areas, they are more likely

to sustain injuries while engaged in exercises and training.

Climatic Conditions

Adverse climatic conditions like rain, fog and glare increase the risk of sustaining injury.

Roads

Poorly maintained roads, roads with sharp bends and narrow roads greatly increase the risk of mechanical transport accidents.

Working Environment

Unhealthy working environment such as inadequate lighting and thermal discomfort, excessive noise and poor house-keeping increase the risk of injuries at work places.

Overcrowding

Overcrowding of machinery and men at work places enhances the risk of injuries.

## Prevention

Most of non-enemy action injuries are preventable if attention is paid to the important preventive measures. Various steps for injury prevention have been elucidated in detailed texts (322 - 324). Road safety has been a major sphere of action by the WHO (325), as well as for the United Nations Organization (326). WHO had dedicated the theme for the year 2004 to prevention of RTAs and the need has been recognized in our country also (327). The following two strategies are important for prevention of accidents and injuries

### Health Promotion

All ranks must be well informed on the various causes of injuries and their prevention. Physical fitness of personnel must be ensured by a balanced diet, good living conditions and proper medical and health care including periodical health check-ups. In addition high standard of morale by good man-management, by good leadership and by provision of adequate recreational facilities will go a long way in reducing the incidence of injuries.

### Specific Protection

It is ensured by various measures as enumerated in Box - 1

### Early First Aid and Definitive Management

it is extremely important to impart first aid and resuscitation, and life / limb saving surgery at the earliest. The "Golden Hour" concept is a rejoinder in this regards. Meticulous training of all ranks in first aid, equipping all personnel / body of troops with first aid kits, rigorous training of paramedical personnel in immediate first aid and critical care, and provision of prompt evacuation facilities to the hospital will go a long way in reducing the morbidity and mortality.

## Burns

Burns may be defined as injury to the tissues of the body arising from exposure to heat, electric conduction or radiation. These are amongst the commonest emergencies both during peace and war.

**Box - 1 : Measures for specific protection against accidents**

- Training of all ranks in the handling of stores and equipment in general.
- Training in specialized trades like MT driving, arms and ammunition, special vehicles/machines and industrial processes.
- Providing healthy work environment.
- Proper maintenance of vehicles, arms and equipment, electrical fittings, etc.
- Antifire precautions.
- Eliminating all types of stresses both at work and at home as far as possible.
- Guarding of dangerous machines.
- Enforcement of personal protective measures in workshops and other work places wherever indicated.
- Supervision of workers.
- Investigation of all injuries with a view to take necessary preventive measures.
- Good house-keeping.
- Proper maintenance and lighting of buildings.
- Securing electrical fittings and eliminating live wires.
- Ensuring adequate precaution, by education regarding handling of stoves, gases, pressure cookers and electrical appliances.

### Epidemiology

In the study of burn injuries the burnt patient is the host, the source of injury is the agent and home and working place constitute the environment. It is the interaction between these factors which results in a burn injury. It is also well documented that a large majority of burns are caused by either carelessness or ignorance and are completely preventable. In addition, a number of cases of accidental burns are related to smoking or else due to carelessness under influence of alcohol (328, 329). Age has an important relationship with burn injuries and their causation. The studies carried out in India have shown that adults and adolescents constitute the majority of cases of burns. As regards Sex, studies carried out by most of the workers have shown that the incidence of burn injuries is higher among females as compared with males. Burns are associated with diseases like epileptic fits, cardiovascular accidents, giddiness, parkinsonism, paralysis and debility. Loose fitting clothing have been found to be responsible for the causation of burns in a large number of cases.

Environment plays an important role in burn injuries by bringing about the contact between agent and the host. It may be domestic or work place environment. The domestic environment consists of the type of home, number of rooms and overcrowding. The work place environment consists of the nature of fire-guards and the

degree of safety precautions. Males suffer more burns injuries at workplace & female suffer more from domestic burns. The domestic burn injuries are more common as compared to those in workplace. Some of the important environmental factors are overcrowding, poor housing, open fire cooking, practice of cooking at the guard level, and, faulty electric connection and fittings.

**Assessment of Severity**

By Extent

An approximate clinical rule in wide use is the 'rule of nines' which acts as a rough guide of percentage of body surface area involved due to burns. As a general rule, an adult with more than 20% and a child with more than 10% body surface involved will require intravenous fluid replacements. A rough guide is that if the age and percentage of burns add together to a score of 100, then the burn is likely to be fatal. The assessment criterion is as follows :

(a) Head, face & neck = 9%
(b) Chest (front & back) = 2 x 9%
(c) Upper limbs = 2 x 9%
(d) Abdomen and back = 2 x 9%
(e) Thighs (front & back) = 2 x 9%
(f) Legs (front & back) = 2 x 9%
(g) Genital area = 1%

By Depth

Deeper the burn, poorer is the prognosis. According to the depth, burns are classified as follows :

(a) **Superficial** : Epidermis only is involved.
(b) **Partial Thickness** : Epidermis and part of dermis are involved
(c) **Deep or Full Thickness** : Epidermis and dermis are involved. It may also involve subcutaneous tissues or even muscles.

By Site

The sites which bear poor prognosis are face, neck, perineum and chest

**First Aid**

Stop the burning process by extinguishing the flames by wrapping the patient in a blanket or any other readily available garment such as the bystanders own clothing. With electric burns, it is important to switch off any live current and with chemical burns, the contact with the chemical should be avoided.

Cool the burnt surface. Immediate cooling of the part is beneficial and should continue for 20 mins. Irrigation with cold water under a tap is best, especially in scalds and chemical injuries. Hypothermia must be avoided. Do not use ice or iced water. The burn should then be wrapped in clean linen and patient transported immediately to hospital.

**Emergency Treatment**

The priorities in the management of a major burn injury is :

A - Airway maintenance
B - Breathing and ventilation
C - Circulation
D - Disability -neurological status
E - Exposure and environment control
F - Fluid resuscitation

It is important to secure large bore intravenous line at an early stage. Having estimated the percentage burnt surface area and measured the body weight, initial fluid resuscitation can be planned. The simplest formula for adults is: 3-4 ml/kg body weight /% burn in first 24 hours. Half of this volume is given in first 8 hours and the rest in next 16 hours. Hartman solution is preferred but other isotonic fluids may be used. A urinary catheter is essential. Urine output is the best guide to adequate tissue perfusion. In an adult one should aim for 30-50 ml of urinary output /hour.

Medical Officers are also advised to refer to further detailed guidelines on burns as available in standard texts (330).

**Prevention**

Burns, like any other injuries are largely preventable. Certain actions are likely to go a long way in this direction.

Box - 2 : Guidelines - Prevention of burns

- Never leave a kindling “bukhari” unattended in a room
- Always put off the bukhari before going to sleep
- Avoid smoking; NEVER smoke while lying down in bed.
- Never throw about the cigarette butts. Extinguish them properly in an ash-tray and dispose in a dust-bin.
- Avoid pressure stoves; prefer wick type stoves.
- After cooking, always close the main supply valve on the cylinder of LPG cylinders, and not simply the regulator on the stove alone.
- Do not put on loose clothes when working near flames. Loose ends of sarees / chunaris should be properly secured in proximity to the body.
- Remember that alcohol consumtion and proximity to an open flame (even as minor as a lighted match stick) make dangerous combination. AVOID this combination.
- Never store petrol, kerosene, and insecticides in any area where flame is likely to be put on.
- Keep safe distance from crackers during festivals; discourage young children from handling crackers.
- Never light up a stove for cooking / warming of food, while traveling in a train or bus or truck, whether military or civil vehicle.
- NEVER use any match box, lighter, cigarettes or any

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# Oral and Dental Health

## Introduction

During the past few decades, oral health authorities in the fields of epidemiology, education, services, health education and disease prevention have given special attention to the highly prevalent oral health problems like dental caries and periodontal diseases. With these approaches, dramatic improvement in scientific knowledge and technology has taken place in the field of oral health.

## Structure of the Tooth

The teeth are hard-calcified structures set firmly in bone sockets in the maxilla and mandible by means of a root or roots. The part visible in the oral cavity is the crown, which is separated from the roots by a narrow portion called the neck or cervical portion of the tooth. The crown is covered with hard shiny enamel. The tissue covering the root is the cementum. The ivory-like structure that forms the bulk of the tooth is the dentine. Enamel lacks the capacity for self-repair since it contains no cells. It resists wear only through its extreme degree of hardness. Dentine is capable of repair, but it is less hard and resistant than enamel. Investing between the roots of teeth and socket wall formed by alveolar bone is the thin periodontal ligament, the fibre-bundles of which help to suspend and anchor the teeth in place. Its cushioning effect also helps in protecting periapical tissues from likely compression during mastication. The dental pulp occupies hollow pulp chambers and pulp canals in the crown and roots of teeth. It contains a plexus formed by connective tissue fibres, nerve endings, blood vessels, tissue cells and lymphatics which communicate with their major source of supply through apical foramina in the roots ends.

The gingival, periodontal ligament, alveolar bone and cementum which support the teeth. are collectively termed as periodontium.

## Dentition

The first detention brings forth the deciduous or "Milk teeth". There are twenty teeth in this set; ten in each jaw. The tooth buds begin to form about the sixth week of prenatal life and calcification starts about the sixteenth week of prenatal life. The position of the first permanent molar determine to a great extent, the position of the other teeth. Therefore, early examination and care will help to ensure their retention throughout life. Decidous teeth are shed about the 7th year onwards, when the permanent teeth follow. There are 32 teeth in the permanent set; 16 in each jaw. Calcification of permanent teeth begins in the jaws about the time of birth. The last four teeth to erupt are the third permanent molars, or "wisdom teeth". They do not erupt until about the age of 18 years or later and may even never erupt. Sometimes they become "impacted" below the gum surface necessitating extraction to preserve the heath of the adjacent teeth . Dentition schedule is shown in Table - 1.

## Tooth Numbering

Table - 1 : Dentition schedule

| | Maxillary | | | Mandibular | | |
|---|---|---|---|---|---|---|
| | **Formation Begins** | **Eruption** | **Shedding** | **Formation Begins** | **Eruption** | **Shedding** |
| **Deciduous Teeth** | **Intra uterine** | **Postnatal** | | | | |
| Central incisors | 4 months | 7½ months | 7 years | 4½ months | 6 months | 7 years |
| Lateral incisors | 4½ months | 9 months | 8 years | 4½ months | 7 months | 7-8 years |
| Canines | 5 months | 18 months | 11-12 years | 5 months | 16 months | 10 - 12 years |
| First molar | 5 months | 14 months | 9-10 years | 5 months | 12 months | 8-9 years |
| Second molar | 6 months | 24 months | 11-12 years | 6 months | 20 months | 10 - 11 years |
| **Permanent teeth** | **Postnatal** | | No definite Schedule | | | No definite Schedule |
| Central incisors | 3-4 months | 7-8 years | | 3-4 months | 6-7 years | |
| Lateral incisors | 10-12 months | 8-9 years | | 3-4 Months | 7-8 years | |
| Canine | 4-5 months | 11-12 years | | 4-5 months | 9-10 years | |
| First pre molar | 1½ years | 10-11 years | | 1½ - 2 years | 10-12 year | |
| Second pre molar | 2-3 years | 10-12 years | | 2-2½ years | 11-12 years | |
| First molar | At birth | 6-7 years | | At birth | 6-7 years | |
| Second molar | 2½ -3 years | 12-13 years | | 2½ -3 years | 11-13 years | |
| Third molar | 7-9 years | 17-21 years | | 8-10 years | 17-21 years | |

The system in current use in the services is as per Federation Dentaire International system. Modified Palmer System. In this two-digit system, the first digit indicates the quadrant and the second digit a particular tooth in that quadrant. Quadrants are allotted the digit 1 to 4 for the permanent and 5 to 8 for the deciduous teeth in a clockwise sequence, starting at the upper right side; permanent teeth within the same quadrant are allotted the digits 1 to 8 whereas deciduous teeth (1 to 5) from the mid-line backwards. The digits should be pronounced separately: thus the permanent canines are teeth one-three, two three, three-three and four three. Numbering system is as follows :

Permanent teeth

| **(Upper right)** | **(Upper left)** |
|---|---|
| 18-17-16-15-14-13-12-11 | 21-22-23-24-25-26-27-28 |
| 48-47-46-45-44-43-42-41 | 31-32-33-34-35-36-37-38 |
| **(Lower right)** | **(Lower left)** |

Deciduous teeth

| **(Upper right)** | **(Upper left)** |
|---|---|
| 55-54-53-52-51 | 61-62-63-64-65 |
| 85-84-83-82-81 | 71-72-73-74-75 |
| **(Lower right)** | **(Lower left)** |

### Functions of Teeth

Besides mastication, the teeth help in phonetics and also contribute towards aesthetics. The process of mastication involves incision and grinding of food. The incisors serve to incise the food and the premolars and molars do the grinding. The food is broken into smaller portions and is thoroughly mixed with saliva before it is swallowed. For efficient performance of their function the teeth must be correctly aligned in arches and meet in normal occlusion. Occlusion means a contact relationship of the teeth when the jaws are closed. Normally mastication is done at one side only at a time. Chewing ability depends upon the soundness of teeth, firmness of their embedment, hardness of enamel, uniformity of occlusion and strength of the jaws. Chewing the fibrous foods such as meat, radish, celery, carrots, apples and so on develops the jaws and at the same time keeps the gums in proper tone by stimulating blood circulation through them. Children should be taught to chew their food thoroughly, but not to crack nuts or very hard items, less it may damage the enamel, so that the teeth and the supporting structures develop properly as a well functioning organ. Teeth that are properly aligned and occlude normally, help in proper pronunciation of words. Facial appearance, beauty, and symmetry depend upon well-developed jaws and a full compliment of teeth developed in proper alignment. If the teeth are mal-aligned or have spaces between them or a few teeth are missing, the speech becomes faulty and lacks clarity. The unpleasing expression due to irregular or missing teeth may cause self -consciousness, which leads to inferiority complex that may ultimately, result in social maladjustment. Teeth and their supporting structures thus considerably influence and affect the personality.

It has always been commonly believed that with the advancing age the loss of teeth should be considered a natural and inevitable occurrence. However, it is now recognised to be a direct result of pathological process. It was earlier inferred, although rather incorrectly, that below the age of 35 years, the tooth loss was the result of dental caries, where as beyond the age of 35 years it results from 'pyorrhoea'. However, from the epidemiological studies world over, it has been established that diseases of four different supporting structures of the teeth (termed collectively as' periodontum') can have their origin even amongst the school going children. Such global surveys therefore indicate, that although drastic and damaging results might be discernable in a majority of population, beyond the age of 35 or more, the damaging influences on the periodontal tissues can be traced to have commenced even as early as 12-15 years of age. The universal axiom that " prevention is better than cure " still holds true, and to be more effective, this too must therefore commence during the school- going age.

### Dental Plaque

Dental plaque is thin, tenacious, firmly adherent and well organized biofilm adhering to the tooth surface, restorations and dentures. It is different from other deposits on the tooth surface such as materia alba and calculus. Materia alba refers to soft accumulations of bacteria and tissue cells that lack organized structure of dental plaque and are easily displaced with water spray. Calculus is a hard deposit that forms by mineralization of dental plaque and is always covered by a layer of unmineralized plaque. Dental plaque is composed primarily of more than 325 different bacterial species and one gram of plaque contains approximately $2 \times 10^{11}$ bacteria. The dental plaque may be cariogenic, causing dental caries or calculogenic, causing periodontal diseases.

### Dental Caries

It is an irreversible progressive disease of the calcified dental tissue characterised by loss of tooth structure resulting from the dissolution of the tooth mineral and the destruction of its organic matrix. Streptococcus mutans, lactobacilli and other strains from calculogenic plaque act upon refined carbohydrates like sucrose, lactose etc. and produce organic acids which cause demineralization of tooth enamel / cementum. The parts of teeth most vulnerable to carious attack are the pits, fissures and proximal surfaces of teeth. Regardless of where caries starts, if unchecked, it proceeds and spreads from the enamel into the dentine and then reaches the dental pulp. Once the pulp is infected, acute pulpitis may occur which is in an acute inflammatory response in the pulpal tissue and most often becomes chronic leading to inflammatory response in periapical tissues.

Diagnosis

Although bacteria on the teeth are the direct cause of dental caries, a large number of microbiological, environmental and host factors interact to determine whether or not an individual will be affected and if affected, how and to what extent. Dental caries is therefore a multifactorial disease.

In the past, diagnosis of dental caries involved the use of a mouth mirror, an explorer and perhaps bite wing radiographs. "Tug back" or a feeling of resistance when the explorer was moved on the tooth surface led to an almost confirmed diagnosis of caries. Treatment of dental caries as per Black's "Extension for prevention" necessitated considerable loss of tooth substance beyond the actual carious lesion. The modern approach to diagnosis and treatment based on a series of important advances differs from Black's rules in almost all respects. The diagnostic process does not focus only on the presence of lesions but is expanded to include identification of factors that lead to the formation of lesions. This approach therefore makes a distinction between the caries lesion and the caries disease and comprises several important stages :

(a) Clinical and radiological examination to detect early lesions.

(b) Evaluation of factors causing formation of cavities.

(c) Diagnosis of caries disease

(d) Control of identified etiological factors

(e) Treatment of caries lesions

(f) Formation of maintenance programme.

Future diagnosis of caries may be improved by the use of subtraction radiography or lasers. Practical tests like levels of streptococci mutans and lactobacilli, secretion rate and buffering capacity of saliva are among the factors that can now be evaluated reliably.

### Prevention

The multifactorial nature of caries allows scope for a number of different approaches for prevention of this disease. It should also be recognized that certain etiological factors have vastly different consequences, depending on the total mix of factors. For example, the consequence of a diet rich in sucrose is quite different for a person who is frequently exposed to fluorides than for one who has very little exposure.

(a) **Diet** : The contribution of sucrose to implantation, colonization and metabolic activities of cariogenic bacteria has been clearly established and has led to search of sucrose substitutes. Non-sucrose sugars like high fructose corn syrup, invert sugar, glucose, fructose are found to be less cariogenic than sucrose. Caloric sweetener like palatinose, non-caloric sweeteners like aspartame, cyclamate and saccharin and sugar alcohols like sorbitol, xylitol and maltitol can be substituted for sucrose in food products, medicines and toothpaste.

(b) **Fluoride** : Recent reports from Australia and United States have confirmed the safety and efficacy of fluoride in preventing dental caries. The United States has set a limit of 4 mg / litre as the maximum allowable level in drinking water and recommends a level of 0. 7 to 1. 2 mg / litre. During decreases in the pH of the dental plaque free fluoride is available and helps in remineralization process. Moreover fluoride used on a regular basis becomes concentrated in dental plaque and appears to interfere with enzymes used by the bacteria in metabolizing sugars. Fluoridated toothpaste, rinses, gels and tablets are important delivery system. Water, salt and milk are highly cost effective vehicles and should be implemented wherever technically feasible.

(c) **Sealant** : The use of dental sealant is an effective way to prevent pit and fissure caries. One of the barriers to increased use, however is the fact that successful placement and retention of sealant are highly dependent on technique and the availability of appropriate equipment.

(d) **Antimicrobials** : Infants acquire the bacteria that colonize the oral cavity and digestive tract usually through normal handling by their mothers or other care givers. Investigators have found that it is possible to interfere with the process of transmission of mutans streptococci by treating mothers and other close family members with antimicrobials like chlorhexidine gluconate 0. 2 or 0. 12%.

### Immunization

An improved understanding of genetics of oral bacteria is also leading to new approaches to development of safe and effective oral vaccines. The possibility of creating a polyvalent vaccine effective against caries, as well as measles, poliomyelitis and other serious infections is under consideration. With successful programme to reduce the effects of etiological agents & increase host resistance, a new approach to treatment of the caries lesion can therefore be outlined as follows :

(a) Incipient Lesion

  (i) Remineralization using topical fluoride therapy.

  (ii) Counselling on dietary and other risk factors.

(b) Initial Cavitation

  (i) Application of a sealant.

  (ii) Restoration with preventive materials after minimal excavation and preparation with hand or rotating instruments if necessary.

(c) Moderately Sized Lesion

  (i) Restoration conserving maximum amount of tooth substance.

(d) Deep Lesion

  (i) Restoration, conserving maximum amount of tooth substance.

  (ii) Endodontic therapy, if necessary.

This new approach can also be applied to retreatment using same steps and repairing physical defects only if

symptoms are evident in the teeth or supporting tissues.

### Periodontal Diseases

The inflammatory diseases, viz. , gingivitis and periodontitis are quite common.

Gingivitis

While caries has been linked strongly with only a few organisms, the development of gingivitis appears to be caused by nonspecific bacterial plaque flora, which changes over time from predominantly gram positive to more gram negative. In gingivitis the gums become spongy, red, swollen, bleed when brushed or touched, stand away from teeth, often causing little pain and discomfort. Gingivitis therefore is often neglected until it has reached an advanced stage. Gingivitis does not necessarily develop into periodontitis. However, periodontitis is always preceded by gingivitis. The disease can spread to involve deeper supporting tissues viz. periodontal ligament, cementum and alveolar bone. Due to apical migration of junctional epithelium there is formation of a gap between teeth and gums known as the periodontal pocket. Such pockets harbour dental plaque and calculus which, if untreated, ultimately leads to alveolar bone resorption, mobility of teeth and exfoliation.

### Diagnosis

Traditional approaches to periodontal diagnosis include assessment of gingival health and measure of pocket depth, alveolar bone height and loss of periodontal attachment. In addition, the presence or absence of dental plaque and supra and sub gingival calculus is recorded. Assessment of gingival health continues to rely on visual evaluation of the tissues and the extent to which gingival gentle probing can provoke bleeding. The height of alveolar bone is assessed from radiographs. A complete assessment of the periodontal situation should include quantification of the loss of attachment around the teeth (pocket depth and gingival recession as measured from the cemento – enamel junction or some fixed points). It is important to note that pocket depth, bone height and periodontal attachment, represents only the cumulative results of past pathological events and do not reflect the rate of progression of lesions unless measurements of radiographic assessments are made at short time intervals. Many diagnostic tests aimed at detecting early events in the disease process such as bacterial cultures, DNA probes, immunofluorescent assays, specific antibody determinations and the measurements of hydrolytic enzymes, break down products and cytokines are currently being studied. Markers of host defence mechanisms, such as chemotactic responses and phagocytic capability of polymorphonuclear leucocytes have also been investigated.

There is no single organism that is pathognomonic of a change from gingivitis to adult periodontitis. Several species like Porphyromonas gingivalis, Prevotella intermedia, Eikenella corrodens, Wolinella recta, Treponema denticola and Capnocytophaga are present in various combinations in patients with adult periodontitis. The association between a gram-negative anaerobic microflora and periodontitis has been extensively demonstrated and elimination / control of this flora will reduce risk of periodontitis.

### Treatment

Epidemiological studies from many countries show that severe periodontal destruction is less prevalent than it was thought to be 10 to 15 years ago. Improvements in oral hygiene are believed to be the primary factor in this change. Due to increased life expectancy, periodontal care will also be needed by many elderly people who are medically compromised, have physical and mental handicaps, or take medications with potentially harmful side effects.

At present, the prevention of periodontitis is based on mechanical removal of plaque, plus antimicrobial and antiseptic mouthwashes, if necessary. Where Oral hygiene levels are generally high, fewer than 10% of adult population develop advanced periodontal destruction. However, treatment of gingival inflammation (gingivitis) and maintenance of gingival health depend on adequate plaque control through self-care. Instruction in good oral hygiene and constant practice early in life may lead to good habits, which will help to prevent the formation of calculus. Regular examinations and frequent removal of calculus are also beneficial. Regular brushing of teeth, using proper brush and correct technique needs no emphasis. Rubbing and cleaning with finger and rinsing the mouth vigorously with water, after eating, also helps.

Moderate or advanced periodontitis can be treated by elimination of bacterial infection and establishment of effective plaque control. It has been conclusively demonstrated that the large majority of periodontal problems can be treated using non-surgical, conservative approaches. With a better understanding of the biology of connective tissue and of the regenerative potential of periodontal tissues, guided tissue regenerative procedures have been shown to enhance formation of new alveolar bone. This approach has great potential value for individual teeth but can not be applied as a general public health measure.

A rare condition, Juvenile periodontitis, seems to be familial and is characterized clinically by inflammation and rapid progression of periodontal lesion. Presence of Actinobacillus actinomycetecomitans may be an early marker of this disease.

Necrotizing ulcerative gingivitis and its most severe form, noma, appear to be associated with malnutrition in children in some parts of the world. Necrotizing ulcerative gingivitis and stomatitis are also sometimes associated with HIV infection.

Lesions of oral mucosa related to secondary immunodeficiency are similar to the oral manifestations of HIV infection. These lesions are often encountered following organ transplantation, radiation or chemotherapy – all procedures that are being used increasingly.

### Malocclusion

People today usually recognize irregular teeth or obvious jaw deformities and seek treatment from orthodontist. Orthodontic treatment is aimed primarily at malocclusion that lies within the normal range of variation, though even severe deformities can be managed with combined orthodontic and surgical treatment. Most cases of malocclusion are not pathological in origin and so the potential for prevention or biomedical treatment is very limited. The main emphasis in this field is assessment of the effect of various forms of treatment and on improvements in appliance design. Examples of advances in these areas include :

(a) Improved design of brackets, arch wires and headgear.

(b) Improved aesthetics through bonding agents and ceramic brackets.

(c) Standardized indices and reliable measures of malocclusion treatment needs and outcomes.

(d) Increased understanding of the mechanics and long term effects of treatment.

(e) Computerized programmes to aid in diagnosis customised appliance fabrication and analysis of treatment.

**Missing Teeth**

Over the years, tooth loss has decreased significantly due to improvements in scientific knowledge and technology. Increased life expectancy and life long sequelae of dental caries and restorative treatment still means that edentulousness and replacement of teeth will remain issues of concern. Most people want to retain their teeth and when this is not possible, they seek tooth replacement. The concept of loss of all teeth at older age is no longer valid. The aim of at least 20 functioning teeth, not requiring prosthesis mentioned by the WHO is not an absolute goal but rather a step towards the retention of all natural teeth by future generations. Prostheses that endanger the remaining dentition and / or supporting tissues are to be discouraged. The development of bonded replacement is a major achievement in this field.

**Dental Implants**

In the recent past, dental implants have been successfully used for replacing missing teeth without unnecessarily damaging adjacent tissues or compromising function. The principle of osseo-integration of dental implants using high biocompatible materials and appropriate prosthetic concepts has provided the oral health profession with opportunities that transcend the original concept of tissue restitution. During the past decade, implementation of this principle in the treatment of total and partial edentulousness has contributed to a rapid increase in replacing removable dental prosthesis with fixed restorations.

**Oro facial lesions**

Through continuous research over the years it is well established that a number of systemic diseases have oral manifestations. Oro-facial lesions include primarily viral, bacterial and fungal infections, ulceration, pre cancerous lesions, oral cancers and oral manifestations of systemic diseases. Prevention is still impossible in many cases and treatment remains largely symptomatic rather than curative. However, comprehensive evaluation of the patient, including assessment of life style and risk profile is essential in all treatment of oro-facial lesions. This evaluation includes a search for systemic disease as a possible causative factor and assessment of any other predisposing factors.

(a) Oral submucous fibrosis (OSF)

Oral submucous fibrosis was initially described in 1966 by Pindborg and Sirsat as an insidious, precancerous, chronic disease that may affect the entire oral cavity and that sometimes extends to the pharynx. Although it is occasionally preceded by the formation of vesicles, OSF is always associated with a subepithelial inflammatory reaction followed by fibroelastic changes of the lamina propria, accompanied by epithelial atrophy. Various factors have been implicated in the development of OSF, the most common of which is chewing areca nut. Associations with tobacco use and vitamin deficiency have also been reported. Symptoms of OSF include the following: Trismus due to oral fibrosis and scarring, pain and a burning sensation upon consumption of spicy food, increased salivation, change of gustatory sensation, hearing loss due to stenosis of the eustachian tubes, dryness of the mouth, nasal tonality to the voice, dysphagia to solids, impaired mouth movements (eg, eating, whistling, blowing, sucking). Classification system for the management of OSF.

(i) Group I : earliest stage, interincisal distance of greater than 35 mm.

(ii) Group II: interincisal distance of 26-35 mm.

(iii) Group III: Moderately advanced cases, interincisal distance of 15-26 mm Fibrotic bands are visible at the soft palate, and pterygomandibular raphe and anterior pillars of fauces are present.

(iv) Group IVA: Trismus is severe, with an interincisal distance of less than 15 mm and extensive fibrosis of all the oral mucosa.

(v) Group IVB: Disease is most advanced, with premalignant changes throughout the mucosa

**The medical management** : Cessation of the habit followed by use of Steroids, Placental extracts, Hyaluronidase. Surgical management in severe cases: excision of the fibrous bands, buccal pad of fat grafting or Split-thickness skin grafting following bilateral coronoidectomy.

(b) Aphthous stomatitis

This most common oral condition has been usually associated with stress, nutritional deficiencies and malabsorption syndrome. Various symptomatic treatment options have been proposed but improvements seen are considered to be due to placebo effect.

(c) Lichen Planus

It is a common oral mucosal disease of unknown etiology, which often occurs without simultaneous skin lesions. In the ulcerated form, the disease often presents significant therapeutic problems. Occasionally, patients may present

with lesions called lichenoid reactions, which are sometimes related to drugs and / or graft versus host reactions.

### Impacted tooth

The definition of an impacted tooth is "tooth that can not, or will not, erupt into its normal functioning position, and is, therefore, pathologic and requires treatment.

Mandibular and maxillary third molars, followed by maxillary canine are the teeth most commonly impacted. Failure of teeth to erupt into their normal position in the arch may result in problems that include pericoronitis, pericoronal abscess, periodontal disease, caries, and root resorption of adjacent teeth, dentigerous cysts or odontogenic tumors.

Clinical features include: redness, swelling and tenderness of the gingiva around the impacted tooth, unpleasant taste when biting down on or near the area, halitosis, pain radiating to ear, trismus, and palpable lymph nodes of submandibular region.

Treatment of impacted third molars involves surgical extraction of the teeth.

### Craniofacial injuries

One of the commonest consequence of RTA is a head injury with Craniofacial fractures. Basic principles of management of these fractures are similar to those of fractures in other regions, however it must be kept in mind the presence of vital structures in the region. The armamentarium required for treating such fractures is quite different from the regular orthopedic appliances. Soft tissue injuries also require careful attention. The repair of soft tissue injuries must be done delicately and diligently in layers so as to prevent and minimize scar formation over the face. The common maxillofacial fractures are described below.

### Mandibular fractures

Mandible is a strong tubular long bone bent into a blunt V-shape. There are areas of weaknesses along which the mandible frequently fractures following trauma. It is a unique bone because of ginglimoid, diarthroidal, fibrocartilagenous joint between the mandibular condyles and glenoid fossa. Mandible plays an important role in mastication, speech and esthetics of the face. The commonest area of mandible to fracture is the angle, but in case of multiple fractures the condyles are the commonest. The fractures of the mandible are displaced along the pull of the muscles attached around the fractured site. Bilateral parasymphysis fractures may cause the tongue to fall back and compromise the airway. The diagnosis of mandibular fractures can be confirmed from presence of swelling, tenderness and step along the borders of the mandible, deranged occlusion, mobility between the teeth segments, irregular arch form, sensory disturbance along the distribution of mental nerves. The radiographic investigations include PA mandible open mouth 10 deg, Lateral oblique view mandible, reverse townes view. Specialized Radiologic investigations include orthopantamagraph which gives a clear picture of whole of mandible. Intraoral periapical (IOPA) radiographs are used for visualizing the teeth and surrounding alveolar bone.

The goals of management of mandibular fractures is to restore form and function. The most important factor to be considered is to return the patient to his natural dental occlusion, failing which patient may not be able to chew food properly and will have discomfort. Treatment consist of either open or closed reduction. Following open reduction internal fixation is done using miniplates and screws. As far as possible intra oral approaches are used to prevent a scar on the face. Closed reduction of fractures in the dentate segment is achieved by stainless steel arch bars which are firmly tied to the upper and lower teeth using steel wires. Fractures are mobilized and intermaxillary fixation is carried out to achieve patients natural occlusion. Miniplates and screws are commonly used for fixation, although wires are also used but with inferior results.

### Midface fractures

The midface consist of the maxillae, nasal bones, zygomatic complex and the bones forming the orbit. The commonest bone to fracture are the nasal bones and followed by zygomatic complex. The midface consist of strong vertical and horizontal buttresses between which are thin fragile bones. These buttresses help to transmit masticatory stresses to the skull base. A fracture of any of the buttresses requires to be anatomically reduced and fixed to prevent imbalance in the transmission of forces and consequent discomfort and pain to the patient. The central midface fractures are also known as Le Fort fractures. Le Fort I fractures are low horizontal fractures just above the level of the nasal floor. Le Fort II level fractures are pyramidal beginning over the nasal bone extending into the orbit upto ethmoids and then leaving the orbital floor inferiorly and laterally to fracture middle of the ptyregoid plates III. Le Fort III level fractures are also called craniofacial dysjunction. Here the fracture begins at the fronto-nasal suture region and the entire facial skeleton is displaced along the cranial base postero-inferiorly, giving the patient a dish face appearance and almost always associated with severe head injury and CSF leak. Some times airway also gets compromised in midface fractures. Management of all the midface fractures is by open reduction and internal fixation where ever possible using intraoral or coronal and brow incisions

### Zygomatic complex fractures

Zygomatic bones form the malar prominence or the cheek bone which are important for facial esthetics and also play an important role in protection of the orbital contents as they prevent a direct injury to orbit unless the injury is by a very small object. It is one of the commonest fractures of the craniofacial skeleton. The zygomatic arches which are present on the sides are especially fragile and fracture readily on impact. The zygomatic bone is a roughly quadrangular strong bone and any impact fractures along its articulations with frontal, maxillary, sphenoidal and temporal bones. Clinically the fracture can be appreciated by presence of depression on the malar eminence,

dimpling on the lateral aspect of face, restricted mouth opening can occur if the zygomatic arches fracture inwards and impinges on the coronoid process of mandible. Step and tenderness can be appreciated at the frontozygomatioc suture region, infraorbital rim, junction of body and arch and intraorally over the zygomatic buttresses in the region of maxillary first molar. The goals of management include restoration of facial form and function. Isolated zygomatic arch fractures can be managed by closed reduction by passing instrument like periosteal elevators or more specialized Rowe's elevator, Bristow's elevator along lateral brow, temporal or an intraoral vestibular approach and elevating the arch. However if fractures are older than 15 days an open reduction and internal fixation using a hemicoronal incision is required. Fracture of zygomatic complex requires open reduction and internal fixation. Normally a three or two point fixation is required to stabilize the fractured segments. The fixation is carried out on the frontozygomatic region by a lateral brow approach, Zygomatic buttress using a vestibular approach and along the infra orbital rim via transconjuctival, subciliary approach (in case of three point fixation) using micro or miniscrews and plates. Usually a two point fixation along frontozygomatic region and over the buttresses suffices.

### Oral Cancer

Worldwide, oral squamous cell carcinoma is one of the most common cancers. Epidemiological and cancer surveillance studies have shown that its prevalence varies from country to country but about 30% of all cancerous lesions of oral cavity occur in our country. Genetic factors, malnutrition, smoking and alcohol abuse are main predisposing factors while some of the oral white and red lesions show variable transformation rates to cancer. At present histopathological investigation of the lesions remains the method of choice for diagnosis but blood antigens, cell surface carbohydrate fractions, DNA cytology, oncogene expression and flow cytometry have an important part to play in early detection.

Treatment of oral carcinoma remains largely surgical, chemo and radio therapeutic. The 5-year survival rate has improved in recent times. Patient's quality of life has undoubtedly been enhanced by improved diagnostic and surgical techniques and rehabilitation but only the very earliest detection of disease can improve survival, as patient's behavior is unlikely to change radically in the short term

### Oral Manifestations of HIV Infections and AIDS

In most of the countries, HIV epidemic is spreading with alarming speed. WHO prediction for the year 2001 was 10 million AIDS cases and 40 million HIV seropositive individuals. In many cases, oral lesions are the first signs of HIV infection and members of the oral health profession should therefore be well trained in recognizing these lesions. The following oral conditions have been reported to occur in HIV infected patients.

(a) Candidiasis
(b) Erythematous, hyperplastic, pseudomembranous hairy leukoplakia
(c) HIV – gingivitis
(d) HIV – Necrotizing gingivitis
(e) HIV – Periodontitis
(f) Kaposi's sarcoma
(g) Non Hodgkin's Lymphomas

In patients with AIDS, treatment of oral Candidiasis should follow general recommended guidelines; use of a triazol drug or Fluconazole may be required. Necrotizing gingivitis and Stomatitis are also frequently encountered. Good oral hygiene is essential, supplemented with antibiotic treatment if necessary. The drug of choice is often Metronidazole. For Kaposi's sarcoma various treatments are used including radiotherapy, surgery and intralesional cytotoxic drugs such as Vinblastine, Vincristine and Bleomycin. Like Candidiasis, hairy leukoplakia is a strong predictor of AIDS.

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# Special Health Issues for the Armed Forces


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# Aviation Health

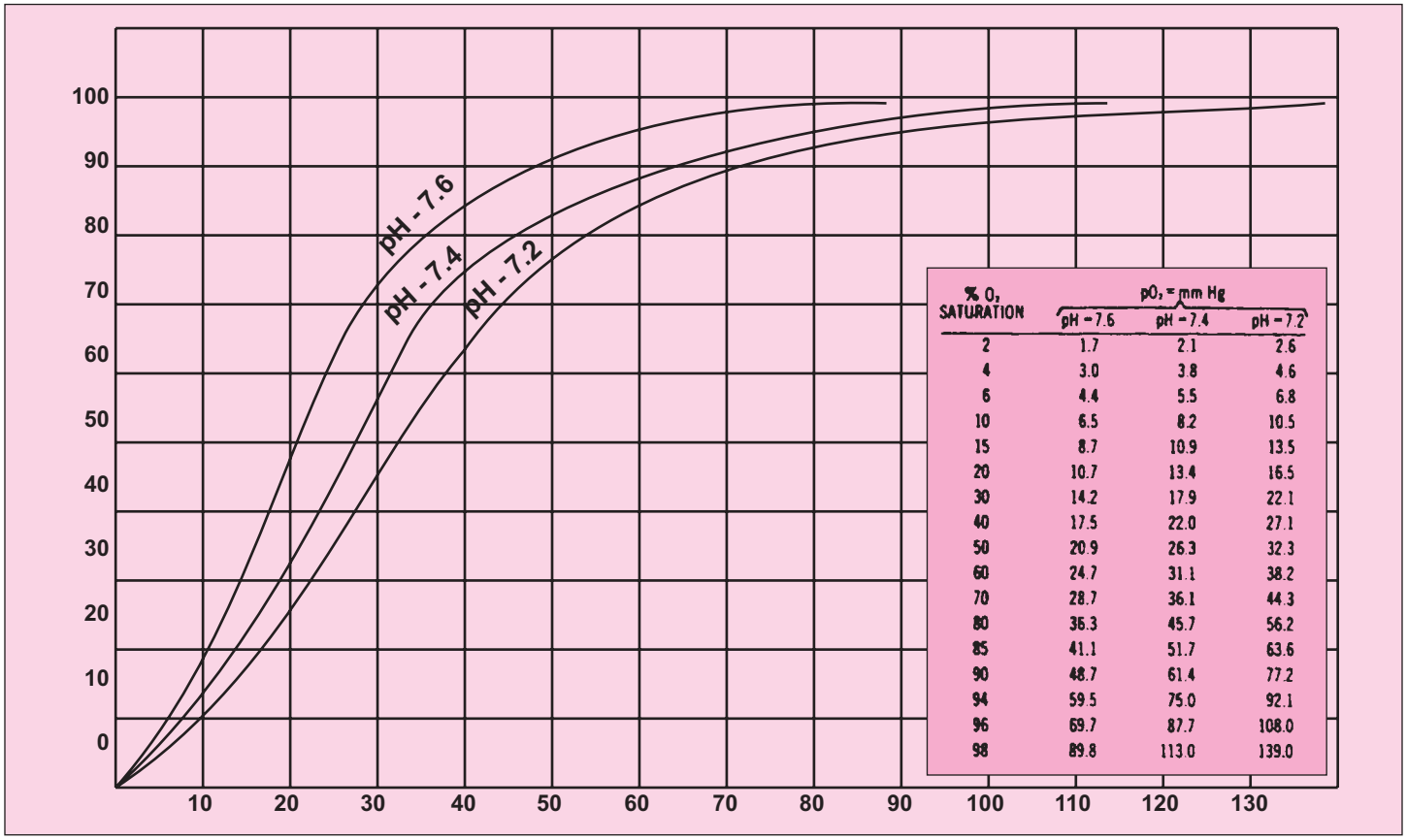
## Introduction

The general principles of maintenance of health and prevention of diseases are the same in the Air Force as in Navy and in Army. However, in recent years, the tremendous increases in the speed, altitude and range of flight of modern aircraft have widened the range of variations in the external environment to which aircrew are exposed. Due to this the aircrew has now become almost completely dependent on specialized equipment for survival in the isolated and extraordinary cabin environment. The design and development of such equipment, instructions for its use by aircrew and its maintenance by ground crew, are of immense aeromedical importance. The IAF medical officer's particular concern with regard to the health of the flyers is to provide him with protection against stresses and strains caused by flying operations. Besides, his periodical physical examination, his care during sickness and injury and application of the conventional preventive medical procedures, the health care of flying personnel requires proper understanding of the physiological problems of flights. Ailments and conditions, which would be considered trivial or minor in other occupations, may be potentially hazardous in the case of a flyer. The safe piloting of an aircraft, under all conditions of weather, specially during landing and take off, during the performance of aerobatics at high speeds and during aerial combats demands a high degree of physical and mental fitness and alertness in all flying personnel whatever may be the nature of their duties in flight. By constant vigilance and endeavour, the medical services are expected to help in maintaining the flyers at the peak of their physical and mental efficiency.

The specific conditions pertaining to aircrew and Air Force personnel in aviation are as under :

(a) Hypoxia.
(b) Rapid decompression & Decompression sickness.
(c) Heat Stress
(d) Motion Sickness (Air Sickness)
(e) Psychiatric and Psychological problems
(f) Accelerations, Supermanouverability
(g) Vibrations
(h) Noise, Otitic barotrauma and barosinusitis
(j) Visual problems in Aviation

Fig - 1 : Oxygen Dissociation Curves for Human Blood (Flight Surgeon's Manual US AF)




| % $O_2$ SATURATION | $pO_2$ = mm Hg | | |
|---|---|---|---|
| | pH - 7.6 | pH - 7.4 | pH - 7.2 |
| 2 | 1.7 | 2.1 | 2.6 |
| 4 | 3.0 | 3.8 | 4.6 |
| 6 | 4.4 | 5.5 | 6.8 |
| 10 | 6.5 | 8.2 | 10.5 |
| 15 | 8.7 | 10.9 | 13.5 |
| 20 | 10.7 | 13.4 | 16.5 |
| 30 | 14.2 | 17.9 | 22.1 |
| 40 | 17.5 | 22.0 | 27.1 |
| 50 | 20.9 | 26.3 | 32.3 |
| 60 | 24.7 | 31.1 | 38.2 |
| 70 | 28.7 | 36.1 | 44.3 |
| 80 | 36.3 | 45.7 | 56.2 |
| 85 | 41.1 | 51.7 | 63.6 |
| 90 | 48.7 | 61.4 | 77.2 |
| 94 | 59.5 | 75.0 | 92.1 |
| 96 | 69.7 | 87.7 | 108.0 |
| 98 | 89.8 | 113.0 | 139.0 |

(k) Specific hazards in IAF depots and workshops /BRDs viz. LOX, LASER, noxious gases and vapours
(l) Problems in Missile bases
(m) Flying Fatigue and Long duration flying with air to air refueling
(n) Spatial Disorientation
(o) Aircraft Sanitation
(p) Ergonomics & Escape from Aircraft
(q) Crew Resource Management
(r) Night Vision Goggles operations
(s) Aircraft Accident Investigation
(t) Women in Aviation

## Hypoxia

The effects of oxygen deficiency in the upper atmosphere are due to reduced partial pressure of oxygen ($PO_2$) in inspired air at altitude and are of vital importance in aviation. The altitude hypoxia leads to oxygen deficiency in tissues, which manifests in the form of physiological, psychological and psychomotor impairments of varying degrees, and may even cause death. In a healthy individual in early stages, the symptoms are fatigue, mild headache, drowsiness, frequent yawning, lethargy & poor judgment. The relationship of partial pressure of oxygen in the alveoli and haemoglobin saturation is given by the Oxygen Dissociation Curve (Fig - 1)

### Time of Useful Consciousness

Time of useful consciousness (TUC) is the period of time from the interruption of the oxygen supply or exposure to an oxygen-poor environment, to the time when capability to perform useful function is lost. The individual is no longer capable of taking proper corrective and protective action to undo his predicament. Table -1 reflects the various altitudes with the corresponding average TUC. These times have been established from observations over a period of years (Flight Surgeon's Manual US AF).

At altitudes higher than 3,048 m (10,000 ft), there is likely to be impaired judgment, overconfidence, tendency to commit mistakes but inability to realize them, repetitive

Table - 1 : Time of useful consciousness

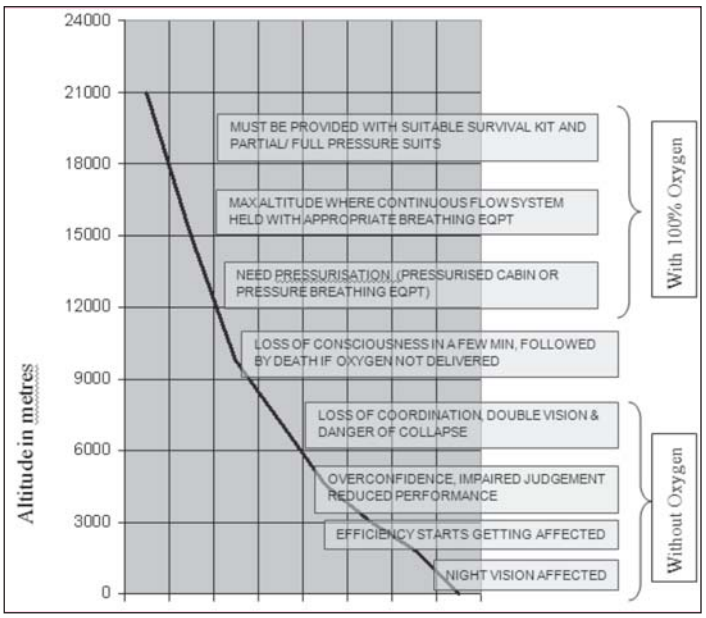
| Altitude (Ft) | TUC |
|---|---|
| 18000 | 20 to 30 Min |
| 22000 | 10 Min |
| 25000 | 3 to 5 Min |
| 28000 | 2. 5 to 3 Min |
| 30000 | 1 to 2 Min |
| 35000 | 0. 5 to 1 Min |
| 40000 | 15 to 20 sec |
| 43000 | 9 to 12 Sec |
| 50000 | 9 to 12 Sec |

thoughts and fixed ideas, loss of memory, changes in behaviour with outbursts of hilarity. At a later stage, the subject begins to show tremors and becomes generally clumsy in his movements. If hypoxia is severe, it leads to convulsions, unconsciousness and even death. The effects of oxygen lack in relation to altitude and pressure are shown diagramatically in Fig 2.

### Prophylactic and Remedial Measures

(a) Use of Oxygen

Fig - 2 : Effect of oxygen lack in relation to altitude and pressure




Normal alveolar oxygen tension must be maintained during flight by use of oxygen through well fitting oxygen masks. The flow of oxygen is regulated through a 'continuous flow or demand system' which must be periodically checked to ensure serviceability. It is advised to use oxygen under the following situations :

(i) At heights above 3000 m during day flying and at heights above 1200 m during night flying for aircrew.
(ii) Passengers, other than aircrew are expected to use oxygen above 3600 m cabin altitude.
(iii) For casualties and the sick, oxygen is used at the discretion of the medical officer.

(b) 100% Oxygen

In an established case of acute hypoxia, 100 percent oxygen must be used. Respiratory and circulatory adjuvants should be used simultaneously in the event of a coexistent respiratory failure or circulatory collapse and may be combined with mechanical or manual artificial respiration, if indicated.

## Decompression Sickness

The atmosphere consists of a mixture of approximately 21 percent oxygen, 78 percent nitrogen and I percent other gases (including carbon dioxide). The total atmospheric pressure at ground level is 1ATA (14.8 psi)

under which pressure, some nitrogen and oxygen are dissolved in the human tissues. Since oxygen is used in the body, little of it exists in the free and uncombined form. Nitrogen being an inert gas is held in solution in the body purely in the dissolved form. It is more soluble in fats than in water. The body fats dissolve 5 to 6 times more nitrogen per unit mass than does the blood. At high altitudes under reduced atmospheric pressure, nitrogen diffuses out of the body tissues and fluids in the form of bubbles. These bubbles may lodge in various areas of the body and produce symptoms by direct mechanical pressure. They also produce indirect effects through production of biochemical substances at the blood bubble interface causing vasoconstriction and intravascular clotting. The bubbles may lodge outside or inside the capillaries causing compression or obstruction. All these situations produce multitudes of disturbances and symptoms.

**Clinical features**

'Symptom-complex' caused by the bubbles of nitrogen released in the tissues and blood stream complicate those produced by expansion of gases within the body cavities which occur on exposure to reduced atmospheric pressures. All these symptoms, excluding those due to hypoxia and cold, fall under a group of features termed 'Decompression Sickness' which may follow exposure to altitudes above 7500 m. The severity of sickness depends on the rate of ascent, altitude, duration of exposure and on the individual susceptibility. Age and obesity, influence individual susceptibility. The symptoms consist of bends, chokes, gas pains, skin manifestations, neurological symptoms, circulatory collapse, fainting, unconsciousness and even death.

(a) Bends

This is the most frequent symptom and is characterized by pain in or near the joints. Residual stiffness and dull ache may persist for a few days after exposure.

(b) Chokes

This respiratory distress of sudden onset is characterized by retrosternal discomfort, sense of suffocation and apprehension, rapid shallow breathing, marked inspiratory distress, non-productive cough and sometimes cyanosis.

(c) Cutaneous manifestation

These consist usually of itching in the thighs, arms and trunks. Rarely erythema or petechiae may develop.

(d) Neurological manifestations

These are varied neurological manifestations, visual field defects being the commonest. These defects are usually transitory but may persist after descent. There may be mental confusion, giddiness or unconsciousness.

(e) Circulatory and pulmonary manifestations

These may be primary or secondary associated with bends and/or chokes. In a severe case it may even lead to circulatory failure, pulmonary oedema, pleural and pericardial effusions, coma and death. Postmortem findings in cases of collapse are essentially those of shock.

(f) Gas pains

These are due to expansion of intestinal gases under reduced external pressure.

**Prophylactic and preventive measures**

(a) Cabin / Cockpit pressurization

To prevent the ill effects of flying at great heights, mainly the decompression sickness, hypoxia and abdominal distension, the most adequate measure is the use of a pressurized cabin or cockpit. All aircraft designed to fly at high altitudes are now pressurized.

(b) Denitrogenation of the body tissues

Denitrogenation of the body tissues before ascent to critical altitudes is done by breathing 100% oxygen at ground level for ½ to 1 hour. This reduces the incidence of bends above 10,000 m by more than 50%.

(c) Diet Control

Gas pains, however, do not respond to above treatment. Avoidance of gas forming food items in diet that are known to cause abdominal distress at ground level minimizes the likelihood of gas pains.

(d) Management of a case

Immediate descent to ground level and no further ascent for at least 48h is the immediate remedial measure. If anything occurs other than itching and uncomplicated 'bends', the subject must be treated as a case of potential post-decompression shock and observed for at least 24h. Blood pressure and haematocrit readings should be taken periodically. If BP starts falling or the haematocrit reading starts rising, the patient must be transferred to the nearest service or civil hospital and treated to maintain the circulatory blood volume with intravenous plasma or dextran. Normal saline and dextrose are less effective. Paraldehyde may be administered to allay excitement; however morphine should not be given. Decompression up to 2 - 3 atmospheres is life saving and is the treatment of choice, where facilities exist. If a hyperbaric chamber is nearby and the patient has continuing symptoms, he should be moved to the chamber and immediately treated as per the hyperbaric treatment table. The effectiveness of treatment decreases as the duration of time between the onset of symptoms and treatment increases. If there is no hyperbaric chamber nearby, arrangements should be made for immediately transporting the patient to the nearest hyperbaric facility capable of administering proper treatment. The patient should be kept on 100% oxygen by aviators mask during transportation to the chamber. (De Hart Textbook of Av Med)

**Rapid Decompression**

A breech in the integrity of pressurized cabin can give rise to the problem of sudden decompression. The severity of effects of rapid decompression depends upon the volume of the cabin, area of the opening in the cabin and the pressure differential between the cabin altitude and the ambient altitude.

The general effects of rapid decompression are due to sudden expansion of gases within the closed cavities of

the body. Sudden expansion of the internal gases can produce severe pain and can produce a shock like reaction if the gases are not allowed to escape. Apart from this, if the glottis is closed then considerable damage to the lungs can occur. Low temperatures may further complicate the effects of rapid decompression cold injuries. Rapid decompression is an emergency and the pilot is advised to descend to lower altitudes as fast as possible.

## Hazards due to Extreme Temperature Variations

### Atmospheric Climate

In a tropical country like India where the climatic variations range from extreme heat to extreme cold, it is essential that the IAF medical officers are conversant with the environmental problems faced by the aircrew when exposed to extreme weather conditions.

### Heat Stress

Heat stress is of greater importance as compared to the cold stress as most of the operational flying is done in hot and dry or humid climates of the West and Eastern parts of this country. As far as heat is concerned, the body is said to be at thermal equilibrium if the gain of heat due to metabolism, convection, conduction and radiation is equal to the heat loss. The various indices of heat stress are WBGT, FITS (Fighter Index Of Thermal Index), ET (Effective Temperature), CET (Corrected Effective Temperature), WDI (Wet Dry Index or Oxford Index) (Fig - 3).

Sources of Heat

(a) Metabolic heat.

(b) Aerodynamic heat or kinetic heating. This is produced by the friction between the surface of the aircraft and the air especially during high speed low altitude run in low level interception, dive bombing and low level flying.

(c) High heat load inside the aircraft, parked in the hot sun, mostly from the accumulated radiant heat and the ambient air temperature. During the hot summer months in Northern India, the temperature inside a fighter / bomber aircraft sometimes reaches as high as 60˚C or even more.

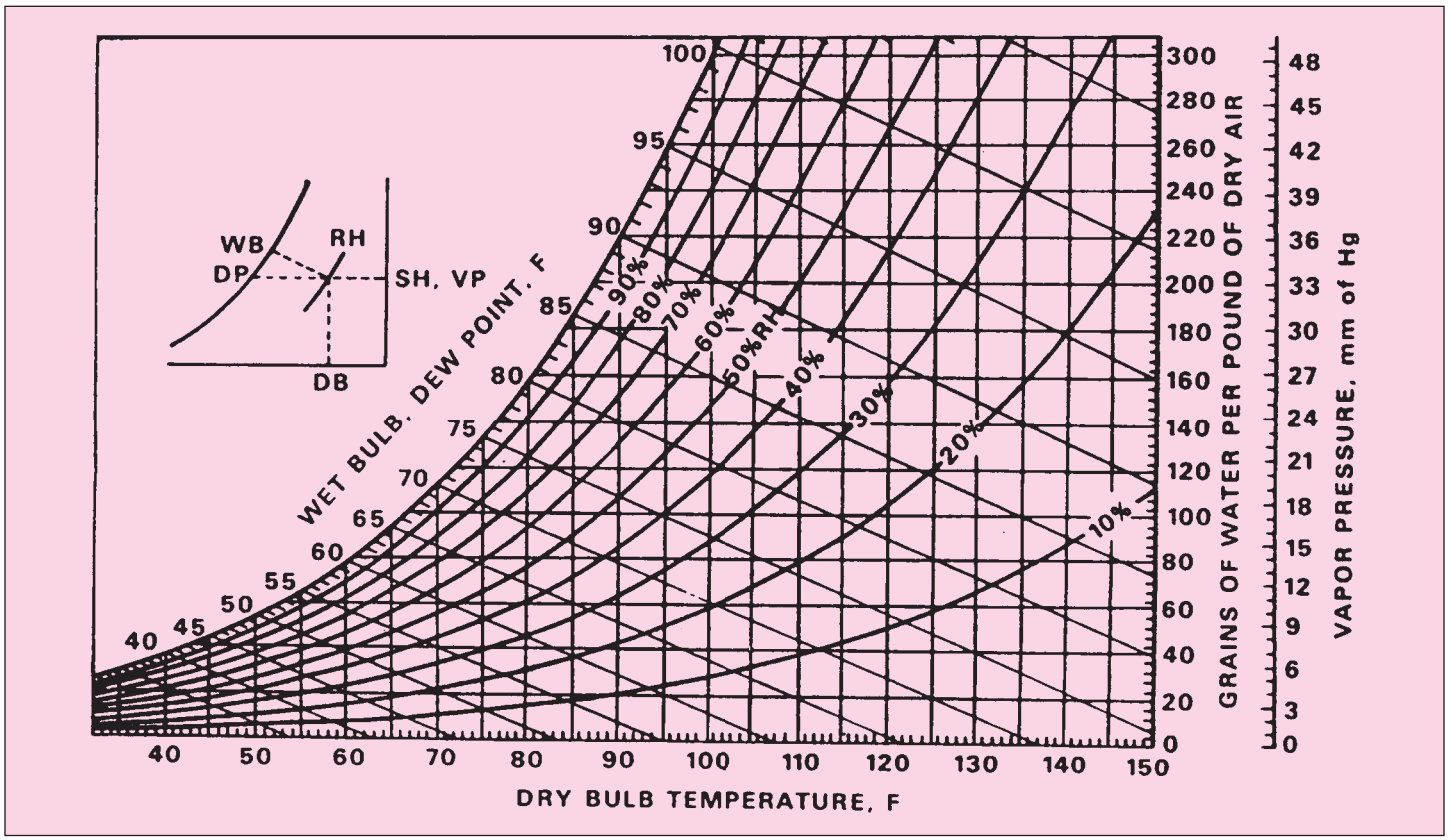
(d) Wearing flying clothing assembly viz, anti 'G' suit, partial or full pressure suit, partial or full pressure helmet, flying gloves, boots, goggles, overall, and sometimes snow and sea survival kits, prevent heat loss from the body and almost block all the channels of heat transfer from the body.

Effects of Heat Stress

The ill effects of heat on a pilot are directly proportional to

Fig - 3 : Psychrometric chart at sea level.

**Variables include dry bulb temperature, water vapor pressure, absolute humidity, wet bulb temperature, relative humidity, and dew point temperature.**



the degree of heat load inside an aircraft and the duration of heat exposure. The later is dependent upon the time taken by the pilot to reach parked aircraft from the aircrew room, time spent on preflight check and to get clearance from the control tower, and taxiing the aircraft to the take off point. This, on an average, works out to approximately 30 min under normal conditions. This does not take into account the delay in take off for various reasons which may extend the exposure time considerably. Heat strain indices include Heat Accumulation Index, Modified Craig's Index and $P_4SR$. Studies conducted at IAM under simulated conditions have shown the following ill effects :

**(a) Psychological Effects**

(i) Irritability.

(ii) Lack of concentration.

(iii) Tendency to fiddle with instruments and other things even when not required to do so.

**(b) Subjective Symptoms**

(i) Sense of suffocation.

(ii) Abdominal discomfort.

(iii) Heat cramps especially in calf muscles.

(iv) Giddiness.

(v) Generalized feeling of discomfort.

**(c) Objective Signs**

(i) Rise in oral temperature between 38.3˚C - 39.3˚C.

(ii) Rise in skin temperature.

(iii) Rise in pulse rate sometimes reaching up to 140/min.

(iv) Rise in tidal volume.

(v) A gradual rise in systolic pressure with gradual fall in diastolic pressure, with consequent increase in pulse pressure. At later stages both systolic and diastolic pressures tend to drop and indicate the end point of tolerance.

(vi) Extra systole in the ECG tracings in some cases.

(vii) Neuromuscular in-coordination.

(viii) Severe sweat loss. An average loss of approximately 500 $g/m^2$ body surface has been reported after 45 min exposure to severe heat stress.

**(d) Physical Injuries**

Blisters have been known to occur when the heated metal parts of the aircraft or harness come in contact with the bare skin surface.

Preventive Measures

The effects of heat stress can be prevented by providing adequate cooling to the pilot. The cooling can be provided either by air conditioning or by providing cool microenvironment between the skin surface and the clothing.

**(a) Air Conditioning**

The conventional type of air conditioning system which makes use of freon gas is not feasible in the modern day fighter aircraft due to its bulkiness, high power consumption, and increased pay load. In the aircraft, air conditioning is usually provided by air-cycle cooling. The hot air is tapped from the engine compressor before the combustion stage. It is passed through primary heat exchanger where the ram air (atmospheric air) acts as the coolant. It is then passed into a cold air unit where it is further cooled by the process of expansion. This cold air is then distributed in the cabin. There are certain disadvantages in this system such as -

(i) The system works only when the engines are running. It is thus useless when the aircraft is parked on the tarmac.

(ii) It makes use of ram air i. e. the aircraft must be in motion to get the best effect and since, at lower altitudes the ram air is hotter than at higher altitudes, the efficiency of the system is much reduced at lower altitudes.

**(b) Cool Micro Environment**

(i) **Air ventilated suit** : This is a suit consisting of numerous tubes stitched into the suit material. The tubes are provided with multiple small holes. The cooling is provided by pumping cold air or dry ambient air through the tubes. Cooling takes place by convection and evaporation.

(ii) **Liquid cooled suit** : This is a close fitting suit made of stretch nylon, which consists of a number of capillary tubes distributed all over the body. A cool liquid (glycol + water mixture) is pumped through this suit and thus provides cooling by eliminating heat.

**Cold Conditions**

Cold environmental conditions in winter and at high altitude tend to lower the temperature in the interior of the aircraft. This gives rise to discomfort, loss of efficiency and in extreme conditions may lead to frostbite. However, such occasions are not frequent. In today's flying conditions, the pilot is exposed to cold only during emergency situations like failure of the pressurization system, either due to enemy action or mechanical failure and bale out at high altitude or over snow bound areas. Besides, a thorough check of the air conditioning system before taking off, provision of impervious clothing with adequate insulation, flying boots, chamois leather gloves, proper head gear and / or the snow survival pack would help in preventing cold injuries. Dangers of cold, snow survival and preventive measures should be taught to and be understood by all flying personnel.

## Motion Sickness (Air Sickness)

Motion sickness causes nausea and, vomiting with variable mental depression during any form of motion. In the air it results from variation in the speed and direction

of motion of an aircraft. There is a very wide range in individual sensitivity, but majority readily adapt to any form of motion. Up to 15% of all flying trainees become air sick at least once during the training period but only about 5% become air sick more than once. Persistent air sickness is not very common.

**Prophylactic and Remedial Measures**

(a) Careful Selection of Aircrew

This should be made by eliminating individuals prone to persistent motion sickness. Individuals showing susceptibility to air sickness and failure to acclimatize should be evaluated psychologically.

(b) Adaptation

This is the most effective preventive measure. Aircrew on their first flight may get severe air sickness but rapidly cease to be troubled by it as their training proceeds. Only a very small minority fail to get adapted. Restriction of head movements may prevent the onset of motion sickness. However, complete prevention of air sickness in military aircraft is difficult to achieve because of the design of the aircraft and the weather conditions in which sorties are flown. Violent maneuvers should be avoided whenever possible, especially when abinitio trainees are on board.

(c) Food and Drugs

There is a great individual variation in the relationship of air sickness to full or empty stomach and to the ratio of liquid to solid food that is taken immediately before or during a flight. Prophylactic therapy is useful in individuals liable to mild air sickness only until he becomes conditioned to the motion of the aircraft. Once adaptation has developed, the therapy should be discontinued. Drugs are usually not permitted for aircrew, but may be given to those engaged in flying at infrequent intervals such as passengers or paratroopers. Of the few drugs useful, hyoscine hydro bromide 0.3 - 0.6 mg taken one hour before take off is still the most useful. The side effects of dose are negligible and it has good anti-air sickness properties. Drugs are of little value in those individuals who get persistent or severe air sickness or fail to adapt.

(d) Motion sickness desensitization programme

This programme incorporates systematic desensitization by simulators viz. Barany's chair / DISO simulator along with psychotherapy and yogic exercises, to tone up the autonomic nervous system.

## Psychiatric and Psychological problems

Aircrew is exposed to a variety of stresses, which place heavy demands on their physical and mental stamina. Any flying accident, particularly a fatal one, in the squadron brings this fear back into the conscious and the aircrew especially an inexperienced one may start feeling that he may be the next victim. This fear affects his performance and he starts committing mistakes, further shaking his confidence in his own ability and thus a vicious circle may set in.

Besides the psychiatric assessment done at various multispecialty AF Hospitals, psychological assessment is done at IAM. Commonly used psychometric tests are- 16 Personality Factor Test, Eyesenck's Personality Inventory and Rorschach's Test.

Aircrew is aware that it is impossible to predict in-flight emergencies and he may land in difficult situations from which it may sometimes be impossible to extricate himself. Split second delay in decision-making may prove fatal. During an in-flight emergency, he alone is responsible for safety of aircraft and its cargo. He has, therefore, to use all his mental and physical reserve to bring the aircraft safely back to the base. No doubt, he can abandon the aircraft if he finds the emergency situation beyond his capabilities but his pride makes him stick to the aircraft till the last moment before abandoning it. To perform best, he has to be at absolute mental ease and must be calm and composed in the face of worst of situations. Fatigue impairs his performance. Hypoxia, 'G' forces, bad weather, hypoglycemia, long flying hours and tenures of duty without leave, lack of sleep, vibration, mental worries, domestic problems, and administrative work loads, all predispose to aircrew fatigue impairing his performance especially in the face of emergencies. Under the circumstances, he may need a higher than normal level of stimulus to respond.

**Preventive Measures**

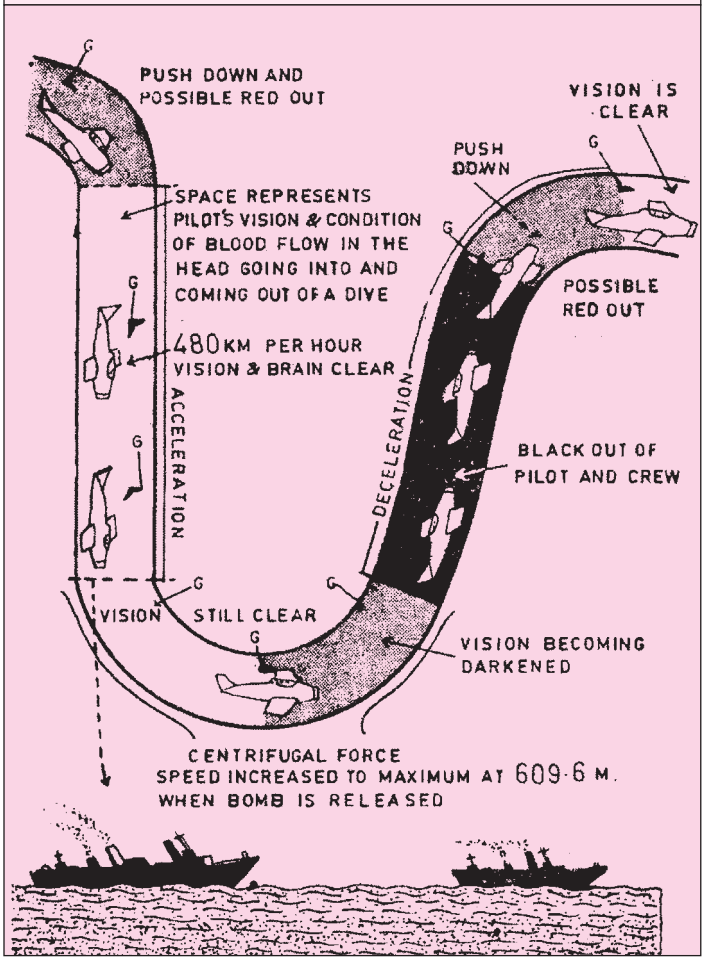
Squadron medical officer should constantly endeavour to understand the aircrew individually, their personal problems, their personality and response to training; their love or aversion for flying and their ability to mix freely with others. A patient and tactful handling of unsure and borderline aircrew can do wonders to build up their confidence. Aircrew should be made to feel that, accidents and fatalities are meant for others and not for them. Flying must continue regardless of the fatal accidents. This is the only way to build up aircrew confidence. This rule is especially applicable to borderline flyers. Nothing can be more detrimental to aircrew morale than interruption of flying after fatal accidents. Easy approachability of a friendly squadron medical officer will encourage the aircrew to come to him with their personal problems and if he can help them solve these problems, he will have not only established himself as a friend of aircrew but can play a very important part in building up aircrew morale. He should be on the look out for the earliest signs of aircrew fatigue and take immediate action with the authorities to deal with it. Comfortable accommodation, adequate sleep, relaxation, rest and recreation, nutritious and palatable food, proper spacing of sorties and short spells of leave after long duty hours are a few of the essentials where a squadron medical officer can help by interceding with the commanders. In the event of a cumulative and chronic fatigue, it may become necessary for a squadron medical officer to take aircrew temporarily off flying.

## Effects of Acceleration

With the introduction of highly maneuverable, high speed jet aircraft, the effects of high accelerations have become important. For considering the details of physiological

effects of acceleration, it is necessary to understand the

Fig - 4 : Effects of acceleration, deceleration, Centrifugal force and push down




terminology used in acceleration :

**(a) Speed**

It indicates the magnitude of motion and is usually expressed as km/mile/m or ft/per second (ft/sec, or m/sec).

**(b) Velocity**

It is the distance travelled per unit time in a given direction and indicates both magnitude of motion and its direction. Thus, it is a vector quantity. It is expressed as ft or m per second in a given direction e. g. 40 ft / sec, south.

**(c) Acceleration**

It is the rate of change of velocity per unit time and as such can be affected by change of speed in magnitude or direction or both. It is expressed as m or ft/ $sec^2$.The same unit is used for deceleration also.

**(d) Jolt**

It indicates the force of onset of acceleration and is expressed in 'g' per second. The higher is the Jolt, the greater are the effects on the body.

**(e) Weight**

It is the force with which a body is pulled by the gravitational force of the earth. A mass weighing 10 kg weight under normal acceleration of earth (one 'G' = 32.2 ft / $sec^2$) will weigh 30 kg if the acceleration force is increased 3 times.

**(f) G Unit**

This is the ratio between the imposed acceleration and that produced by earth's gravity. An imposed acceleration of 96.6 ft/$sec^2$ is thus equal to 3 G units. It is one way of expressing the accelerative force by which physiological effects can be easily understood. Under 3G conditions, the same body will weigh three times its original weight.

**(g) Inertial force**

This is the force with which a body resists the change when disturbed from a state of rest or constant velocity. This is proportional to the accelerative force and is in the opposite direction. As an example, it is the inertial force which presses a person back into the seat of an automobile during forward acceleration or pushes him forward during deceleration. Depending on the direction of the inertial force the following terminologies are used :

(i) **Positive 'G'**
Inertial force acts from head to foot.

(ii) **Negative 'G'**
Inertial force acts from foot to head

(iii) **Transverse 'G'**
Inertial force is directed through antero-posterior axis of body i. e. chest to back or back to chest.

(iv) Inertial force directed through lateral axis of body i. e. right to left or left to right.

**Types of Acceleration**

(a) Linear Acceleration

These are produced when changes in speed occur without any change in direction. These can be positive, negative, transverse, or lateral e. g. crash-landing.

(b) Centrifugal Acceleration

This is produced when a moving body changes direction along the area of a circle. It is positive, negative, transverse or lateral depending upon the position of the human body e. g. aerobatic maneuvers like loops, dives etc.

(c) Angular Acceleration

This is imposed when the body undergoes changes in speed as well as in direction e. g. rolls.

**Physiological Effects of Acceleration**

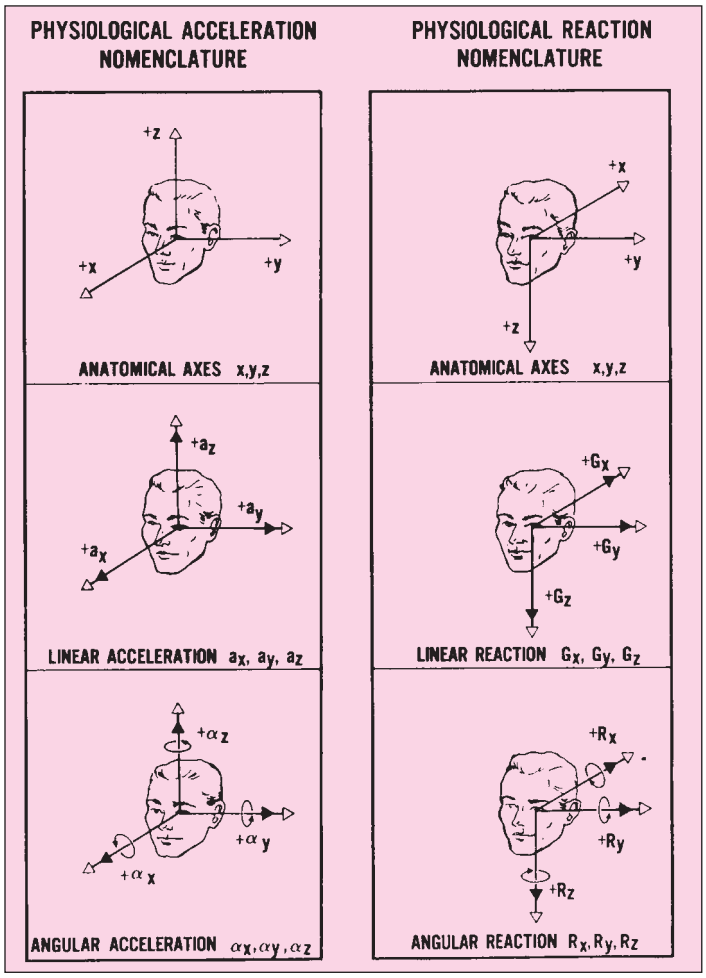
The effects depend upon the magnitude, rate of onset, duration and direction of these accelerations and on the area of the body surface exposed to these.

**Linear Accelerations**

Rapid changes in speed during catapult takeoffs and arrested landings in carrier borne naval aircraft, crash landings, ejection escapes from aircraft and parachute opening impose linear accelerations of varying

magnitudes. Generally these accelerations are abrupt

Fig 3: Description of the Anatomical Position




with a high rate of onset, have large magnitude and are of short duration. In this type of acceleration, duration is too short to produce any physiological changes. Main effect is the structural failure in the body e. g. ruptures tears and fractures. Injuries produced by the impact of the human bodies against lethal structures in the cockpit or due to the jolt, can be serious or even fatal.

(a) Ejection Escape

Escape of the pilot or crew from aircraft flying at high speed is not possible without assistance. The seats of these aircrafts are charged with cartridges that fire when the pilot pulls the firing handle. The seat along with him leaves the aircraft, gaining an upward velocity of 20 to 25 m/s in a fraction of a second and imposes 18 to 20 'G' loads on the pilot. Fig - 5 shows the action and inertial forces. The pilot's body is subjected to a collapsing and a compressing force that puts high loads on the dorso lumbar vertebrae. The likely injuries are compression fractures of the lower dorsal and upper lumbar vertebrae. Proper alignment of the spine by sitting erect so that the back fits in with the seat-back contour and the vertebral bodies take the load squarely and evenly. This is considered as an essential safeguard against spinal injuries. Since an unsupported head would flex violently during ejection a 'canvas-blind' that follows the firing handle comes over the face and keeps the head against the head rest during the jolt. Recent designs of seats have employed rocket motors under the seats. These rocket assisted seats do not have to depend entirely upon the cartridges for their escape velocity so that the 'G' acceleration loads get reduced to 16 G or less.

(b) Parachute Opening

The velocity of a freely falling body in air comes to a steady value when the air resistance equals the weight of the man and the unopened parachute. This value is called 'Terminal Velocity' and is higher at high altitudes. The person escaping from an aircraft will do so at the aircraft velocity which will soon be washed off by the air drag to the limits of terminal velocity. If a parachute is opened before this, it decelerates the free fall velocity over a very short time. The abrupt change over from the initial high velocity to the parachute speed imposes very high 'G' loads on the person. These loads may tear the parachute canopy. The upward drag imposed through the parachute harness produces serious injuries if the jolt is high. The commonest injuries produced by a parachute opening shock (POS) are lacerated wounds under the axilla, injury over antero-lateral aspect of lower abdomen, injury over upper 1/3 of thigh and buttocks, fracture of symphysis pubis and injury of the scrotum and testicles. Therefore, aircrew ejecting out from a high speed aircraft is instructed to wait for the attainment of terminal velocity before opening the parachute. Since the terminal velocity is lower at lower altitudes, they are also trained to wait to reach lower altitudes before operating the parachute. In modern ejection seats an automatic parachute deployment system has been incorporated to ensure opening of the parachute at a pre set altitude.

(c) Crash landings

A crashed aircraft impacts the ground in various attitudes with differing magnitudes of horizontal and vertical velocities. Angle of the terrain, its texture and nature determine the distance over which the impact velocities are finally brought to zero. The forces imposed are abrupt and high. Since the jolt values are high, severe stresses are imposed on the human body and the restraint systems (Fig - 4). Injuries are produced not only due to forces per se, but also due to physical throwing forward of the body when one's restraint systems fail. One of the most important requirements in a survivable crash is the material integrity of seats and straps.

**Centrifugal or Radial Acceleration (Positive 'G')**

Combat aircraft undergo quick changes of direction during their missions involving interception, dog fights, and air to air attacks. The maneuvers are fast and impose centrifugal 'G' loads on the pilot. The human tolerance to the 'G' loads primarily depends upon the physiological effects produced by shift of blood in large blood vessels that lie in the line of the centrifugal force in a normally seated pilot. This acceleration is slow in onset, moderate in magnitude and of longer duration. The centrifugal acceleration increases the virtual weight of solid heavier particles in its line of action and produces the

Table - 2 : Nomenclature of the reaction forces in acceleration

(Gell c. Table of equivalents for acceleration terminology, recommended for general international use by the aerospace medical panel, agard. Aerospace med. 1961; 32 : 1109).

**A. Direction of Acceleration**

| Linear Motion | AC Standard | Acceleration |
|---|---|---|
| Forward | +ax | Forward acceleration |
| Backward | -ax | Backward acceleration |
| Upward | -az | Headward acceleration |
| Downward | +az | Footward acceleration |
| To the right | +ay | Right lateral |
| acceleration | | |

**B. Inertial Resultant of Body Acceleration**

| Linear Motion | Physiologic Descriptive | Physiologic Standard | Vernacular Descriptive |
|---|---|---|---|
| Forward | Transverse PA G, prone G, back to chest G | -Gx | Eyeballs-in |
| Backward | Transverse AP G, supine G, chest to back G | +Gx | Eyeballs-out |
| Upward down | Positive G | +Gz | Eyeballs- |
| Downward | Negative G | -Gz | Eyeballs-up |
| To right | Left lateral G | +Gy | Eyeballs-left |
| To left | Right lateral G | -Gy | Eyeballs-right |

sedimentation towards the bottom of the glass tube full of fluid. If the glass tube is replaced by a rubber tube, the centrifugation makes the tube swell at its bottom due to pooling of the fluid that shifts away from the upper parts of the tube in the line of centrifugal force. The Cardiovascular system can be visualized as consisting of many interlacing rubber tubes in which the blood tends to shift and pool towards distal parts under the influence of a centrifugal force. The magnitude of 'G' acceleration is directly proportional to the square of the velocity and inversely to the radius of turning aircraft i. e. $G = V^2 / 32r$ where V = Velocity in ft / sec and r = Radius of turn in ft. Since weight (i. e. force) is equal to the product of mass and 'G' acceleration, the weight of every part of the body and the fluids in it changes proportionately. A turn that produces a centrifugal acceleration equal to 3G for example will increase the weight to three times its original weight.

### Subjective Manifestations of Positive Centrifugal Acceleration

There is a feeling of being pressed into the seat, limbs become heavy and can only be lifted with additional effort. At 3G, it becomes impossible to get up from the seat. Face mask and goggles tend to slip down if improperly fitted. The mouth opens, lower eyelids droop and face muscles sag down giving appearance of an aged person. Tingling sensations in the legs may occur.

(a) Grey out

At about 4.0 to 4.5 G, the cephalic mean blood pressure drops due to the shift of blood to distal parts and it can just overcome the intraocular tension, As a result the peripheral vision suffers and the pilot's vision becomes dim or hazy.

(b) Black out

At about 4.5 to 5.0 G the fall in cephalic mean blood pressure is serious enough to curtail retinal circulation and the central vision is lost. Consciousness is, however, retained because the little pressure still present is enough to perfuse the blood through the low resistance cerebral vessels. During actual flight the level of unconsciousness is not reached if the pilot relaxes on the controls as soon as blackout sets in. The blackout stage, therefore, marks the limit of human tolerance in so far as operation performance is concerned. The recovery from blackout is immediate as soon as the pilot eases on the controls. On recovery, the subsequent performance may not be adequate enough for taking stock of things that happened during the blackout. The delays involving psychomotor performance due to this cause may be hazardous at critical stages of fight.

(c) G-induced Loss of Consciousness

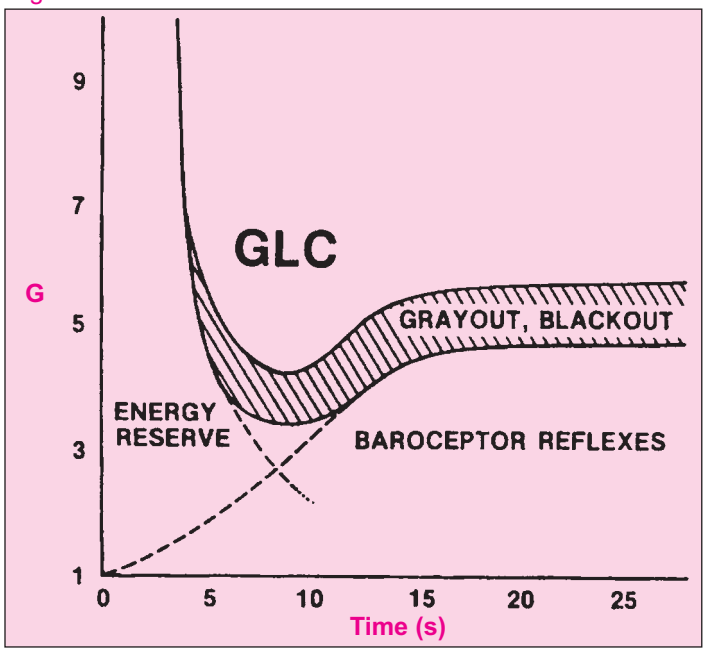
G-induced loss of consciousness (GLOC) has become an issue of major research and operational interest. GLOC is "a state of altered perception wherein (one's) awareness of reality is absent as a result of sudden, critical reduction of cerebral blood flow as a result of increased G forces"

The loss of aircraft and aircrew are, of course, a major concern, but every GLOC episode does not result in loss of an aircraft. But this is obviously an issue of major operational concern. Research on the degree of incapacitation caused by GLOC has indicated that there is an average total incapacitation (unconsciousness) time of 15 seconds followed by a period of relative incapacitation (confusion and disorientation) of 12 to 15 seconds, resulting in a total time of incapacitation of between 24 and 37 seconds. Research is now focusing on ways to prevent GLOC episode as well as to shorten the periods of

Table - 3 : ROR G Tolerances of 1000 subjects (1 g/sec onset rate).

| Criterion | Mean Threshold (G units) | Deviation (G units) | Standard Range (G units) |
|---|---|---|---|
| Grey out or loss of peripheral vision | 4.1 | +/-0.7 | 2.2-7.1 |
| Peripheral vision | 4.1 | +/-0.7 | 2.2-7.1 |
| Blackout | 4.8 | +/-0.8 | 2.7-7.8 |
| Unconsciousness | 5.4 | +/-0.9 | 3.0-8.4 |

Fig - 6 : G-Time Tolerance Curve




incapacitation.

**G-Protection**

Several protective strategies to increase G tolerance and to prevent GLOC have been under development and in some cases already put into operational use. These strategies include centrifuge training, weight training, newer G suits and G valves, altering the seat back angle in the aircraft, and the use of positive pressure breathing both assisted (with counter pressure) and unassisted.

Objective

With the onset of 'G', the muscle tension in the spinal and limb muscles increases so as to maintain control and posture. The descent of the diaphragm and ribs impedes respiration, which becomes faster and shallower. The heart shifts its axis and becomes more vertical. The fall of mean pressure in carotid sinus initiates the compensatory reflex that produces an increase in the peripheral vascular tone. This tends to decrease the pooling of blood and raise the mean cephalic blood pressure. Generally, the compensatory mechanism cannot become effective after 4G. At this level of G, the venous return from the dependent parts becomes insignificant (due to increase in weight of the blood column in the veins). The pooling of blood in the limbs is accommodated by the increase in volume of the tissues and when sustained, leads to oedema and petechial haemorrhages. Pilots who were subjected to high G loads during maneuvers while breathing 100% oxygen at low altitudes and wearing anti G suits have been known to have atelectasis at the base of the lungs.

Prophylaxis

Since the highest G threshold is an essential requirement for a combat pilot, certain measures are adopted to raise this limit. These are :

**(a) General**

Continuous practice, consistent flying, good morale, motivation, freedom from anxiety and fatigue, good health, absence of clinical or sub clinical ailments, nourishing food, adequate sleep are important.

**(b) In-flight Actions**

By these methods an additional gain of 1G tolerance can be achieved.

(i) **Crouching** : While still keeping the instruments and the exterior in view, crouching reduces the vertical height of the blood column between the heart and the head. This reduces the extent of fall of mean blood pressure in the cephalic region.

(ii) **Anti G Straining Maneuver** : Straining of abdominal muscles as in forced expiration with a partially closed glottis raises the intra-thoracic and intra-abdominal pressures and prevents pooling of the blood.

**(c) Use of Anti G Suit**

An anti G suit consists of a garment that contains built-in rubber bladders over the calves, thighs and lower abdomen. These bladders get automatically inflated by an anti 'G' valve that regulates the pressure. They prevent increase in the volume of the tissues and help prevent the pooling of blood. An additional tolerance of 1.5 to 2G is obtained in this manner. It is important that the suits are always kept fully serviceable.

**Negative 'G'**

Whenever the inertial reaction promotes shift of blood and tissues from foot to head, the 'G' producing this reaction is called negative 'G'. Standing on the head itself imposes 1'G' negative (-1 'G') and produces congestion of the face, neck and eyes. Same would happen during inverted flights. When this 'G' is applied at a rapid rate and for prolonged periods, the shift of blood towards cephalic region produces a throbbing headache, as if the skull would burst. The conjunctiva gets congested and hemorrhages may occur. The limiting factor towards tolerance of this 'G' is the occurrence of severe subjective symptoms. When this 'G' is imposed as jolt, as in downward directions and tumbling during a free fall at high altitudes the abrupt shift of blood produce rupture of small blood vessels of conjunctiva and the skin of the face and neck. Occurrence of mental confusion is a common feature during this type of accelerations. During negative 'G' maneuvers the pilot sometimes sees red mist in his field of vision (Red out).

Fig - 7 : Mk II Anti G Suit

Avoidance of negative 'G' maneuvers is the only way of preventing the effects of negative 'G'. Except for mild negative 'G' suffered in inverted flying and pushovers, performance of any maneuvers that impose higher negative 'G' values is prohibited.

**Angular acceleration**

This occurs when the centre of rotation lies within the aircraft or the man himself. The rotation is around the axis of the object itself as occurs during spinning and rolling. The main effect produced is that of disorientation. In case of uncontrolled rotations occurring due to tumbling and spinning of the human body after escape from an aircraft at high altitudes, additional effects on vascular system such as haemorrhages in conjunctivae, skin of the face and neck are produced due to violent shift of blood. However, as spinning and rolling are essential flying practices to get confidence over the aircraft, they are unavoidable. Practice, training, and visual cues obviate occurrence of disorientation. To prevent tumbling and spinning of man and the seat after escape, special stabilizers' have been designed and incorporated in the modern ejection seats.

## Vibrations

Varying degrees of low frequency vibrations are encountered during flight especially in low level high speed flights principally as a result of air turbulence. At times, these vibrations are severe and bring about a decrement in aircraft performance. The effects on human body depend on the frequency, amplitude, duration and periodicity of vibrations. When the induced frequencies are close to the natural frequencies of the whole body or the individual organs, the effects felt are amplified. Such frequencies range between 5 to 12 Hz. Vibrations originate in the propellers of piston engine aircraft and rotor blades of helicopters, engines, gear boxes and transmission systems, air turbulence and gusts of wind, in aircraft escape systems, in parachuting and during weapon firing. The effects of vibrations are-

(a) Annoyance, discomfort and fatigue.
(b) Decrement in psychomotor performance and in performance of fine and skilled tasks.
(c) Hyperventilation.
(d) Impairment of vision and speech. R/T conversation becomes difficult.

**The protection strategies involve :**

**(a) Control at Source**

(i) Avoiding turbulent and bad weather whenever operationally feasible.
(ii) Reduction from internal sources e. g. modification of design of propellers, engines etc.

**(b) Control of transmission**

(i) Modification of airframe design
(ii) Relocation of seats and their orientation vis-a-vis source of vibrations.

**(c) Minimizing effects on human body**

(i) Minimizing exposure to vibrations.
(ii) Modification of design of display and controls.
(iii) Training and experience.
(iv) Physical fitness.

## Effects of noise

Noise is an annoying sound. Some workers have defined it as a complex form of sound with no fixed periodicity and consisting of a mixture of various frequencies. Types of noise can be continuous, intermittent, impulse, fluctuating and explosive. Effects of noise depend upon the three parameters; duration, frequency and sound pressure level (SPL). The following examples of sound values illustrate the noise intensity.

Noise in aviation is produced by aircraft on the ground and in the air. On the ground the source of noise is the running of the engines during taxiing and take off and landing and also during test runs of the engine. The personnel most susceptible to this noise are the technical ground staff and the crew who are located close to the runway. On the other hand, the noise from aircraft while flying, usually affects people on the ground during low level flights and also during sonic boom when the aircraft crosses the speed of sound. Exposure of the unprotected ears to sound levels with the overall sound pressure exceeding 85 db, may lead to a loss of hearing which will appear as an elevation of the hearing threshold. It is usually temporary with partial or complete recovery in course of time. The degree of permanent hearing loss that persists indefinitely depends on the individual susceptibility, presence of any aural disease, and whether or not the protective ear plugs or noise barriers were used; character of noise as regards its overall intensity level and frequency spectrum; and the time factor related to the duration of exposure, whether the noise is continuous or intermittent, and intervals between exposure to noise. The first evidence of such a noise induced permanent hearing loss is seen as a 'dip' at 4000 cps frequency in a pure tone audiogram. At this stage the process may be reversed. If exposure is continued the loss becomes progressive and irreversible.

Table - 4

| | |
|---|---|
| 80 to 90 decibels | Police whistle at 5 m, Motor horn at 7 m, Fire siren at 23 m |
| 90 to 100 decibels | Pneumatic drill at 3 m, NEWS- paper press room, inside cabin of aircraft not soundproofed |
| 100 to 110 decibels | Boiler shop, whistle of steam engine, steel riveting machine at 5 m |
| 110 to 112 decibels | (This is the threshold of painful feeling). Thunder (overhead), heavy gunfire (in close proximity) un-muffled aircraft engine |

**Conservation of Hearing**

(a) Assessment of the Noise Environment

This would entail assessment of the overall sound pressure level noise, Octave Band analysis and the exposure time, with a view to identify, designate and monitor areas where personnel are likely to be exposed to hazardous noise.

(b) Audiometric Assessment of Personnel

This includes establishing base line reference audiogram and monitoring audiometry of personnel who are routinely assigned tasks in the hazardous areas, as indicated above. This will enable early detection of hearing loss and institution of appropriate measures.

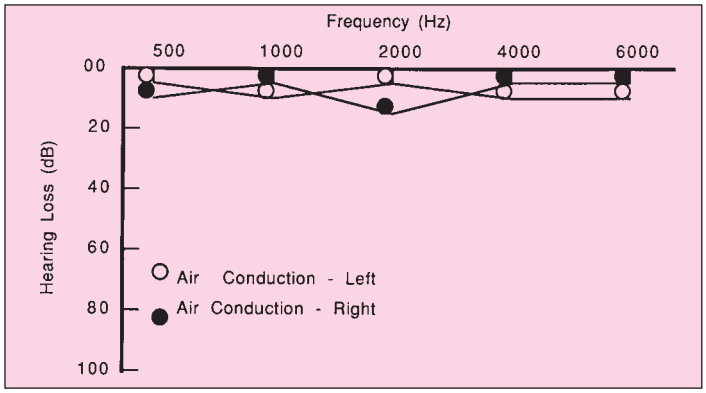
**(i) Conductive Loss**

A conductive hearing loss affects only air conduction curve, which is depressed according to the severity of the hearing loss. The gap between air and bone conduction curves is called the air-bone gap and is diagnostic if it is equal to or more than 10db. Lesser air bone gap can be correlated with Weber's test.

**(ii) Sensorineural hearing loss.**

A sensorineural loss affects both air and bone conduction

Fig - 8 : Normal Audiogram




curves equally, so they are depressed approximately to the same degree and tend to intertwine, (Fig - 9). There is usually no air-bone gap. However, less than 10dB gap may be present in some cases.

(C) Noise Abatement Measures and Personal Protective Devices

This entails issue and individual fitting of personal protective equipment and supervision of the use and care of the equipment.

(d) Central Control and Coordination of the Entire Programme

Fig - 9 : Conductive hearing loss - right ear

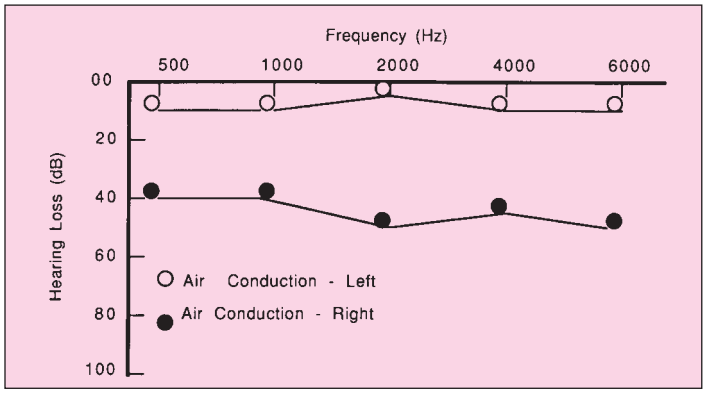
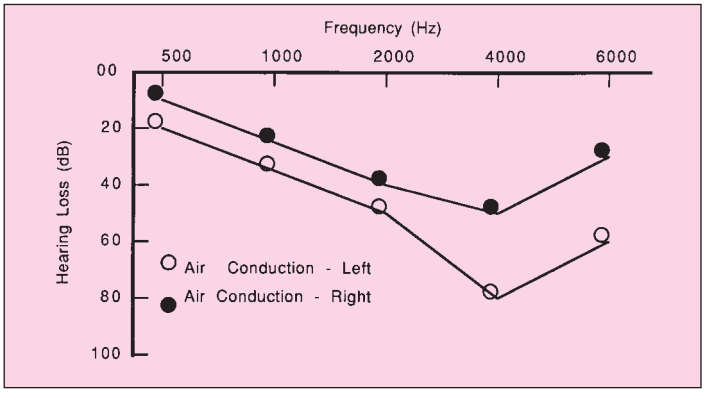



Fig - 10 : NIHL - Bilateral High Frequency Hearing Loss. Aviator's notch at 4000 Hz




The total programme, out of necessity, could cover many more aspects of the problem such as education of all personnel on the effects of individual measures against noise, deafness investigation, engineers efforts in replacement of noise, replacing noise producing machines by noiseless ones, restrictions on noise production etc.

Table 5 : Recommended Noise Exposure Limits

| dBA | Duration of Exposure Hours | Minutes |
|---|---|---|
| 82 | 16 | 960 |
| 85 | 08 | 480 |
| 88 | 04 | 240 |
| 91 | 02 | 120 |
| 94 | 01 | 60 |
| 97 | 0.5 | 30 |
| 100 | 0.25 | 15 |
| 103 | 7.5 | |
| 106 | 3.8 | |
| 109 | 1.9 | |
| 112 | 0.9 | |
| 115 | 0.5 | |
| | | |

## Effects due to rapid Ascents & Descents on ears

In military aviation, for tactical reasons, ascents and descents are executed at a very rapid rate. This may result in the crew being subjected to a rapid and wide variation

of atmospheric pressure and may result in otitic barotrauma (aerotitis) and sinus barotrauma (aerosinusitis). During ascent the atmospheric pressure decreases and causes expansion of air in the middle ear and sinuses. As the ascent is continued excess air escapes periodically through the Eustachian tube and nose, and the inner pressure is equalised with the outside pressure. On descent however, the atmospheric pressure increases pushing the eardrum inwards. To increase the middle ear pressure and restore the eardrum to the normal position, air has to enter through the eustachian tube, which is difficult due to the anatomical peculiarities of the tube. Similarly, the air cannot readily enter the sinuses. An active effort has to be made, as by swallowing, chewing or yawning, or by Valsalva's maneuver (i. e. a forced nasal expiration with mouth closed). If the pressure differential created by descent exceeds a certain limit, active swallowing or even voluntary forced nasal expiration may fail to equalise the pressure, with the result that the conditions of aerotitis and/or aerosinusitis supervene. These have a definite chain of symptoms characterised by pain, deafness, and inability to clear the ears, tinnitus and vertigo. Otoscopic examination may reveal injection and invagination of the tympanic membrane, effusion or bleeding into the middle ear cavity and sometimes rupture of the drum head. In aerosinusitis severe headache particularly along the frontal sinuses occurs.

**Prevention**

As the flying personnel are pre-selected, usually aerotitis results due to either inadequate knowledge about it or due to various contributory factors like a severe cold. The following precautions should be observed to prevent aerotitis and aerosinusitis by aircrew and passengers :

(a) Autoinflate the ears by swallowing, chewing and forced nasal expiration. As each of these methods can clear only a limited pressure differential, it is not desirable to delay the equalization of pressure.

(b) Not to fly when suffering from cold, sore throat and other respiratory infections.

(c) If there is pain in the ears during descent, further descent should be stopped and valsalva must be carried out. If the flight conditions permit, slight ascent reducing the pressure differential, will clear the ears and the descent to ground level at a lesser rate may be possible without damage.

(d) To report to the medical officer on landing for a check up in case of any difficulty experienced with the ears during a sortie.

## Visual Problems in Aviation

Aviation requires the pilot to have high acuity of vision, rapid perception, quick adaptation to darkness or light, good ocular muscle balance to bring about rapid accommodation and convergence and coordinated eye movements and good colour vision.

Under normal conditions on the ground, the ocular functions are not usually taxed but in aviation various factors affect visual performance such as glare, reversal of light distribution, hypoxia, empty visual field, speed and acceleration.

**Effects of Glare**

It may be sub-divided into three types

(a) Veiling Glare

It is caused when excessive light illuminates the whole field of vision without the source of light being in it. If a dark object is placed in a very bright field, the excess light makes it appear less dark, reduces its contrast with its background and its visibility. This glare is uniformly superimposed on the retinal image of the object and is termed 'Veiling Glare'.

(b) Dazzle Glare

It is caused by the very bright source of light in and against the dark background field of vision. The headlights of an in coming car at night gives rise to this type of glare produced by adventitious light, refracted and scattered in the eye so as not to form part of the retinal image.

(c) Scotomatic Glare

It is caused by the bright source of the light in and against the uniformly bright field of vision. A pilot searching for an aircraft in the direction of the sun is subjected to this type of glare. It is produced by light of such intensity as to fatigue the retinal sensitivity to below the comfortable level for visual perception.

Protection

Veiling glare is the commonest of the three encountered in flight and can be prevented by shading the eyes with the visor in the half down position. Dazzle and Scotomatic glare can only be prevented by using a filter, which reduces the luminosity of the visual field. A filter with a flat transmission curve for the whole visible spectrum is preferred. It should have a 15 per cent transmission between 400 and 700 nm with not more than a 5 per cent deviation, and a negligible transmission in the infrared and ultraviolet regions. The 'sun glass' type of spectacle has certain disadvantages. To be shatterproof, the glass must be of full thickness, which makes the spectacle too heavy and uncomfortable. Steaming of the glass may occur. The spectacle is not very stable under high 'G' forces and may be pulled off by gusts of wind. Spectacles are also difficult to remove and replace in-flight without unhooking the oxygen mask and taking off the helmet. Plastic visors either mounted on or integrated with a helmet are now in general use. The visor can either be fixed in intermediate positions over the eyes or else pushed out of the field of vision when not required

**Reversal of light distribution at High Altitudes**

At ground level, glare comes from the sky, which is bright with the sunlight scattered by large particles of moisture and dust held in suspension. At high altitudes, the atmosphere is purer, having less suspended particulate matter, the sky above gets darker, whilst the atmosphere below dense with its light scattering particles appears brighter. At an altitude above the cloud layer, light is also reflected from the under cast clouds. Thus, there is a

complete reversal of light distribution. The glare source is below and the sky above is dark. At 40, 000 ft a pilot finds himself in such an environment. This reversed light distribution has two effects -

(a) The contrast between sunlight and shadow increases, principally because shadows become darker. The areas of the cockpit, which are in the shade get very dark and the instruments, cannot be read. It is necessary to make special provision for lighting the instrument panel and to increase its luminance by painting the interior of the cockpit, especially behind and at the pilot's side, with a light coloured matt paint which would diffusely reflect light on to the instrument panel especially whilst the aircraft is being flown towards the sun.

(b) The glare in the peripheral visual field depresses the central retina. Whilst the pilot gazes outside, his eyes are exposed to the bright cloud floor beneath him. When he glances at his instrument panel he sees it through the positive after image of the cloud floor, which persists for a while on his retina. There now appears a haze in front of his instruments, and he finds it difficult to read the pointers and the graduation marks, especially if they are in a shadow.

**Effects of Hypoxia on Vision**

Hypoxia causes visual changes by depression of the visual pathway and comprises of the following -

(a) Peripheral constriction of the visual field occurs at 3350 m under day light conditions.

(b) A marked and progressive reduction of night vision occurs 5% at 1220m, 25% at 3700m & 40% at 4275m.

(c) Prolongation of the persistent positive after - image is noticed at as low an altitude as 1500 m.

(d) Prolongation of the recovery time after dazzle occurs in slight oxygen deficiency at lower altitudes.

(e) Ocular muscle balance shifts towards esophoria.

(f) Accommodation is weakened.

**Empty Field Myopia**

A visual field, wherein there is no visible detail for the eye to focus upon, is termed an 'empty visual field'. A cloudless blue sky at high altitude (night myopia), fog, a uniformly overcast sky merging into snow covered ground (Arctic white-out) all offer an empty visual field. In the absence of focusable details the following effects are seen in empty visual fields -

(a) The accommodation cannot be relaxed completely and remains in a state of constant activity, fluctuating about a level of 0.5D, thereby rendering an emmetrope, myopic by this amount. The effect of this myopia is to double the minimum visual angle i. e. targets have to be twice the size to be detected. The pick-up range is halved, assuming that the image is formed at the fovea. If it is formed elsewhere, the acuity falls off so that reduction in the pick-up range will be more than half. In effect, the target appears smaller and its distance is consequently over-estimated - if on a converging path, the approach speed appears greater than it really is.

(b) Accurate fixation is not possible since there is no visible detail to which the fovea can be directed, and hence it is difficult to scan an empty field. Due to this and the constant to and fro movements of the eyes while observing the various illuminated instruments on board, the pilots suffer from ocular fatigue, specially during night and blind flying. The instrument panel is designed so that the instruments, which are most frequently looked at are aggregated in the line of vision.

(c) The perception of motion in a target moving against the empty background is extremely difficult, as the featureless background provides no parallactic displacement.

(d) In snowy 'white out' conditions due to absence of contrast, the depth perception is affected making landing more difficult.

**Effects due to Speed of Aircraft on Vision**

Speeds at which the jet aircrafts are flown make demands on the latent periods required for perception, appreciation, cerebration and volition. A perfectly ordinary situation such as sighting an object a mile away, can turn into a calamity because the pilot cannot see, identify, decide and act as soon as object comes into his field of view, as these events take an interval of time which is worth hundreds of thousands of feet in a high speed aircraft. Consider a pilot is flying at 960 km/h when another aircraft comes into his peripheral vision. He travels 27 m before he 'sees' it i. e. before the image is transmitted from the retina to the brain. He travels 280 m, before he has recognized it as an aircraft. He travels about 2 km before he can actually change his flight path to avoid or attack. At 2880 km /h these distances are trebled and he has covered nearly 5 km before he alters his flight path. For two aircraft on opposite courses the distance they travel relative to each other would be double those given in table 6.Suppose two aircrafts broke cloud on a collision course at 2880 km/h. If they emerged 150 m apart they should crash before either pilot had seen the other aircraft. If they emerged 5 km apart they would crash before the pilots have decided what action to take and if they emerged 8 km apart, they still will not have enough time to change the flight paths of the aircrafts. Even at 960 km/h the pilots would have to see each other 3 km away at the very minimum before they could avoid collision. The importance of good visual acuity is thus evident. The better the visual acuity the greater the pick up range and the more time the pilot has at his disposal to decide upon and carry out a course of action.

When a pilot shifts his gaze to his instrument panel to read an instrument and then looks outside, a time interval of 2.39 seconds has elapsed and at 960 km/h, he has travelled blind for 641m. At 2880 km/h his vision is

Table - 6

| Operations | Time in seconds | | Distance travelled in meters | | | |
|---|---|---|---|---|---|---|
| | | | (at 960 Km/h) | | (at 2880 Km/h) | |
| | During operation | From 1st sighting | During operation | From 1st sighting | During operation | From 1st sighting |
| Sensation (light travels from retina to brain) focusing with central vision | 0.10 | 0.10 | 27 | 27 | 80 | 80 |
| Motor reaction to prearrange eye movement | 0.175 | 0.275 | 47 | 74 | 141 | 221 |
| Eye movement | 0.05 | 0.325 | 13 | 87 | 40 | 261 |
| Focusing with Fovea | 0.07 | 0.395 | 19 | 106 | 57 | 318 |
| Perception (minimum recognition) | 0.65 | 1.045 | 174 | 280 | 523 | 841 |
| Deciding what to do (estimated minimum) | 2.0 | 3.045 | 536 | 817 | 1608 | 2451 |
| Operating controls | 0.40 | 3.445 | 108 | 924 | 322 | 2773 |
| Aircraft changes flight path | 2.0 | 2.445 | 536 | 1460 | 1608 | 4381 |
| | | | | | | |

interrupted for more than 1.5 km. Therefore, good cockpit lighting and well designed and correctly located instruments are of prime importance in high speed aircraft since poor lighting and poor design will greatly lengthen the instrument reading time. The above intervals are absolute minimum due to the unchanging characteristics of the human eye, mind and muscle. Anything that interferes with the pilot's vision such as haze or a grey out, fatigue, hypoxia etc. further increase the time interval. The majority of mid air collisions are attributable to the failure of the pilot to see the other aircraft. With the advent of head up display (HUD), now being incorporated in most of the modern aircrafts, the necessity of shifting the vision from outside to inside during critical phases of flight, is being eliminated. In this system, the necessary instrument information required by the pilot is projected at infinity in the pilot's line of vision while he is looking outside.

### Effects of Acceleration on Vision

Positive 'G' or head to foot acceleration, drains the retinal vessels causing a peripheral constriction of the visual fields leading to a 'grey out' and eventual 'black out'. Negative 'G' or foot to head acceleration, results in pooling of blood in the head and causes engorgement of the conjunctival and extra ocular vessels and oedema of the extra ocular tissue, interfering with the action of the extra ocular muscles resulting in diplopia.

Table - 7 : Pick up range at various visual acuity Levels fuselage-dimensions 214 cm

| Visual acuity | Pick up range (Meters) | Time interval |
|---|---|---|
| 6/12 | 3.6 Km | 4.4 seconds |
| 6/9 | 4.6 Km | 5.8 seconds |
| 6/6 | 6.6 Km | 8.9 seconds |
| 6/5 | 8.5 Km | 10.7 seconds |
| 6/4 | 10.5 Km | 13.3 seconds |

### Dark Adaptation

A good dark adaptation is essential for night flying. The rods are responsible for dark adaptation. The rods are sensitized through rhodopsin which functions under very low brightness levels ranging from moonless cloudy nights to about three quarters moonlit nights. The vision is limited to the perception of vague outlines, demarcated by the difference in the brightness between the objects and their backgrounds. No colour is perceived. The 6.5 million cones and 125 million rods vary in their distribution in the human retina. There are no rods in the fovea, which contains the densest concentration of cones. 5° beyond the fovea the cone density falls to a low level, the rapidly increasing rod density reaches its maximum 10° to 20° from the fovea. The night visual field is characterised by a central scotoma, and maximum sensitivity to dimly illuminated objects is obtained 15° from the point of fixation (off centre of vision). An individual passing from daylight to a dark room at first sees nothing, gradually his vision gets dark adapted. Maximum rod sensitivity is reached after 30 to 35 min in the dark. Since the rods are relatively insensitive to red light, a stay for a similar period in dim red light has the same effect. Exposure of the dark adapted eye to bright light results in a fall in its sensitivity in direct proportion to the intensity of the light and duration of the exposure. Vitamin 'A' is an essential link in the formation of visual purple and hence its deficiency results in poor night vision. Hypoxia has an adverse effect reducing the retinal sensitivity to a marked degree. Alcohol and smoking have a similar effect by affecting utilization of oxygen.

Precautions

The following precautions should be taken to maintain good night vision in flight :

(a) The natural ability for dark adaptation of an individual selected. Night vision should be tested while selecting personnel.

(b) Preflight adaptation with red goggles or dim red light for half an hour.

(c) The use of oxygen from ground on all night flights.

(d) The avoidance of alcohol and tobacco for 12 h prior to night flying.

(e) The practice of 'off centre' viewing of dim objects on dark nights.

(f) The use of a systematic scanning technique.

(g) Keeping windscreens and canopies scrupulously clean.

(h) Preserving dark adaptation in flight by avoiding bright light and using only red lights in the cockpit.

(j) Staring at isolated points of light at night to be avoided.

(k) An optimum intake of vitamins should be ensured for dark adaptation.

## Liquid Oxygen System (LOX)

LOX is a cryogenic liquid which has a boiling point of -183˚C. One litre LOX = 840 Lt of oxygen in gas phase = 1.13 kg (2.527 lb). It is light blue in colour, odourless, tasteless and promotes ignition. LOX is stored in a special double walled high vacuum container and is being provided in lieu of gaseous oxygen in some of the modern aircraft because of the space and weight penalty imposed by gaseous oxygen.

The system is in use in some of the Indian aircraft viz. Jaguars, Mirage 2000 and under trials in LCA. LOX is associated with hazards mentioned below

**(a) Fire Hazard**

Fig. 11 - Liquid Oxygen System (LOX)

No oil, grease, kerosene, wood or paint should be allowed to come in contact with LOX. Its mixture with powdered organic or inorganic materials is likely to explode.

**(b) Volume Change during Vaporization**

LOX contained in the vessel vaporizes by gaining heat from the surroundings with a large change in volume. It is, therefore, dangerous for a container to be completely sealed since it would explode as the volume increases.

**(c) Effects of low Temperature**

LOX causes freezing and destruction of tissues whenever it comes in contact. There is, however, no pain until thawing occurs. Parts of skin coming in contact with the uninsulated pipes may be torn off due to freezing of moisture of the skin as it comes in contact with the pipe, may cause it to get glued to the metal of the pipe. Inhalation of cold gas may produce discomfort. Eyes may be damaged because of the cold gas coming in contact with it.

**Protective measures**

(a) Avoid contact with skin. On spillage, LOX spreads over large areas. One must stand clear of the spilled fluid.

(b) LOX should be kept in well-ventilated open space.

(c) Dry leather gloves should be worn while handling LOX. Eyes should be protected with a face shield while handling.

(d) Overalls should be donned while handling and should have no turn ups and pockets. No watches, rings or bangles should be worn while handling LOX.

(e) First Aid

(i) Remove all tight clothing.

(ii) Place the affected part in a water bath at 42˚ to 45˚C and NOT dry heat. In case of extensive exposure, the whole body may be immersed in a warm water bath.

(iii) Thawing should be done gradually because it will lead to pain. Morphine may be given for pain.

(iv) Cover the part with a dry sterile dressing.

(v) Administer Tetanus toxoid booster.

(vi) Patient should avoid alcohol or smoking.

(f) Shock should be treated if it arises.

## LASERS in Aviation

LASERS are used primarily in target acquisition, ranging, and aiming, and so far are not primarily antipersonnel or anti-material weapons. However, they may be employed to dazzle or flash blind, and therefore, of course, frustrate the pilot's attempt to zero in on a target. Since there are very many LASER wavelengths, no protective eye wear (that can be seen through) can protect against all types.

In some ways, LASER exposure is similar to ordinary light, indirect exposure to bright sunshine is of course harmless, but looking directly at the sun magnifies its power 10, 000 times and will catastrophically burn its focal point, the macula, in only a few seconds. For this reason, visible wave length LASER (400-700 nanometers)

is the most dangerous to eyes. Also, near infra-red wave lengths still focus on the retina and are used in many target designators.

#### Ophthalmology

The current laser protective goggles are a compromise and protect against the most commonly used wavelengths. Serious eye (or even bodily) injury at present is a problem mostly in accidental exposure to personnel working with LASER and at very close ranges.

Evaluation of LASER eye injuries follows standard procedures for any eye examination. "Treatment" of LASER eye injuries is basically triage since there is no specific therapy for most retinal injuries and the eyelid and corneal injuries are treated like any other burn.

## Problems in Missile Bases

Missiles are playing a vital role in many spheres of tactics and defence strategy. A number of toxicological problems are, however, associated with missiles. Special chemicals are used for missile propulsion because extremely high speeds have to be attained within a very short period. Some of these chemicals are highly toxic to human beings, animals and plants and cause air, water and soil pollution.

The dangers from missile operations are due to exhaust gases originating from solid propellants like carbon monoxide, sulphur dioxide, hydrogen sulphide, hydrogen chloride, and from liquid propellants like carbon dioxide, nitrogen dioxide, nitric oxide. Nitrogen tetraoxide and unsymmetrical dimethyl hydrazine (UDMH). The toxic hazard arises mainly from missile maintenance procedures and missile operational procedures. Fuel handlers, missile maintenance personnel and the launch crew are exposed to the maximum risk of exposure, which occurs through inhalation, ingestion and direct contact with skin and eyes. The chemical composition of fuels, oxidizers and propellants used in missiles is classified information but it must be remembered that oxidizers are extremely poisonous substances and may cause severe burn on the skin and eyes. Toxicity may occur through their inhalation also. Fuel also is a strong poison. Their inhalation or spillage on body may lead to toxic manifestations and burns. These manifestations may be headache, cardiac asthenia, haematological changes, central nervous system disorders, irritation of lungs and eyes. Other chemicals used in maintenance of missiles are alcohol, spirit, petrol, carbon tetrachloride, grease etc. and cause irritation of eyes, aplastic type of anaemia and central nervous system disorders.

During missile operation, the missile is placed on the launcher for firing which is remotely controlled. Cordite, which is the main explosive of first stage, leaves hardly any smoke. In the absence of smoke, an unwary victim may consider the launching site as harmless, though it leaves behind numerous toxic exhaust gases like carbon monoxide, hydrogen suphide, hydrogen chloride, carbon dioxide, nitrogen dioxide, nitric oxide etc. These gases remain suspended in the air and may pose a toxic hazard.

#### Safety Precautions

(a) Because of the fuming and corrosive properties of fuels, special suits have been designed for personnel handling the equipment. They are covered from top to bottom. Breathing is done through oxygen masks and cylinders carried on the backs. Gloves and boots are provided as a safeguard against spillage of fuels.

(b) A quarterly medical check up is carried out for all fuel handlers. Apart from general examination, haemoglobin estimation, blood cell count and ESR are carried out. Each handler is given 1lt of milk daily.

(c) Treatment is carried out immediately. Thorough wash is given by clean water. Sodium bicarbonate or soap solution is then poured over the affected area and covered with sterile cotton wool and gauze. Patient is transferred to an airy room and all his tight garments loosened. Oxygen inhalation is administered in serious cases.

## Effects of Noxious Gases & Vapour in an Aircraft

Contamination of the atmosphere in the cockpit of an aircraft may result from exhaust gases, fire extinguishing agents, acrolein, aldehydes and vapours of gasoline, hydraulic fluid, coolant etc.

#### Exhaust Gases

The composition of exhaust gases varies according to the grade of aviation fuel and the fuel to air ratio of the engine. Of the various exhaust gases, carbon monoxide, methane and hydrogen sulphide result from incomplete combustion of the fuel. An increasing completeness of the combustion with the optimum fuel to air ratio increases the percentage of relatively nontoxic carbon dioxide in the exhaust gases with a corresponding decline in the percentage of carbon monoxide but as the mixture becomes richer, the carbon monoxide content of the exhaust gas increases. Single engine aircraft with its engine directly in front of the fuselage are subject to greater contamination than the multi engine aircraft with laterally situated engines. Liquid cooled single engine aircraft are more likely to be contaminated by exhaust gases than air cooled radial engine ones. Aircrafts which are originally free from contamination or with only slight amount of carbon monoxide detected at the initial test may allow leakage due to deterioration from wear and tear or as a result of structural modifications introduced while in service. Periodical tests will reveal such contamination and serve as a check on the adequacy of the maintenance service.

The maximum permissible concentration of carbon monoxide (CO) in flight in the cockpit is 0.005%. When flying personnel suspect the presence of CO in the aircraft, either because of the odour of the exhaust fumes or because of untoward symptoms such as headache, nausea, dizziness or dimness of vision they should turn off exhaust heaters if in use and wear oxygen masks and breath 100% oxygen so as to avoid breathing cockpit air. When xylidine containing aviation fuel is used, the oxides of nitrogen appear in exhaust gas. The oxides of nitrogen are more toxic than carbon monoxide. Oxides of nitrogen

are present in much lower concentration in exhaust gas than carbon monoxide. Thus, if carbon monoxide pollution is controlled, protection against the oxides of nitrogen will automatically be afforded.

**Gasoline Vapours**

(a) Aviation gasoline is a complex fuel consisting of a mixture of aliphatic and aromatic petroleum hydrocarbons and special additives such as tetraethyl lead and tricrasyl in varying proportions. The maximal safe concentration for exposure to vapour of ordinary gasoline is about 500 parts per million or 0.05%. The symptoms and pathological changes induced by gasoline are caused by its irritant and lipolytic actions. The action of the volatile aliphatic saturated hydrocarbons is essentially physio-chemical. These compounds are highly soluble in fat and are absorbed particularly in the lipid constituents of the nervous system and the blood corpuscles, where they exert their detrimental effects. Acute poisoning is marked by burning of eyes and lacrimation and severe cerebral manifestations such as restlessness, excitement, disorientation, disorders of speech, vision and hearing followed by convulsions, coma and death.

(b) Tetraethyl lead - Tetraethyl lead is fairly volatile and hence absorbed through the pulmonary epithelium. Absorption of toxic amounts is followed by a prodromal period of 2 to 8 days, after which various neurological manifestations such as general weakness, muscular disturbances, various sensory abnormalities, and psychiatric aberrations appear. The permissible amount of tetraethyl lead in the various specification of aviation fuel is insufficient to produce harmful effects through the inhalation of gasoline vapours. The hazards of lead poisoning occur only under special conditions of handling the fuel where gross spillage occurs in confined storage places.

**Hydraulic Fluid Vapour**

A small leak from a hydraulic pipe or gauge under pressure produces a fine spray of fluid, which spreads quickly, or large leaks may produce a pool of liquid on the floor and the cockpit air attains a high degree of concentration of the volatile constituents of the hydraulic fluid. Hydraulic fluids with petroleum base and castor oil base are at present used for the aircraft hydraulic system, the gear shock struts, the auto pilot and the shimmy damper. In several models both fluids are used for different parts. The former type of fluid contains the mineral oil and a viscosity index polymer, both of relatively low volatility, and their vapours possess low toxicity. The later type of fluid contains diacetone, butylcellosolve, ethylene and propylene glycol and octyl and isoamyl alcohols in varying proportions. The volatile constituents, especially butylcellosolve, the glycol derivatives and the alcohols, are toxic when inhaled. The alcohols, for example, are about 12 times as potent a narcotic as ethyl alcohol. In addition, they cause considerable irritation of eyes and respiratory tract as well as headache and vertigo. Butylcellosolve vapours cause irritation and impairment of judgement and vision. The toxic effects are accentuated by high temperature and altitude.

**Vapours from Fluid, Fire Extinguishing Agents, Acrolein and Aldehydes**

(a) Coolant Fluid

Coolant fluid, for use in liquid cooled engines, consists of ethylene glycol diluted with varying amounts of water. Ethylene glycol is toxic when ingested. Although it is fairly volatile, it does not exert any important toxic effects through inhalation of its vapour, and no instances of in flight intoxication by coolant fluid vapours have been reported.

(b) Fire Extinguishing Agents

The following compounds have been used as fire extinguishing agents

**(i) Carbon Tetrachloride**

This was the first vapourising liquid used for extinguishing fires. The chief danger lies in breakdown to phosgene gas, which is highly toxic, anaesthetic and a liver poison. It is rarely used these days.

**(ii) Carbon Dioxide**

This is the extinguishing agent used in 'Carbon Dioxide Extinguisher', 'Dry Chemical Extinguisher' and 'Gas Cartridge Extinguisher'. In a confined space carbon dioxide released under pressure may cause a feeling of suffocation, narcosis, elevated blood pressure and collapse with death. Direct contact of the skin with carbon dioxide 'snow' may produce severe skin burn. The carbon dioxide extinguishers are not commonly used because of high weight penalty.

**(iii) Soda Acid Extinguisher and Foam Extinguisher**

These are less toxic agents. Compressed carbon dioxide acts as a propellant in these extinguishers. In the former, sodium sulphate solution is sprayed whilst in the latter, extinguisher foam from the combination of sodium bicarbonate, water, ferric chloride and aluminium sulphate is produced.

**(iv) Methyl Bromide**

This is most effective although toxic. It produces vesication of skin and by absorption through lungs can produce a wide range of CNS symptoms. In mild cases the onset is usually delayed. Fatal cases are primarily due to pulmonary oedema.

**(v) Acrolein and Other Aldehydes**

These are the breakdown products of lubricating oils. May be present in varying quantities in exhaust gases. These can also be produced by oil leaks on to hot surfaces and fire. 5 ppm gives rise to irritation of the eyes and upper respiratory tract. Presence of these vapours usually indicates that CO may also be present.

**Flying Fatigue and Long Duration Flying**

Nervous exhaustion caused by the cumulative effects of daily fatigue results in a progressive drain of total energy. Over a period of days, sleep becomes less refreshing and the aircrew feels unfit to work which may further lead to other psychological symptoms. In aviation, there are various factors at work which cause fatigue, e. g. stress of taking off and landing at high speed, the mental anxiety of night flying or flying through cloud and fog and the discomfort of a confined and cramped position. The vitality is lowered through cold draughts, the effects of noise on the auditory nerve, hypoxia at high altitudes and the injurious effects of carbon monoxide fumes contaminating the cockpit or the cabin atmosphere. Preventive measures to combat these fatigue producing factors are summarized below :

(a) Auto pilots, artificial horizon, aerial compass, wireless and Night Vision Goggles have done much to simplify night and blind flying.

(b) Attention to the design and positioning of seats have overcome cramping to some extent.

(c) Air conditioning, though it can provide an agreeable temperature in all climates without draught, yet owing to undesirable extra weight has not been found generally practicable in all service machines.

(d) Electrically heated flying clothing are recommended for conditions of extreme cold. An air-ventilated suit for use under extreme tropical conditions has been in use in some aircrafts.

(e) Sound proofing in airliners and the provision of special air pads in service machines, as already described, have materially overcome the noise factor.

(f) Oxygen is provided to counteract hypoxia.

(g) Attention to the positioning of the exhaust has done much to overcome the fume nuisance. However, the occurrence of a persistent headache not relieved by aspirin demands a close investigation for the possibility of carbon monoxide poisoning of a mild degree.

## Spatial Disorientation

Spatial disorientation is a term used to describe a variety of incidents occurring in flight in which the pilot fails to sense correctly the position, motion or attitude of the aircraft or of him or herself within the fixed coordinate system provided by the surface of the earth and the gravitational vertical. A disorientated pilot is thus uncertain or unaware of his position or the attitude of his aircraft. In flight, the problem of disorientation is much greater than it is on the ground. Here the man does not have physical contact with the ground to orientate himself. Moreover, the aircraft operates on its own power independently of the force and direction of gravity and thus can create sensory confusion leading to disorientation.

The factors which aggravate disorientation are :

(a) Fatigue

(b) Inexperience

(c) Hypoxia, cold, alcohol and drugs

(d) Emotional stress

(e) Lack of visual cues viz. cloud flying, night flying etc.

(f) Changeover from visual to instrumental flying and vice versa

(g) Violent maneuvers

(h) Diseases of vestibular system

### Operational Significance

The following measures adopted safeguard the aircrew from the effects of spatial disorientation :

(a) Selection

Candidates selected must have no vestibular disability which may aggravate or predispose to disorientation in flight.

(b) Indoctrination and training

The most obvious safeguard against the disturbing effects of disorientation is absolute reliance on instruments. Understanding why it occurs, respecting its existence as a hazard, coupled with explicit faith in instruments will always overcome its disabling effects.

(c) Instrument Flying Practice

To have faith in instruments one must be in constant practice It is more so after being on ground for some time e. g. after a prolong desk job, medical grounding for sometime or after leave.

## Specific Hazards in IAF

### Escape from Aircraft

There is a continuing requirement for medical personnel in aviation to be knowledgeable about aircraft escape systems. Squadron Medical Officers have multiple responsibilities in this regard. First, a Squadron Medical Officer must understand the operation of escape systems. A Squadron Medical Officer must be prepared to answer queries concerning biomedical aspects of escape. The second responsibility of a Squadron Medical Officer is to have a clear understanding of ejection, crash landing, ditching, and bailout dynamics in order to properly diagnose and treat the injuries that are likely to be received by an aircrew. An aviator who is suddenly propelled into a windblast of several hundred knots or is involved in a crash can be subjected to unusual and very damaging compression and torsion forces. When a rescued aviator is returned to a carrier or medical facility, the Squadron Medical Officer must be able to recognize the injury or possible injury immediately and deal with it effectively.

### Crew Resource Management (CRM)

Crew Resource Management training has been developed in response to growing evidence that interpersonal factors contributed to a substantial proportion of aviation accidents (Cooper et al 1980). This type of training originally called 'Cockpit Resource Management' is now used widely and indeed is mandated by many aviation regulatory authorities. CRM is application of human

factors in the aviation system. John K Lanber, a psychologist member of National Transportation Safety Board (NTSB) has defined CRM as **"using all available resources information, equipment and people to achieve efficient, effective and safe flight operations".** CRM includes optimizing not only the person machine interface and the acquisition of timely appropriate information but also interpersonal activities including leadership, effective team formation and maintenance, problem solving, decision making and maintaining situational awareness. Thus, training in CRM involves communicating basic knowledge of human factors concept that relate to aviation and providing the tools necessary to apply these concepts operationally. A typical CRM program begins with a seminar that provides background in group dynamics, the nature of human error and the issues that arise when people work with machines. Members of a cockpit crew are asked to review accident case studies that highlight the importance of the interactions among the crew members. CRM has expanded the use of simulator as a training tool. Initially, simulators were employed only to evaluate and teach pilots flying skill. Today they enable crew to test themselves in tackling complex problems ranging from bad weather to mechanical failures that cannot be resolved by simply following a procedure outlined in the flight manual.

### Night Vision Goggles

Night vision goggles (NVG's) are designed to electronically amplify moonlight and starlight to display images on a small video screen mounted within the apparatus. Images produced by NVG's are elicited by photons striking a photocathode, which in turn causes a release of electrons within an adjacent micro channel plate. An electric field then guides the electrons to a phosphor screen which produces an amplified light image. The image produced is green, which disallows for any color discrimination of objects. A clamp voltage mechanism is present to protect against excessively bright light sources (search lights, flares, flashlights, lasers, etc).

### Aircraft Accident Investigation

The requirement for a Squadron Medical Officer to participate in the deliberations of an Aircraft Mishap Board is contained in the IAP-4305.Aircraft Accident Investigations elaborates on the various duties of the Squadron Medical Officer as a member of this board. There is a requirement that the Aircraft Mishap Board and the Squadron Medical Officer work together and address issues that may arise during accident investigations and which may be of significance. The Aircraft Accident Report and the Squadron Medical Officer's Report must be complementary. This does not mean that they must say the same thing. It is interpreted to mean that the same issues must be treated and evidence must be presented that the two sides have communicated on medical issues of significance and that each has developed its position addressing that problem.

### Women in Aviation

The changing roles for women within most societies have caused military planners to consider an expanded occupational potential for women in the military.

Anthropometric selection screens out individuals who are incompatible with the workspaces they occupy and with equipment they work. Potential female pilots should meet the present male crew entry standards. Each pilot should be able to meet the operational requirement for reach, vision and clearance for configuration of seat and rudder pedals. This is 'fitting pilot with cockpit' and this cannot be avoided as long as differences in crew station geometry are prevalent. Four anthropometric dimensions that are critical for selection are stature, sitting height, thigh length and leg length. Sitting height is selected due to its influence on head clearance. Thigh length is chosen because of its clearance with seat pan and main instrument panel. Leg length was chosen because of its influence on reach to rudder pedals. Accommodation assessments are based on aircraft requirements for head clearance, leg reach and clearance. Weight measurements are also taken to study the ejection seat occupant weight limitations and to lay the minimum weight criteria for all types of ejection seats.

Anthropometric criteria that must be satisfied for current

Table - 8 : Anthropometric Criteria for Fitness

| Parameters | Minimum value (cm) | Maximum value (cm) |
|---|---|---|
| Height | 162.5 | ..... |
| Sitting Height | 81.5 | 96.0 |
| Leg Length | 99.0 | 120.0 |
| Thigh Length | ---- | 64.0 |

IAF aircrew are listed in Table - 8.

#### Harness System

Breast anatomy imposes aero medical limitations that are amenable to properly fitting equipment. For example care needs to be taken when fitting the parachute harness. The harness can rise from 10 to 20 cm as a result of compressing the buttocks during opening shock and can cause breast injury if the straps are adjusted below the breasts. However, women under going G stress testing in the centrifuge have reported no breast discomfort.

#### Other Ergonomic Problems

a) The initial entry Standing Height requirement for flying duty officers is 162.5 cm and for ground duty lady officers is 142 cm.

b) While working on Air Traffic Controls, sitting height shorter than 80 cm may find inadequate panel vision.

c) About 50% of females below 150 cm height have lower popliteal height than 39 cm, which is the standard minimum height at the seat of an office chair. While shoes render some compensation, the

prolonged sitting in the chair may lead to postural discomfort.

(d) **Menstrual Cycle :** IAM carried out a project on female pilots and performance with regards to Pre Menstrual Syndrome. The observations are -

(i) Indian women pilots are affected by pre menstrual symptoms two days prior to menstruation with abdominal pain, a feeling of tiredness and backaches.

(ii) There is no demonstrable reduction in performance but some did report sick during menstrual cycle.

(e) **'G' Tolerance**

(i) Tolerance to 'G' was tested in the Human Centrifuge at IAM. The subjects did not wear anti G-suit.

(ii) The subjects were given ROR runs at I G per second and the peak G was maintained for 15 seconds. Thereafter the subjects after a period of relaxation were given GOR run at 0.I G per second. These runs were given until PLL was noticed.

(iii) The study showed that relaxed G tolerance of Indian females is at par with their male peers, and acceleration tolerance need not be a concern for induction into fighter fleet (AR&DB 802).

(f) **Tolerance To Hypoxia**

(i) This study was carried at the Altitude Chamber at IAM. The physiological parameters recorded were arterial oxygen saturation, pulse rate, respiratory rate, minute expiratory volume and end tidal carbon dioxide. These were recorded at ground level, 15, 000 ft, and 18, 000 ft.

(ii) The physiological changes on induction to high altitude seen in Indian females had no significant variation seen in males.

(g) **Psychological Factors** : Female and male individuals are expected to react differently in most situations. Based on this theory, Hamburg Testing Center in Germany carried out a study on 'Sex Difference Concerning Performance and Personality Trait'. It identified differences in Technical Comprehension, Spatial Orientation and to minor degree in Mathematical Reasoning between both sexes. Mastery in technology was seen more with men. However, it was observed that gender differences in Spatial Orientation have decreased during the last decade.

## Sanitation in Flight

The following are some of the important measures

### (a) Water Supply

The ultimate responsibility for the water supply lies with the commander of the aircraft. But it is the duty of the medical officer to satisfy himself that safe drinking water is supplied. Adequate supply of safe water should be arranged as per the nature of flight and type of aircraft. Special attention should be paid to the containers and provision should be made for their periodical cleaning and sterilization.

### (b) Food

It is undesirable to arrange cooking during flight in military aircraft. Food ready for consumption is carried in the aircraft for the crew and passengers. Necessary provision for supplying a hot meal should be made for flights of long duration. Food to be consumed during the flight should preferably be light with a high energy value.

### (c) Disinfection of catering equipment and utensils

All portable food transportation equipment, food contact surfaces such as shelves, tables, cutting boards, meat blocks, refrigerators, stoves, hoods, ray racks, including all “multi-used” eating and drinking utensils, should be kept clean and free from dust, dirt and other contaminating material. After a thorough washing, best sanitization treatment is a final fresh water rinse at a temperature of at least 85˚C (185˚F) for at least 30 seconds.

### (d) Emergency Rations

All aircrew carry their emergency flying rations along with other survival equipment. The emergency rations are packed in airtight containers. The medical officer should inspect regularly these rations for their fitness for consumption and life period of food contents.

### (e) Disposal of Wastes

Smaller aircrafts are fitted with a rubber relief tube for disposal of urine. Larger aircrafts are provided with a commode, which should contain a small quantity of 5% solution of cresol. After landing, the accumulated contents should be disposed off and lavatories must be cleaned with 5% cresol solution and replaced in the aircraft. For collection of vomit and spit, paper or suitable bags should be provided which should be properly disposed off after landing.

### (f) Ventilation problems of Aircraft

The main criterion is the removal of body odour. It is recommended that air velocities be confined to 20-60 ft/min and that special attention be given to the distribution of air to prevent draughts or dead air space in any part of the cabin. The amount of fresh air supplied should be at least 35-40 $ft^3$ ($1m^3$) /min considering that the net air space per person will generally be 100 $ft^3$ ($3m^3$) or less. In pressurized cabins when it is necessary to re-circulate the air, the entire ventilating system should be flushed with fresh air as frequently as possible.

## Disinfection

Disinfection of aircraft is carried out as per the International Regulations laid down. These are given in the Government of India's “Indian Aircraft Manual 1964” as Schedule VI, Chapter IV, Part II. The procedures are as follows :

### (a) Disinfection of Aircraft

The airport health authorities should be consulted when a case of infectious disease has been carried aboard an aircraft. On the rare occasions when this occurs, the notification may arrive several days after the infected person has traveled by which time the aircraft will probably have departed and carried several hundred of passengers on a number of flights. Under these circumstances disinfection may not be practicable or useful.

It is because of this eventuality that the regular use of an efficient bactericide (as already mentioned) in the daily cleaning routine of aircraft interiors and the incorporation of a bactericide in the chemicals added to aircraft toilets are important procedures, ensuring that the aircraft has at least received some form of disinfection. Should an infectious disease be diagnosed either during the flight or immediately on arrival, and before the aircraft departs again, disinfection may be of value.

The method and materials used will depend on the nature of the infectious disease, as well as on the recommendations of the health authority that is responsible for requesting the disinfection. The disinfectants most commonly employed are sodium hypochlorite diluted to strength of 100 mg/l and a 5% solution of formalin, which itself is a 40% solution of formaldehyde gas in water. The spraying can be done with a hand pump, knapsack sprayer or stirrup pump. The nozzle tip should be capable of producing a flat fan spray of a uniform pattern with a spray angle of 60˚. The size of the nozzle should be 0.4 mm. All removable articles should be disinfected in the usual way.

Sodium hypochlorite is often used when disinfecting aircraft after the carriage of a person infected with a food- or waterborne disease such as cholera. Personnel (wearing waterproof gloves) should swab the following areas with the sodium hypochlorite solution, which should remain in contact with these surfaces for 30 minutes before they are rinsed with warm water and dried to remove any residual chlorine:

(i) All surfaces in the toilet compartment.

(ii) All surfaces and food containers in the galley.

(iii) All meal tables, seat armrests and ashtrays in the cabin.

The aircraft water system should be completely drained into a specially allocated toilet cart and discharged into the sewerage system. The aircraft water system should then be treated with hypochlorite.The toilet system should be drained and flushed in the normal way, but before servicing in the usual manner, chemical fluid containing a bactericide should be allowed to stand in the toilet system for at least 2 hours.

The fabric covers of the seat in which the infected person sat, and those of the seats in the row in front and the row behind should be removed, soaked in the disinfectant solution for 1 hour and, after air drying, sent for dry cleaning, suitably marked. As this situation occurs so rarely, and the resulting cost is insignificant, it would be a sensible alternative simply to destroy the covers by incineration. The remaining seats and carpets should be vacuum-cleaned and the dust incinerated.

All hard surfaces, including those mentioned above (already treated with sodium hypochlorite), should be swabbed with the formalin solution, which, after 30 minutes' contact, should then be rinsed away with warm water. (The personnel engaged in this work should wear not only water proof gloves but face masks in addition)

Special needs

There are occasions when special action is needed during flight - for example, when seats or carpets are soiled by a sick passenger. This sickness might be the result of an infection, and part from the nuisance caused to other passengers-there might be a health hazard. Since a major cleaning, involving the replacement of soiled seat covers cannot be undertaken until arrival at the next airport, the cabin crew should be supplied with material for use in such an emergency. Aerosol dispensers containing a detergent/bactericide/odour-counteragent will satisfactorily deal with the problem until more effective action can be taken on the ground. In cases where a special cleaning will be needed on arrival, a radio message should be sent so that arrangements can be made beforehand and delays prevented.

The methods used by some airlines to decontaminate surfaces in the case of a spill or leakage of etiological agents (infectious substances) include the following:

(i) The use of carboxide (a mixture of 10% ethylene oxide and 90% carbon dioxide), which needs to be applied at the rate of 136 kg for every 28$m^3$ of space (300 1b/1000 ft).The temperature in the aircraft must before than 21$^oC$ (70$^oF$) and the relative humidity 30%. The aircraft is sealed and the gas admitted through plastic or copper tubing with perforated holes along its length, until a cabin pressure of 48kPa (71bf/$in^2$) is obtained. This pressure should be maintained for 6-12 hours.

(ii) A mixture of ethylene oxide and Freon II can also be used at the rate of 68 kg for every 28 $m^3$ of space (150 1b/1000 $ft^3$).

(iii) A third method is the introduction of betapropiolactone in vapour form at the rate of 4.5 l for every 700 $m^3$ of space (1.2 gal (US), 1 gal (UK)/25000$ft^3$). For this, relative humidity must be over 70% and temperature 21$^oC$ (70$^oF$). Exposure time is e hours, and the aircraft can return to service after a further 2 hours, since the vapour is rapidly dispersed. Betapropiolactone must be 98% pure, otherwise a polymer will form a settle on surfaces as a sticky coating that is difficult to remove.

When any of the above three ingredients is used, disinfecting should be carried out only by trained personnel.

**(b) Procedure of Disinfestation of Aircraft**

The interior of the aircraft (inclusive of all places likely to harbour mosquitoes such as cockpits, freight compartments, cabins) should be sprayed with a

pyrethrum, DDT aerosol containing not less than 0.4% pyrethrum and 3% DDT, at the rate of not less than 8 to 10 seconds per 30 cubic meter (1000ft$^3$) of free air space. The stop cock in the case of an aerosol dispenser other than the Westing House type being kept open not less than half a turn during the operation and in the Westing House type the cap being removed completely. All opening into the aircraft shall be kept tightly closed during spraying and for a period of not less than five min thereafter.

## International Health Regulations

The fifty eighth World Health Assembly ratified the revised Health Regulations 2005 which have since been adopted by India. The following information relevant for international travel is extracted from the International Health Regulations 2005.(1).

### Definitions

**Affected** : means persons, baggage, cargo, containers, conveyances, goods, postal parcels or human remains that are infected or contaminated, or carry sources of infection or contamination, so as to constitute a public health risk;

**Affected area** : means a geographical location specifically for which health measures have been recommended by WHO under the International Health Regulations 2005.

**Aircraft** : means an aircraft making an international voyage

**Airport** : means any airport where international flights arrive or depart

**Arrival of a conveyance means :**

(a) In the case of a seagoing vessel, arrival or anchoring in the defined area of a port

(b) In the case of an aircraft, arrival at an airport.

(c) In the case of an inland navigation vessel on an international voyage, arrival at a point of entry.

(d) In the case of a train or road vehicle, arrival at a point of entry

**Competent authority** : means an authority responsible for the implementation and application of health measures under the International Health Regulations 2005.

**Container :** means an article of transport equipment

(a) Of a permanent character and accordingly strong enough to be suitable for repeated use.

(b) Specially designed to facilitate the carriage of goods by one or more modes of transport, without intermediate reloading

(c) Fitted with devices permitting its ready handling, particularly its transfer from one mode of transport to another.

(d) Specially designed as to be easy to fill and empty.

**Contamination** : means the presence of an infectious or toxic agent or matter on a human or animal body surface, in or on a product prepared for consumption or on other inanimate objects, including conveyances, that may constitute a public health risk. ("conveyance" means an aircraft, ship, train, road vehicle or other means of transport on an international voyage)

**Conveyance operator :** means a natural or legal person in charge of a conveyance or their agent.

**Crew** : means persons on board a conveyance who are not passengers.

**Decontamination** : means a procedure whereby health measures are taken to eliminate an infectious or toxic agent or matter on a human or animal body surface, in or on a product prepared for consumption or on other inanimate objects, including conveyances that may constitute a public health risk.

**Departure** : means, for persons, baggage, cargo, conveyances or goods, the act of leaving a territory.

**Deratting** : means the procedure whereby health measures are taken to control or kill rodent vectors of human disease present in baggage, cargo, containers, conveyances, facilities, goods and postal parcels at the point of entry.

**Disease** : means an illness or medical condition, irrespective of origin or source, that presents or could present significant harm to humans.

**Disinfection** : means the procedure whereby health measures are taken to control or kill infectious agents on a human or animal body surface or in or on baggage, cargo, containers, conveyances, goods and postal parcels by direct exposure to chemical or physical agents.

**Disinsection** : means the procedure whereby health measures are taken to control or kill the insect vectors of human diseases present in baggage, cargo, containers, conveyances, goods and postal parcels.

**Health** : measure means procedures applied to prevent the spread of disease or contamination; ahealth measure does not include law enforcement or security measures

**Ill person** : means an individual suffering from or affected with a physical ailment that may pose a public health risk.

**Infection** : means the entry and development or multiplication of an infectious agent in the body of humans and animals that may constitute a public health risk.

**International voyage** : means

(a) In the case of a conveyance, a voyage between points of entry in the territories of more than one State, or a voyage between points of entry in the territory or territories of the same State if the conveyance has contacts with the territory of any other State on its voyage but only as regards those contacts.

(b) In the case of a traveller, a voyage involving entry into the territory of a State other than the territory of the State in which that traveller commences the voyage.

**Isolation** : means separation of ill or contaminated persons or affected baggage, containers, conveyances, goods or postal parcels from others in such a manner as to prevent the spread of infection or contamination

**Medical examination** : means the preliminary assessment of a person by an authorized health worker or by a person under the direct supervision of the competent authority, to determine the person's health status and potential public health risk to others, and may include the scrutiny of health documents, and a physical examination when justified by the circumstances of the individual case.

**Public health emergency of international concern** : means an extraordinary event which is determined, as provided the International Health Regulations 2005:

(a) To constitute a public health risk to other States through the international spread of disease and

(b) To potentially require a coordinated international response;

**Public health risk** : means a likelihood of an event that may affect adversely the health of human populations, with an emphasis on one which may spread internationally or may present a serious and direct danger.

**Quarantine :** means the restriction of activities and/or separation from others of suspect persons who are not ill or of suspect baggage, containers, conveyances or goods in such a manner as to prevent the possible spread of infection or contamination.

**Surveillance** : means the systematic ongoing collection, collation and analysis of data for public health purposes and the timely dissemination of public health information for assessment and public health response as necessary.

**Responsible authorities**

Each State Party shall designate or establish a National IHR Focal Point and the authorities responsible within its respective jurisdiction for the implementation of health measures under these Regulations. The National IHR Focal Points shall be accessible at all times for communications with the WHO. The functions of National IHR Focal Points shall include:

(a) Sending to WHO IHR Contact Points, on behalf of the State Party concerned, urgent communications concerning the implementation of these Regulations.

(b) Disseminating information to, and consolidating input from, relevant sectors of the administration of the State Party concerned, including those responsible for surveillance and reporting, points of entry, public health services, clinics and hospitals and other government departments.

**Notification**

Each State shall notify WHO, by the most efficient means of communication available, by way of the National IHR Focal Point, and within 24 hours of assessment

of public health information, of all events which may constitute a public health emergency of international concern within its territory in accordance with the decision instrument, as well as any health measure implemented in response to those events. If the notification received by WHO involves the competency of the International Atomic Energy Agency (IAEA), WHO shall immediately notify the IAEA.

Following a notification, a State shall continue to communicate to WHO timely, accurate and sufficiently detailed public health information available to it on the notified event, where possible including case definitions, laboratory results, source and type of the risk, number of cases and deaths, conditions affecting the spread of the disease and the health measures employed; and report, when necessary, the difficulties faced and support needed in responding to the potential public health emergency of international concern.

Information-sharing during unexpected or unusual public health events

If a State Party has evidence of an unexpected or unusual public health event within its territory, irrespective of origin or source, which may constitute a public health emergency of international concern, it shall provide to WHO all relevant public health information. In such a case, the provisions of notification shall apply in full.

Role of competent authorities

**The competent authorities shall:**

(a) Be responsible for monitoring baggage, cargo, containers, conveyances, goods, postal parcels and human remains departing and arriving from affected areas, so that they are maintained in such a condition that they are free of sources of infection or contamination, including vectors and reservoirs.

(b) Ensure, as far as practicable, that facilities used by travellers at points of entry are maintained in a sanitary condition and are kept free of sources of infection or contamination, including vectors and reservoirs.

(c) Be responsible for the supervision of any deratting, disinfection, disinsection or decontamination of baggage, cargo, containers, conveyances, goods, postal parcels and human remains or sanitary measures for persons, as appropriate under these Regulations.

(d) Advise conveyance operators, as far in advance as possible, of their intent to apply control measures to a conveyance, and shall provide, where available, written information concerning the methods to be employed.

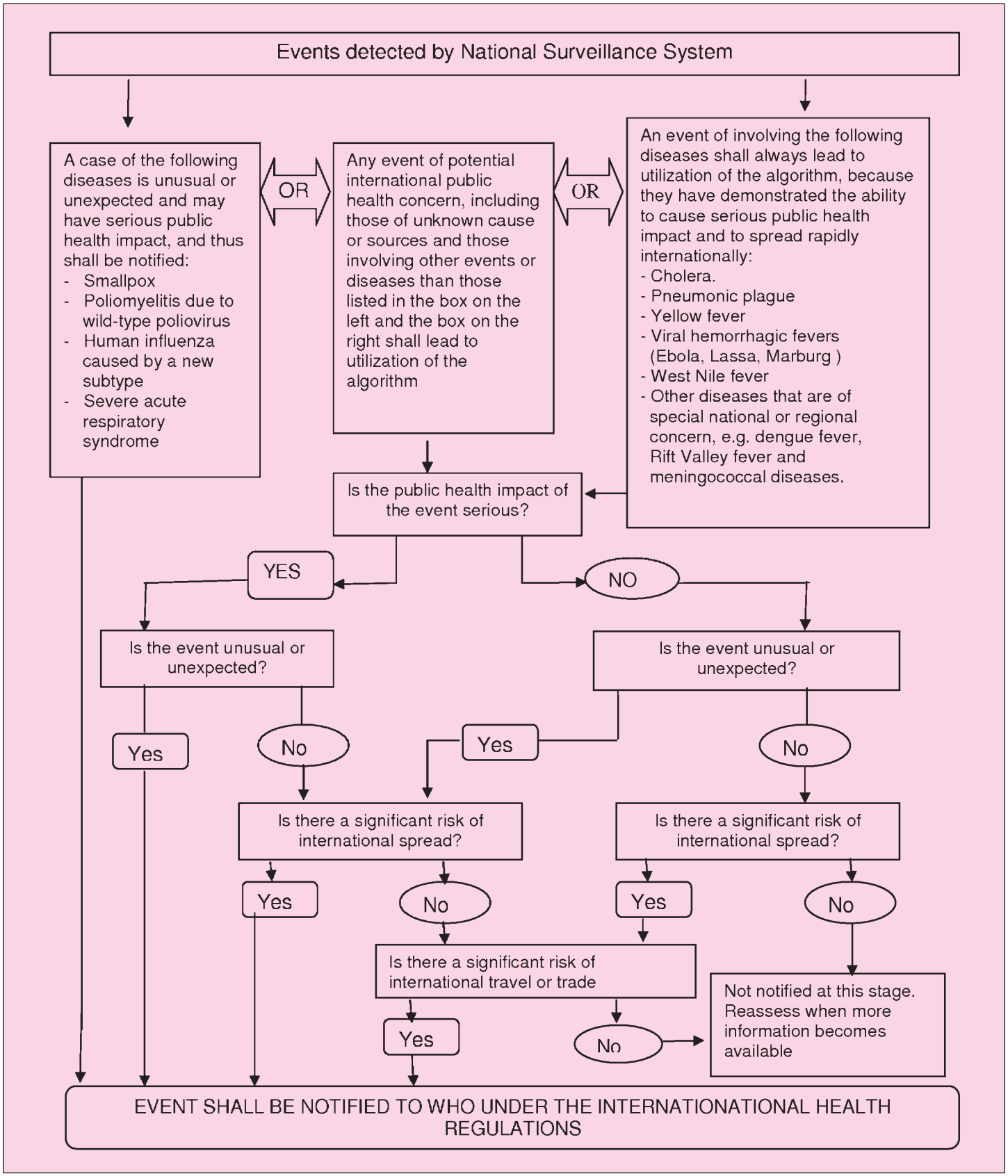
(e) Be responsible for the supervision of the removal and safe disposal of any contaminated water or food, human or animal dejecta, wastewater and any other contaminated matter from a conveyance.

(f) Take all practicable measures consistent with these Regulations to monitor and control the discharge by ships of sewage, refuse, ballast water and other potentially disease-causing matter which might contaminate the waters of a port, river, canal, strait, lake or other international waterway.

(g) Be responsible for supervision of service providers for services concerning travellers, baggage, cargo, containers, conveyances, goods, postal parcels

after each use, and treated in the same manner as portable toilet containers.

Public Health Emergency of International Concern



and human remains at points of entry, including the conduct of inspections and medical examinations as necessary.

(h) Have effective contingency arrangements to deal with an unexpected public health event

(j) Communicate with the National IHR Focal Point on the relevant public health measures taken pursuant to the International Health Regulations 2005.

Health measures recommended by WHO for travellers, baggage, cargo, containers, conveyances, goods, postal parcels and human remains arriving from an affected area may be reapplied on arrival, if there are verifiable indications and/or evidence that the measures applied on departure from the affected area were unsuccessful.

Disinsection, deratting, disinfection, decontamination and other sanitary procedures shall be carried out so as to avoid injury and as far as possible discomfort to persons, or damage to the environment in a way which impacts on public health, or damage to baggage, cargo, containers, conveyances, goods and postal parcels.

**Health measures on arrival and departure**

Subject to applicable international agreements and relevant articles of the International Health Regulations 2005, a State may require for public health purposes, on arrival or departure:

(a) With regard to travellers :

(i) Information concerning the traveller's destination so that the traveller may be contacted.

(ii) Information concerning the traveller's itinerary to ascertain if there was any travel in or near an affected area or other possible contacts with infection or contamination prior to arrival, as well as review of the traveller's health documents if they are required under the International Health Regulations 2005; and/or

(iii) A non-invasive medical examination which is the least intrusive examination that would achieve the public health objective.

(b) Inspection of baggage, cargo, containers, conveyances, goods, postal parcels & human remains.

On the basis of evidence of a public health risk obtained through the measures provided in the previous pragraph, or through other means, States may apply additional health measures, in accordance with the International Health Regulations 2005, in particular, with regard to a suspect or affected traveller, on a case-by-case basis, the least intrusive and invasive medical examination that would achieve the public health objective of preventing the international spread of disease.

No medical examination, vaccination, prophylaxis or health measure under the International Health Regulations 2005 shall be carried out on travellers without their prior express informed consent or that of their parents or guardians, except as provided in paragraph 2 of Article 31, and in accordance with the law and international obligations of the State.

Travellers to be vaccinated or offered prophylaxis pursuant to the International Health Regulations 2005, or their parents or guardians, shall be informed of any risk associated with vaccination or with non-vaccination and with the use or non-use of prophylaxis in accordance with the law and international obligations of the State. States shall inform medical practitioners of these requirements in accordance with the law of the State.

Any medical examination, medical procedure, vaccination or other prophylaxis which involves a risk of disease transmission shall only be performed on, or administered to, a traveller in accordance with established national or international safety guidelines and standards so as to minimize such a risk.

**Requirements Concerning Vaccination or Prophylaxis for Specific Diseases**

Vaccination against yellow fever (2)

Recommendations and requirements for vaccination against yellow fever:

(a) For the purpose of the International Health Regulations 2005:

(i) The incubation period of yellow fever is six days.

(ii) Yellow fever vaccines approved by WHO provide protection against infection starting 10 days following the administration of the vaccine.

(iii) This protection continues for 10 years.

(iv) The validity of a certificate of vaccination against yellow fever shall extend for a period of 10 years, beginning 10 days after the date of vaccination or, in the case of a revaccination within such period of 10 years, from the date of that revaccination.

(b) Vaccination against yellow fever may be required of any traveller leaving an area where the WHO has determined that a risk of yellow fever transmission is present.

(c) If a traveller is in possession of a certificate of vaccination against yellow fever which is not yet valid, the traveller may be permitted to depart, but the provisions of paragraph (g) may be applied on arrival.

(d) A traveller in possession of a valid certificate of vaccination against yellow fever shall not be treated as suspect, even if coming from an area where the Organization has determined that a risk of yellow fever transmission is present.

(e) States shall designate specific yellow fever vaccination centres within their territories in order to ensure the quality and safety of the procedures and materials employed.

(f) Every person employed at a point of entry in an

Model international certificate of vaccination or prophylaxis

## MODEL INTERNATIONAL CERTIFICATE OF VACCINATION OR PROPHYLAXIS

This is to certify that [name] ....., date of birth ....., sex ....., nationality ....., national identification document, if applicable ..... whose signature follows .....
has on the date indicated been vaccinated or received prophylaxis against:
(name of disease or condition) ..... in accordance with the International Health Regulations.

| Vaccine or prophylaxis | Date | Signature and professional status of supervising clinician | Manufacturer and batch No. of vaccine or prophylaxis | Certificate valid from..... until ..... | Official stamp of administering centre |
|---|---|---|---|---|---|
| 1. | | | | | |
| 2. | | | | | |

- This certificate is valid only if the vaccine or prophylaxis used has been approved by the World Health Organization.
- This certificate must be signed in the hand of the clinician, who shall be a medical practitioner or other authorized health worker, supervising the administration of the vaccine or prophylaxis. The certificate must also bear the official stamp of the administering centre; however, this shall not be an accepted substitute for the signature.
- Any amendment of this certificate, or erasure, or failure to complete any part of it, may render it invalid.
- The validity of this certificate shall extend until the date indicated for the particular vaccination or

area where the Organization has determined that a risk of yellow fever transmission is present, and every member of the crew of a conveyance using any such point of entry, shall be in possession of a valid certificate of vaccination against yellow fever.

(g) A State in whose territory vectors of yellow fever are present, may require a traveller from an area where the WHO has determined that a risk of yellow fever transmission is present, who is unable to produce a valid certificate of vaccination against yellow fever, to be quarantined until the certificate becomes valid, or until a period of not more than six days, reckoned from the date of last possible exposure to infection, has elapsed, whichever occurs first.

(h) Travellers who possess an exemption from yellow fever vaccination, signed by an authorized medical officer or an authorized health worker, may nevertheless be allowed entry, subject to the provisions of the foregoing paragraph of this Annex and to being provided with information regarding protection from yellow fever vectors. Should the travellers not be quarantined, they may be required to report any feverish or other symptoms to the competent authority and be placed under surveillance.

Air-sickness containers

Used containers should be stored during flight in the toilet compartment. They should not be put down the toilet, and a notice to this effect should be placed in the toilet compartment. They should be re-moved from the aircraft by the toilet servicing team and disposed of along with the aircraft toilet wastes. If any receptacle is used on the aircraft for storage of used sickness containers, it should be thoroughly cleaned, washed and disinfected

References
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2. World Health Organization, Geneva. International Health Regulations 2005.
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# Naval Health

## Introduction

Oceans cover nearly 71% of the earth's surface. The ocean depth ranges from shallow continental slopes to the deepest point 36,200 ft below MSL at Mariana trench in Pacific Ocean. Hence, the life at sea, is confronted with various environmental factors different from those on land. Restricted space, close community life, limited resources, limited supplies of rations, and lack of dispersion affects the physical and psychological environs of sailors. Disposal of wastes is a comparatively easier proposition free from risk of contamination of food, fouling of living place and fly breeding as is usual on land. However strict standards of sanitation have made disposal of human waste from ships at harbour a complicated process to render it environmentally safe. The duties of the medical officer are principally the same at sea as on land except that at sea he is the sole adviser to his commanding officer without aid from any other colleague. Medical officers should take all opportunities to learn and familiarize at first hand the problems of life onboard the ship, the peculiar hazards that the personnel of each trade confront and the solutions to them. He should also know the layout of the ship as well as be conversant with its daily routine and administration.

The sickbays and hospitals afloat constitute the centres of all medical activities onboard the Ship. The planning and arrangement of sick bays and hospital space in naval vessels will never remain static, being dependant on changes in the ship's design, nature of operation and doctrines of medical and surgical practice. A description of a current medical department onboard the ship, therefore, may not be applicable after passage of time. Moreover, the scope of the medical facilities provided in a vessel depends upon the complement of attached personnel and role of the ship. Thus, in a submarine or in small surface ships, medical care is rendered by a medical assistant with a minimum of equipment and supplies; while a larger war ship with its medical officer, dental officer, medical assistant and superior equipment and supplies is in a position to render complete and definitive medical care. The practice of medicine onboard the ship does not materially differ from that practiced ashore. But due to shortage of storage space, careful planning is necessary in determining and ensuring the supply of a basic minimum quantity and quality of essential medical stores and equipment.

## Naval Health Problems

General principles of hygiene and sanitation for maintenance of health and prevention of disease afloat are also similar to those on land. Some of the problems afloat, however, need special attention and forethought, in planning the various preventive measures. In a modern navy the problems vary with the size, type, role and construction of the ship. The medical officer must know the basic problems likely to be encountered in various types of ships, submarines and in naval aviation. Problems connected with habitability, sanitation, food supply and preservation and pest control will frequently engage his attention in addition to the curative treatment for diseases and injuries which he will be expected to carry out as his main function. The preventive medical aspects comprise of the following :

(a) Habitability conditions of ships
(b) Submarine microclimate
(c) Diving illnesses
(d) Survival & death at sea
(e) Problems in naval aviation
(f) Water supply
(g) Food supply and preservation
(h) Disposal of refuse
(j) Pest control measures
(k) Prevention of communicable disease, quarantine rules and International Health Regulations.

### Habitability Conditions of Ships

#### Ventilation

The medical officer serving afloat should be able to define the criteria that constitute 'environmental comfort' for ship's personnel and assess the limits of tolerance for varying climatic conditions. The ship design should meet the requirements of the habitability conditions in terms of temperature, humidity, air movement and heat radiation. The environment must maintain the body heat balance, must not contain any harmful gases, and provide a sufficient supply of oxygen. All modern ships are provided with centralized atmosphere monitoring system (CAMS) for measuring temperature, humidity, air movement, radiation levels of inboard & outboard and other climatic data. Heat from the machinery spaces in the sealed hull must be removed by the 'balanced system' of ventilation. The air-duct terminals must be located to the best advantage of the occupants. The supply of fresh air to a warship with watertight compartments without weakening the ship's stability needs engineering ingenuity.

Since, it is not always feasible especially under operational conditions, to provide optimum environmental conditions, the ship designer and medical officer may be required to determine the limits of tolerance under such circumstances. The P4SR values, corrected effective temperature and the comfort zones provide a guide for assessment of such limits. As a rough and ready rule, a rise in body temperature and pulse rate in any individual, especially when resting in the place of his work, necessitate remedial action. Spot cooling is used in certain hot places such as the engine room, where it is difficult to provide sufficient fresh air to maintain satisfactory temperature throughout the space. Near each watch

station, a high velocity blast of cool air is introduced so as to produce a spot of comfort in front of the blower terminal into which the watch-stander can move whenever required. This system is effective even at high ambient temperature as the spot- temperature is considerably lower than the ambient temperature in the compartment.

Oxygen lack or depletion, and accumulation of noxious gases may occur in closed spaces. All such spaces should be thoroughly ventilated before entering. An oxygen apparatus should be kept ready; a 'life line' should be attached to the person entering such a compartment. Various noxious constituents and contaminants and their effects on body are discussed in a subsequent para. Air-conditioning of selected places, or better still the complete vessel, is the most effective way to ensure healthy habitable conditions for the personnel. In air-conditioning, atmospheric conditions in a compartment, which are artificially modified are temperature, humidity, air motion and purity of air. The plant cleanses, cools, moistens or warms the air as required. The whole system consists of a refrigerating plant, cooling or warming chamber, humidifiers, air filters, blower, exhaust fans, air duct louvres and blast sets. Modern ships are completely air-conditioned.

Effects of Noise, Vibration, Non-ionizing Radiation and Illumination

The ill effects of noise, vibration and non ionizing radiation on the human body have been studied at length and have been sufficiently qualified and quantified. Safe levels and protective measures have also been extensively enumerated, both for navies and industrial workers in the developed countries. Most of the effects of exposure to noise, vibration & non-ionizing radiation occuring at our working place (i.e. onboard ships) can pose significant health hazards, unless proper preventive measures are in place. It is our primary responsibility to ensure that the prime fighting force is not handicapped by any occupational hazards. Ship borne MO's have a pivotal role to play in prevention, detection, early diagnosis & treatment, as well as in providing proper advice to the command and health education.

**(a) Noise**

In a ship that is both the home and place of work for the seamen, one is obliged to live with some noise twenty-four hours a day. This problem may be much more severe than land based combinations of separate working and living areas. Ears of naval personnel may be subjected to a variety of sounds onboard. Noise has many sources and can have a widespread effect: both aural and non-aural noise induced acoustic disorders (NIAD), depending upon the type of noise and duration of exposure. As there is no treatment for noise induced hearing loss (NIHL), it is imperative that education, proper monitoring, adequate training and preventive measures are instituted onboard.

**(b) Vibration**

Vibration is the transmission of oscillation energy from its source to another object. Vibration can have localized effects on the circulatory system, bones and joints, nerves or muscles or it can have generalized effects on the whole body as such. It can enter the body at the hands, feet, seat, or the back. The personnel most commonly exposed to vibration are engine room and electrical sailors as well as shipwrights and seamen using pneumatic tools. To prevent the deleterious effects of vibrations it is necessary to redesign ships by applying proper ergonomics and instituting regular health education.

**(c) Non-ionizing Radiation**

The part of electromagnetic radiation that does not cause nuclear changes is called non-ionizing radiation. Non ionizing radiation extends from ultra violet radiations through the visible range up to the infrared range and the radio frequency cum microwave radiation zone. These radiations are present in varying amounts onboard and can have significant harmful effects. Of particular concern are emissions from sunlight, radar, communication and video display units (VDUs). Preventive measures are generally restricted to education, proper sign posting and use of protective equipment. In the long term, modification of equipment and spacing can be envisaged to offer better protection.

**(d) Lighting**

Adequate lighting onboard ship is essential for efficiency and safety. Fatigue and eyestrain develop rapidly in poor illumination. Work performance is reduced, accidents increase and the individual's morale deteriorates. Good lighting is important, especially in the engine room, galley, chartroom, and companionways. In the engine-room, high-level illumination free from glare is desirable. Lights should be located so that crewmembers will cast the least possible shadows upon their work, and equipment will not create pools of darkness. Adequate illumination in the areas where food is served and prepared is essential for proper food handling and for the maintenance of adequate standards of sanitation.

**Submarine Microclimate**

The ventilation system in a submarine needs special consideration. It has three functions. It must maintain acceptable conditions of habitability for the crew; it must provide sufficient air for the engines when they are operating; and it must meet battery ventilation requirements under various conditions of battery operations. The whole ventilation system is invariably the 'balanced system' with the combination of the plenum and exhaust, designed to provide efficient ventilation when the submarine is surfaced. The ventilation of submarines, however, is difficult during submerged cruising, when air has to be recirculated. Depletion of oxygen, increase of carbon dioxide and moisture vitiate this air by the ship's crew. Heat produced by the machinery, by gases from cooking and batteries, and under some unusual circumstances evolution of chlorine and other noxious gases act as health hazards. Close monitoring is therefore necessary when the submarine is cruising submerged. The habitability of the submarine from the point of atmospheric conditions depends upon pressure, movement, temperature, humidity, and constituents of the air.

In a submarine, air for the engine enters through the main

air induction valve located in the conning tower and through outboard piping to the engine room via hull valves. The air supply for ventilation enters through the hull air induction valve, also located in the fin through a separate outboard valve to the hull supply fan. Air is then distributed by the hull supply fan within the submarine through the main ducts running the entire length of the ship and branching into each compartment. Forced draft blowers take air through the main supply duct and distribute it to the various compartments. Exhaust is delivered to the engine room to be discharged through the engines when they are running, and overboard when they are static. When the vessel is submerged, the air is not exhausted through the engines but is returned to the supply system through the air-conditioning unit, which filters, cools and dehumidifies it. For the purpose of recirculation of air, cross connection is provided between exhaust fan discharge and the supply fan intake. These methods of air movement are supplemented by the use of compartment electric fans and portable blowers.

The temperature within a submarine is often extremely high, especially in the tropics. While cruising submerged, some cooling is obtained through the hull's contact with the cooler sea water. Relative humidity in submarine often approaches the saturation point during an extended submerged run from the moisture given off by the occupants, by the process of cooking and from the batteries, causing considerable discomfort to the crew. In the absence of air-conditioning, it causes the bulkheads to drip, moistens all clothing, mattresses etc. making them continually damp, thus adding to the health hazards amongst the crew. The air conditioning unit can control the temperature and humidity as well as the air circulation.

(a) Oxygen

During an extended submergence, vitiation & contamination may alter the composition of air. Oxygen concentration should not be allowed to fall below 17%, as otherwise symptoms of hypoxia such as weakness, vertigo, cyanosis, nausea and collapse may follow. There is also danger of oxygen leaking from oxygen propelled torpedoes. Hence oxygen level in the torpedo compartment need to be measured periodically i.e. at least every 1/2hr with the help of central monitoring system or by using portable analysers. If the level of oxygen falls to 19 - 18%, then oxygen is to be released from oxygen banks or by using regeneration chemicals (Peroxide of sodium/potassium) or by hydrolysis of water. Besides oxygen depletion on account of its consumption, increase in CO2 or other gases also need emergency release of oxygen after elimination of such gases.

(b) Carbon Dioxide

The normal carbon dioxide production may be 20 L / man per hour. Additional amount of $CO_2$ comes from galley, oxidation of CO and leakage from engine exhaust particularly after a crash dive or during snorting. The effects of carbon dioxide are directly proportionate to its partial pressure. A submarine carrying a normal complement of its crew may safely operate submerged for about 20 hours without requiring to absorb $CO_2$. In general, $CO_2$ tension of 3 % causes mild symptoms; between 3 to 6 % causes headache, discomfort and deep breathing; between 6 to 9 % extreme distress, panting and collapse may be caused and concentration above 9 % is rapidly fatal. Increasing the oxygen tension has no beneficial effect unless the excess of $CO_2$ is removed. Hence it is important to eliminate as much carbon dioxide as possible from the atmosphere, particularly if flooding for escape is contemplated. The removal of carbon dioxide is accomplished by the use of $CO_2$ absorbents viz. Soda lime (NaOH), regeneration chemical ($Na_2 O_2$) which absorbs $CO_2$ and releases $O_2$, MEA (Monoethanolamine) which absorbs $CO_2$ when cooled and releases it when heated or molecular sieves.

(c) Carbon Monoxide

It is produced by incomplete combustion of any kind of fuel and is a constituent of the exhaust gases from engines. It is also found after fires or explosions in closed compartments where there is an insufficient supply of oxygen to afford complete combustion. If the presence of this gas is suspected in a compartment, no one should enter without wearing an appropriate respirator. Symptoms are produced basically due to hypoxia resulting from carboxyhaemoglobin. The symptoms include exhaustion with breathlessness, feeling of nausea, increasing weakness, dizziness and vertigo, a noticeably pink tongue, pallor and finally loss of consciousness. First aid treatment for CO poisoning constitutes allowing the patient to breathe fresh air or oxygen and artificial respiration. Prevention is by using absorbent filters in ventilation system or burners, which help in reducing CO in the compartment air. Definitive treatment is Hyperbaric Oxygen therapy.

(d) Hydrogen

It is physiologically harmless but chemically active. An air mixture containing 4.1 % hydrogen in oxygen is explosive. Hydrogen in a submarine is produced by electrolysis within the storage batteries, particularly during charging. Separate ventilating system is provided for the batteries and the air is discharged outboard during surface runs and inboard during submerged runs. Hydrogen burners located in battery compartments continuously burn the hydrogen evolved from batteries and also oxidises carbon monoxide and hydrocarbons. Each battery compartment contains hydrogen detectors for determining the %age of hydrogen continuously and an alarm alerts the watch keeper if $H_2$ levels exceed more than 4%. The maximum permissible amount in the battery ventilating system is 3%.

(e) Chlorine

It is produced in a submarine when seawater comes in contact with the sulphuric acid in the batteries. It is two and half times heavier than air and remains close to the deck unless disturbed by air currents. A concentration of 1 ppm causes coughing, 10 ppm is dangerous if breathed

for half an hour and 100 ppm may be fatal if breathed even for a few minutes.

(f) Tobacco Smoke

It presents a real hazard in a submerged submarine. The bad effects are due to the nicotine absorbed and the foul odour. There is irritation of the eyes and the respiratory tract. The smoke in the rebreathed air of the enclosed space exerts its harmful effects upon personnel not habituated to tobacco. Therefore, the use of tobacco is forbidden. Acceleration of the pulse rate caused by nicotine causes confusion in the estimation of cardiovascular tolerance and response to deleterious environment expressed in terms of pulse rate.

(g) Other Pollutants

In the closed atmosphere the other pollutants are accumulated due to toasting & frying in galley which produces CO, CO2, acrolein etc, foul odours like sulphur dioxide, hydrogen sulphide & ammonia come from WCs, arsine and stibine from batteries and bacteria from men. These pollutants are to be absorbed by using Hopcalite and activated carbon filters.

(h) Air Pressure

The air pressure in a submarine is normally equal to the atmospheric pressure. While diving, the pressure increases slightly due to the compression of the hull, mild leaks of High Pressure Air and venting (blowing) of the tanks inboard. During 'submarine escape' the air pressure inside the flooded compartment must exceed the pressure of the outside seawater for opening the escape hatch. Preparatory to an escape from a sunken submarine, the partial pressure of the gases in the compartment will increase while eqaualising pressure of inside with that of outside. As the outside water pressure rises by one atmosphere (1 kg/cm$^2$) for every 10m depth, at a depth of 50 m the pressure will be equal to 6 atmospheres. The partial pressure of oxygen would, therefore be increased to 6 times, exerting the physiological effect of 2.2 atmospheres of pure oxygen on the body. Prolonged breathing of this concentration of oxygen may be dangerous. The partial pressure of Nitrogen in the compartment also increases correspondingly resulting in "narcotic effect", which is equivalent to 1 oz of Martini intoxication for each 10m of depth.

(j) Effect of Submarine Sailing on Crew

Submariners during the period they are at sea, are exposed to various unfavourable factors which lower their endurance. In addition to the factors mentioned above, the other factors, which influence submariners are given below. Preventive measures include proper selection of men from their health point of view. Psychological selection is essential because individual peculiarities can be detected during this examination. Planning of proper living and working conditions in the submarine right from the design to construction stages is essential. In other words optimum hygienic living and man-machine adaptation on sound ergonomic principles should be planned.

**(i) Emotional and Psychological Stress**

Every submariner shoulders specific additional responsibility during underwater sailing. All these create a charged emotional situation. Coupled with this is the isolation from land, separation from families, limited information regarding families and world affairs.

**(ii) High Noise Level**

An average noise level in a submarine is around 80 to 90 decibels and in the engine room this may be as high as 100 to 110 decibels. The damaging effect of this continuous noise on the functional capacity of man increases with high temperature, humidity and presence of noxious gases.

**(iii) Vibration**

The vibration level in submarine is 2 to 3 times higher than the safe physiological limits.

**(iv) Changes in Central Nervous System**

In the second half of the cruise, men start complaining of headache, irritability, disorder of sleep and depression etc. A careful neurological examination reveals such findings as tremors of fingers & eyelids, unequal tendon reflexes, impaired thermal and pain sensitivity. As a result of above changes, there is reduction in the mental working capacity, which may be reflected in their professional activity.

**(v) Changes in Sensory Organs**

- **Eyes:** After a long cruise, the adaptation to darkness takes longer time. Acuity of vision is considerably reduced. Field of vision is narrowed. Myopia in submariners is higher as compared to those in other naval personnel. This may be due to over fatigued ciliary muscles due to close viewing of small objects for a long time.
- **Ears:** The leading specific factors, which influence the auditory organs, are the level of noise and to a lesser degree the pressure changes. Problem of deterioration of acuity of hearing in engine room crew is also important. Prolonged underwater sailing will reduce both air and bone conductivity.

**(vi) Changes in Cardiovascular and Respiratory Systems**

In the second half of a long cruise, the crew starts complaining of pain in the precordium, palpitation, oedema of lower extremity and dyspnoea on exertion. Clinical examination may reveal tachycardia, a fall in diastolic and rise in systolic blood pressure leading to increased pulse pressure. During the cruise, the respiratory rate is increased and the vital capacity is lowered. This may be due to the adaptation of a submariner to increased carbon dioxide level.

**(vii) Changes in Digestive System**

The changed working conditions and food habits may cause the following changes in the digestive

system of submarines viz. loss of appetite, belching, heart burn, constipation etc.

## Diving Disorders

Divers are directly exposed to water whereas submariners are protected by the pressure hull and are mainly confronted with problems of closed space living. Submariners, however face direct exposure to watery environment during escape training and in rare contingency of actual escape from a sunken submarine. The basic concern of underwater medicine is the support of life and activities in an unfamiliar environment. This calls for physiological adjustment and supplementation with the help of suitably designed equipment when directly exposed to watery media and atmosphere control in case of closed space living in submersibles.

### Physics of Diving

(a) Pressure

The earth is surrounded by atmosphere, which has a pressure standardised as 760 mm of Hg measured at sea level. Instead of mercuric column, if seawater is used, the barometer shows 10m. i.e.

1 ATA (Atmosphere absolute) = 760 mm of Hg
= 10 m sea water
= 1 Kg/ $cm^2$
= 1 Bar

The commercial divers are already working at 600 m depth. That means the diver is exposed to 61 $Kg/cm^2$ pressure. The diver is able to sustain and work under such great pressure because the human body contains 75% liquid and 25% solids, both of which are not compressible as per Pascal's law. The effects of diving on the human body are caused by the gas present in the body both in physical and dissolved forms, which obeys certain physical laws viz. Boyle's law, Dalton's law and Henry's law etc, which will be discussed later.

(b) Buoyancy

Archimedes Principle states that "A body immersed in a liquid, either wholly or partially, is buoyed up by a force equal to the weight of the liquid that is displaced by that body." Whether an object floats or not depends upon the relative magnitudes of the weight and upthrust. There are three possible cases: negative, positive or neutral buoyancy. The effects on divers are:

**(i) Ballast Weights**

Under normal conditions a diver in the water is positively buoyant. It is necessary to increase his weight by the addition of ballast weights in order to bring him to a state of neutral or negative buoyancy when totally immersed. The weight required varies depending on the type of equipment being used, amount of underclothing and area of operation (i.e. density of the water) .

**(ii) Change of Buoyancy with Depth**

A self-contained diver in an underwater swimming dress is buoyant because of the air in his lungs and air trapped in the dress. To assist his descent he vents his suit at the surface before swimming down. As the water pressure increases and compresses the air in his dress, his displacement is reduced, he is made more negatively buoyant and his speed of descent is increased.

**(iii) Suit Inflation and Dangers of Blow-Up**

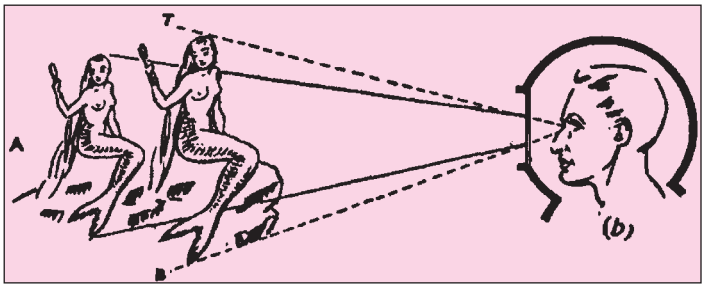
If a diver on the bottom having slight negative buoyancy inflates his dress, he displaces a greater amount of water and assumes positive buoyancy and speeds his ascent to the surface. The diver has means of deflating his dress by releasing air from his cuff and so checking this tendency to surface. The standard diver must take action quickly, since he is in danger of being 'blown up' to the surface.

(c) Underwater Vision

Even in the cleanest ocean water, only about 20% of the incident light reaches a depth of 10 m and only 1% reaches 85 m. Coastal waters with more suspended material scatters the light and restricts the vision. When the diver focuses in water, there is refraction at cornea-air interface and also at air-glass-water boundary. This results in an apparent size increase of about 30%. This makes objects appear closer than they are. Masks also restrict vision by narrowing the peripheral fields and distort objects. (Fig - 1)

(d) Underwater Sound

Fig - 1 : Underwater Vision




In air, sound travels at about 335 m/sec. In water, sound travels almost five times as fast as in air. While this allows a diver to pick up sounds more easily underwater, it does present the diver with some difficulties. The sound energy is lost when being transmitted from air to water; therefore, for divers to hear sounds from the air above them, the sounds must originally be very loud. Directional discrimination by the human ear is dependent upon the ability to detect the difference in time of arrival of sound in each ear. Sound is received, or detected, by vibration response to the sound that reaches the eardrum. In air, we are able to discern the different times that sounds reach our two ears, allowing us to readily detect the direction from which the sound is originating. Since sound travels at a much higher speed underwater, however, the time interval between arrival at each ear is usually indiscernible by the diver. It is therefore difficult to determine the direction of any sound source underwater. Another negative characteristic of sound travel underwater to the diver is the low attenuation of sound intensity over large distances. Low attenuation of sound underwater makes it difficult for divers to determine if the noise emitted is from

a source directly overhead, or several hundred feet away. This also makes it difficult to ascertain what direction the sound is traveling, or whether it is approaching or moving away.

Breathing oxygen-helium gas mixture or air at high pressures changes the voice to a higher pitch. The higher the pressure the greater this effect becomes until at great depths the voice becomes so distorted that telephone communication is almost impossible. This effect is due to the different speed of sound in gases of different densities. The fact that sound in water travels much faster than in air makes it almost impossible to pinpoint a source of sound underwater, and it is possible to obtain only a general idea of the direction.

(e) Phases of Diving

Diseases / accidents peculiar to underwater activities depends upon the phase of diving which are as under:-

(i) Descent to bottom.

(ii) Stay at bottom.

(iii) Ascent to surface or decompression.

### Effects of Pressure on Human Body

Effects of pressure on human body during a dive are as under:-

(a) Direct Physical Effects or Barotraumas

The physical effect is due to a direct effect of increased pressure by a column of water on the human body. It causes drastic changes in the volume of air in the various air containing cavities of the body and may profoundly change the respiratory dynamics which is of considerable importance to diving.

(b) Indirect Biological Effects

The biological effects are indirect in nature and are due to change in partial pressure of the gases breathed and depend on the saturation / desaturation of the tissues with dissolved gas and change of body functions by abnormal gas tension.

### Classification of Diving Medical Problems

Medical problems encountered by the divers may be classified according to the phase of diving as under: -

**(a) Phase of Descent to Bottom**

(i) Otitis, sinus, dental barotrauma.

(ii) Face or thoracic / body squeeze.

(iii) Acute hypoxia.

(iv) Hyperbaric arthralgia.

(v) High pressure nervous syndrome (HPNS) .

**(b) Phase of Stay at Bottom**

(i) Respiratory problems at depth.

(ii) Oxygen, $CO_2$, CO toxicity.

(iii) Inert gas narcosis.

**(c) Phase of Ascent to Surface and there after.**

(i) Decompression sickness.

(ii) Pulmonary barotrauma.

### Decompression Sickness (DCS)

DCS, Caisson disease and bends are the same conditions produced by the evolution of nitrogen bubbles into the body fluids and tissues.

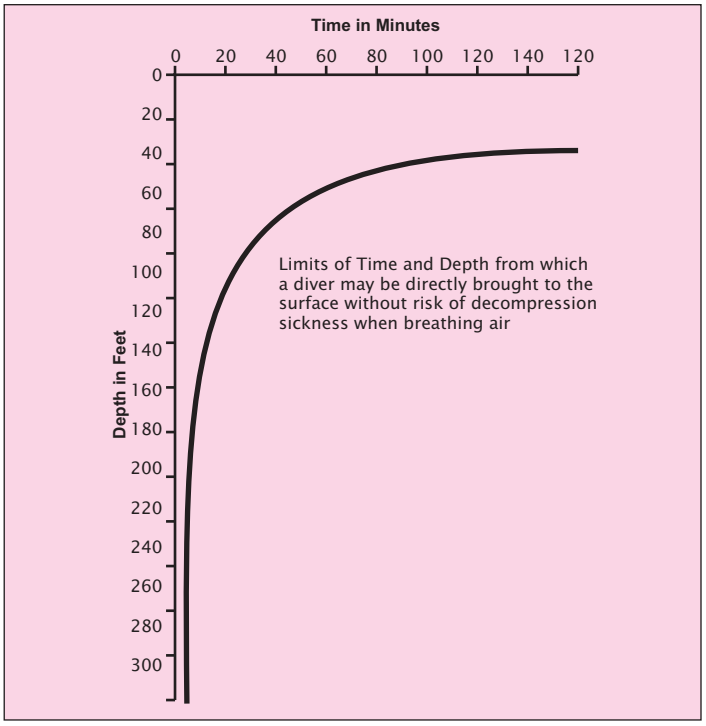
(a) Aetiology

Any medium under pressure absorbs excess gases in accordance with Henry's Law. If the pressure is suddenly reduced the dissolved excess gases come out from the liquid in the form of bubbles. Body tissues of a man under pressure also take up gases in accordance with the solubility of the various gases in the tissues. For example, fat tissues take up 5 times more nitrogen than other tissues in the body. It is the inert gas such as nitrogen, which is important in the production of bubbles. There is a certain pressure duration relationship that can be accepted by the body without producing DCS (Fig-2) .

(b) Pathology

DCS is the result of evolution of bubbles in the body fluids and tissues as well as of the mechanical and humoral effects that it triggers. The main pathology is secondary to vascular occlusion by bubbles. Any organ can be affected in this process. Some of the common examples are air embolism in pulmonary system, occlusion of the vessel in cerebral circulation leading to embolic stroke infarction and occlusion of coronary arteries producing myocardial damage. Gas bubbles also act as foreign surfaces, which attract platelets and activate Hageman factor to trigger off the coagulation system. This process leads to formation of microthrombi. The delayed effects of these asymptomatic silent emboli manifest as damage to long bones by way of aseptic bone necrosis or to the central nervous system as generalised degeneration of neurons.

Fig - 2




(c) Signs and Symptoms

DCS could present with acute and fulminant symptoms or delayed and mild symptoms. Generally the shorter the time intervals after surfacing from a dive, the graver are the symptoms. By and large these symptoms which appear after 1 1/2 h on surfacing are of the milder variety. But DCS can occur upto 24 h after surfacing from a dive.

**(i) Severe DCS**

The fatal and fulminate symptoms are produced because of gas emboli of the pulmonary system (choke syndrome) , the central nervous system and /or the coronaries. The patient can have severe dyspnoea, any kind of paresis or paralysis, speech disturbance, cerebellar disturbance, mood disturbance and disturbance of consciousness. Paraperesis and paraplegias are common; so are convulsions. If any of the above signs and symptoms are present, the patient has to be immediately repressurised in a Recompression Chamber (RCC) following the various therapeutic tables without wasting time for investigations and diagnosis.

**(ii) Mild DCS**

Usually comes after an interval of minutes or hours of surfacing from a dive. It manifests as pain in a joint or as an itchy skin rash. Such symptoms may also be a part of severe DCS, when it is to be treated as a part of the whole spectrum of the disease and not as the mild variety.

(d) Treatment

If a diving manual, Indian Naval BR 2806 is available at the site of treatment, one should proceed as per the instructions contained in articles 5502 to 5523. However, most of the decompression sickness encountered in diving at less than 70 meters depth can be effectively treated by the oxygen tables. (Table - 1 & 2)

(e) Treatment of DCS in the Absence of RCC

In the absence of the compression chamber, a patient of DCS should be administered 100% O2 by oronasal mask. Give plasma expanders like Dextran to prevent sludging

Table -1 : Oxygen recompression therapy (for mild cases only)

| Gauge Depth (metres) | Stoppages | Elapsed time | Rate of ascent (metres/minute) |
|---|---|---|---|
| 18 | 20 ($O_2$) | 0000-0020 | - |
| 18 | 5(Air) | 0020-0025 | - |
| 18 | 20 ($O_2$) | 0025-0045 | - |
| 18-9 | 30 ($O_2$) | 0045-0115 | 3m in 10 mins |
| 9 | 5 (Air) | 0115-0120 | - |
| 9 | 20 ($O_2$) | 0120-0140 | - |
| 9 | 5 (Air) | 0140-0145 | - |
| 9-0 | 30 ($O_2$) | 0145-0215 | 3 m in 10 mins |
| Surface | | 0215 | |

TABLE- 2 : Oxygen recompression therapy (for fulminant cases)

| Gauge Depth (metres) | Stoppages | Elapsed time | Rate of ascent (m/min) |
|---|---|---|---|
| 18 | 20 ($O_2$) | 0000-0020 | - |
| 18 | 5(Air) | 0020-0025 | - |
| 18 | 20 ($O_2$) | 0025-0045 | - |
| 18 | 5(Air) | 0045-0050 | - |
| 18 | 20 ($O_2$) | 0050-0110 | - |
| 18 | 5(Air) | 0110-0115 | - |
| 18-9 | 30 ($O_2$) | 0115-0145 | 3m in 10 mins |
| 9 | 15 (Air) | 0145-0200 | - |
| 9 | 60 ($O_2$) | 0200-0300 | - |
| 9 | 15 (Air) | 0300-0315 | - |
| 9 | 60 ($O_2$) | 0315-0415 | - |
| 9-0 | 30 ($O_2$) | 0415-0445 | 3m in 10 mins |
| Surface | | 0445 | |
| | | | |

of RBC and haemoconcentration. Aspirin may be given for limb bends. In fulminating cases Low Molecular Weight Heparin is indicated.

(f) Air Evacuation of Diving Casualty

Diving casualties may be transported in aircrafts, which can maintain a cabin altitude of upto 1000 feet or in helicopters which maintain altitude of 500 ft.

(g) Prevention

DCS can be prevented by the strict adherence to diving schedules given in diving manuals. The air diving table followed in the Indian Navy is given in Table - 3. As adipose tissues take up considerable amount of excess gas, obese people should not be allowed to dive. Working at high altitudes and in extreme cold conditions can predispose to DCS. As the ambient pressure of atmosphere is low at high altitude, the table is to be modified as given in the diving manual.

Table - 3 : Air Diving table

| Depth not exceeding (m) | Bottom time (min) | Stoppages at different depths (m) | | | | | Total time for decompression (min) |
|---|---|---|---|---|---|---|---|
| | | 25m | 20m | 15m | 10m | 5m | |
| 9 | No limit | | | | | | |
| 10 | 230 | - | - | - | - | - | 1 |
| | 420 | - | - | - | - | 5 | 5 |
| | 480 | - | - | - | - | 10 | 10 |
| 15 | 80 | - | - | - | - | - | 1 |
| | 85 | - | - | - | - | 5 | 5 |
| | 90 | - | - | - | - | 10 | 10 |
| | 100 | - | - | - | - | 15 | 15 |
| | 110 | - | - | - | - | 25 | 25 |
| | 120 | - | - | - | - | 30 | 30 |
| 20 | 45 | - | - | - | - | - | 1½ |
| | 50 | - | - | - | - | - | 5 |
| | 55 | - | - | - | - | - | 10 |
| | 60 | - | - | - | - | - | 15 |
| | 65 | - | - | - | - | - | 25 |
| | 70 | - | - | - | - | - | 30 |
| 25 | 25 | - | - | - | - | - | 2 |
| | 30 | - | - | - | 5 | 5 | 10 |
| | 35 | - | - | - | 5 | 10 | 15 |
| | 40 | - | - | - | 5 | 15 | 20 |
| | 45 | - | - | - | 5 | 20 | 25 |
| 30 | 20 | - | - | - | - | - | 2 |
| | 25 | - | - | - | 5 | 5 | 10 |
| | 30 | - | - | - | 5 | 10 | 15 |
| | 35 | - | - | - | 5 | 20 | 25 |
| 35 | 15 | - | - | - | - | - | 2½ |
| | 20 | - | - | - | 5 | 5 | 10 |
| | 25 | - | - | - | 5 | 15 | 20 |
| | 30 | - | - | - | 5 | 25 | 30 |

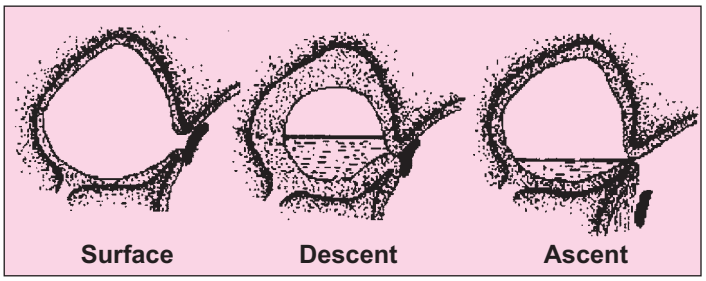
**Barotrauma**

Barotrauma is defined as tissue damage resulting from the expansion or contraction of enclosed gas spaces and is the direct effect of gas volume changes alterations with pressure, causing tissue distortion. It is the most common occupational disorder of divers, experienced to some degree by almost all. It must be realised that changes in volume caused by changes in pressure are greater near atmospheric pressure. Therefore, the effects of pressure changes in the body caused by changes in depth are more noticeable when the diver is near the surface and accidents are much more likely to happen there. Any spaces that are gas-filled viz. sinuses, ears, lungs will be affected by change of pressure in accordance with Boyle's Law.

(a) Sinus Barotrauma

The paranasal sinus cavities are lined with a mucous membrane similar to that in the nose. Bony canals add to provide means of equalisation of pressure between the cavities and the mouth. This means that normally, there is a free flow of air to the sinuses from the back of the nose and throat. However, if the canal through the bone becomes blocked by mucus or swelling of the tissues, the flow will not occur. In these circumstances, the volume of air in the sinuses contracts on increase in external pressure, causing pain and damage to the sinus mucosa, which may burst causing the cavities to fill with blood. If that should happen, there will be a decrease in pain and the diver will feel more comfortable. However, on ascent, the air in the sinuses will expand and, may force the blood out through the canal, resulting in a nose or mouth bleed. Prevention is achieved by avoiding diving when suffering from a cold, catarrh or throat infection (Fig - 3).

Fig - 3 : Sinus Barotrauma

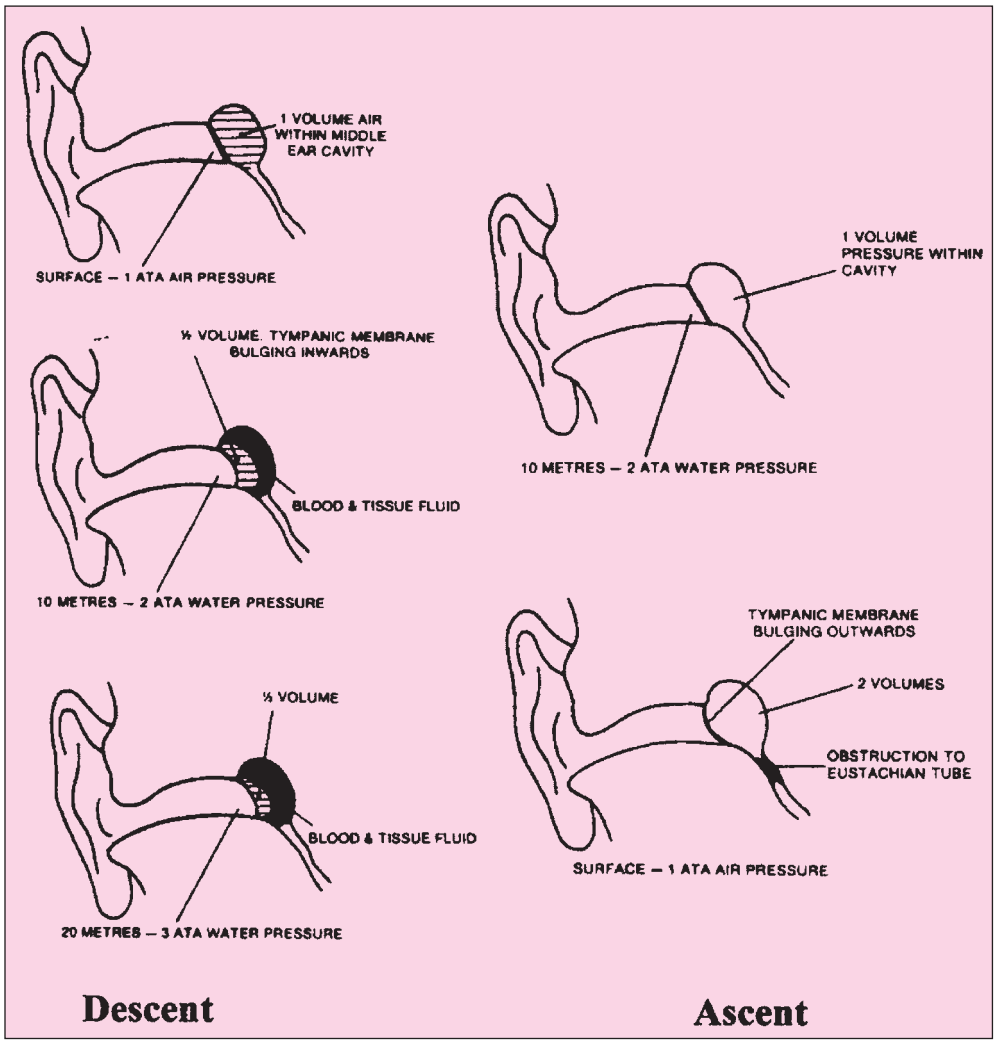



(b) Aural Barotrauma

The Eustachian tube is only lightly closed and usually opens in the healthy individual during the act of swallowing. Its function is to allow air in or out of the middle ear to maintain pressure. However under large pressure differences, the tube does not open freely and discomfort is felt as the drums are stretched inwards (Fig - 4).

This discomfort is overcome by opening the Eustachian tube and allowing air to pass into the middle ear to equalize the pressure on each side of the drum. This can usually be done by either swallowing or yawning, which opens the tube, or by blowing against a nose clip (valsalva maneuver), which forces air through the tube. The act of clearing is evident either as a feeling of relief or as an audible click in the ear. The clearing of ears is required at the pressure of 2.2, 4.4, 7.3, 10.8 m and so on. During ascent the air escapes by itself and clearing is not usually necessary. Middle ear barotrauma is the most common occupational disorder of divers. If the Eustachian tube is blocked by swelling or mucous as in the upper respiratory tract catarrh, the pressure equalisation between middle ear and external ambient atmosphere will not take place resulting in inward bulging of ear

Fig - 4 : Aural barotrauma



drum with stretching pain, haemorrhage and finally perforation. Treatment includes pain relief by use of analgesics, antibiotics if indicated. The diver is unfit to dive until the ear has recovered. Prevention includes pre dive ENT examination, avoidance of diving with nasal or ear symptoms and slowing of descent rate.

(c) Pulmonary Barotrauma

For an average person the maximum capacity of the lungs is about six litres. When a person has exhaled as much as possible, there is still an amount of air left known as the residual capacity. For the average man it is about 1.5 litres. The damage occurs to lungs due to contraction or expansion of gases in accordance with Boyle's law. This is the most serious form of the Barotrauma, and causes most concern in all types of diving operations. i.e. descent and burst lung associated with ascent.

**(i) Lung Squeeze**

When a diver descends, the increase in pressure of water column causes a decrease in volume of the air in the lungs. At about 30 metres the volume of air will have decreased to the residual capacity. On further descent the chest and lungs will not contract any more. So, as the external pressure on the tissues continues to rise, fluid and tissues will be forced into the chest and lung air spaces to equalize the pressure and, in extreme cases, the ribs will crack and the chest will cave in. This is known as lung squeeze and is prevented by supplying gas at the same pressure as the surrounding water.

**(ii) Burst Lung and Embolism**

The incidence of pulmonary barotrauma among naval divers is 1 in 3000 free ascents and fatality rate is 1 in 50,000 free ascents. Decreasing pressure on ascent will cause the gas in the lungs to expand. If the gas is not allowed to escape the alveoli will rupture. This requires only an excess of about 0.035 bar. Thus it is essential to breathe out on a free ascent or breathe normally when using breathing apparatus. Thus the causes are voluntary breath holding during ascent, inadequate exhalation caused by panic, sudden blow to the breathing bag resulting in back pressure, obstruction in the pulmonary airways viz. asthma, tuberculosis, cysts, lung infections etc. A 'burst lung' produces the following main effects:

- Pulmonary tissue damage due to the result of over distention and rupture of lung alveoli. The patient may have haemoptysis and chest pain on deep inspiration.
- Pneumomediastinum: Surgical emphysema and Pneumomediastinum occur due to tracking of respiratory gases along the air passages resulting in dyspnoea, dysphagia, left recurrent laryngeal nerve palsy and brassy tone due to compression on the voice box.
- Air Embolism: The ruptured alveoli may allow gas to enter the blood stream. These gas-bubbles will travel around the body; expanding as pressure decreases and blocking the blood supply to vital organs such as the brain and heart. If a large quantity of gas enters the bloodstream death is rapid
- Pneumothorax: Air will escape from the lungs into the chest cavity, causing partial collapse of the lungs resulting in dyspnoea and hypoxia.

The symptoms apparent are pain in the chest behind the sternum, difficulty in breathing, bloody froth around the lips from blood getting into the lungs after the alveoli are ruptured, rapid unconsciousness and death. The manifestations may be in the nature of acute pulmonary and CNS symptoms described in decompression sickness. Immediate treatment is by recompression to 50 meters for 30 min after which the patient is decompressed according to the under mentioned table. A doctor or a paramedical person should go with the patient in the chamber and continue resuscitation while repressurisation is going on. Ancillary measures such as treating a pneumothorax with needle drainage in fluid may be necessary.

**Prevention:** Its prevention is by observing the correct drill of keeping the airway during ascent and breathing freely

Table - 4 : Modified air recompression therapy

| Gauge Depth ascent (mtrs) | Stoppages Ascent (min) | Elapsed time (hours) | Rate of (metres/min) |
|---|---|---|---|
| 50 | 30 (Air) | 0000 0030 | -- |
| 50-18 | 4 (Air) | 0030 0034 | 8 m/min |
| 18 | 20 ($O_2$) | 0034 -0054 | -- |
| 18 | 5 (Air) | 0054 -0059 | -- |
| 18 | 20 ($O_2$) | 0059 - 0119 | -- |
| 18 | 5 (Air) | 0119 - 0124 | -- |
| 18 | 20 ($O_2$) | 0124 - 0144 | -- |
| 18 | 5 (Air) | 0144 - 0149 | -- |
| 18-9 | 30 ($O_2$) | 0149 - 0219 | 3 m in 10 min |
| 9 | 15 (Air) | 0219 - 0234 | -- |
| 9 | 60 ($O_2$) | 0234 - 0334 | -- |
| 9 | 15 (Air) | 0334 - 0349 | -- |
| 9 | 60 ($O_2$) | - 0449 | -- |
| 9-0 | 30 ($O_2$) | 0449 - 0519 | 3 m in 10 min |

in and out. No one with pulmonary disease should be allowed to dive.

**Breathing Gas Associated Disorders**

The problems associated with oxygen depend upon the partial pressure of oxygen in the breathing mixture. The less percentage of oxygen in the breathing air causes

hypoxia, whereas higher percentage of oxygen breathing causes toxicity. At higher partial pressure, the pollutants like carbon dioxide and carbon monoxide will exert their toxic effects. Breathing of air beyond 50 m depth causes narcotic effect. The medical problems associated with the breathing of improper gas are briefly discussed below.

(a) Hypoxia

Breathing of less than 17 % of oxygen in breathing gas; this can occur due to wrong preparation of gas mixture, empty air cylinder, malfunctioning of reducers or accumulation of foul gases in breathing bag. It is difficult to detect in early stages and the first symptoms are false sense of well being and over confidence. If $O_2$ % continuously falls, the diver may become unconscious. Prevention is to ensure correct flow of gas mixture and also to clear the counter lung (to prevent dilution hypoxia).

(b) Oxygen Toxicity

When breathing under pressure at greater depths deeper than 20 meters, oxygen becomes toxic and produces symptoms of acute oxygen poisoning. This maybe experienced by a diver as twitching of lip & other facial muscles, dizziness, vertigo, nausea, unusual tiredness, disturbances of breathing like hyperpnoea, apnoea or dyspnoea; euphoria, disturbances of sight like tunnel vision, unconsciousness and general convulsions similar to a grand mal seizure. By far the most dangerous symptoms to the diver are the unconsciousness and convulsions, since such conditions could easily lead to his losing the mouthpiece or mask and drowning. For this reason while using 100% $O_2$ in diving, depth is restricted to 8 meters for free swimming and 10m for light work. In normal practice, oxygen is not used for diving beyond these depths. Treatment is to remove the breathing apparatus and suit, place the patient in fresh air to recover. Restrain the patient during convulsions to prevent self-injury, and gag the patient's mouth with a piece of wood to prevent him from biting his tongue. The patient must be kept under observation for at least 12 hours, because loss of memory almost invariably occurs. Prevention is by limiting the partial pressure of oxygen in the mixture breathed to two bars absolute, i.e. 10 metres under light working conditions and eight metres when working hard.

(c) Hyperbaric Oxygen Therapy ($HBO_2T$)

Breathing 100% oxygen at more than one atmospheric pressure in a pressurized chamber is called hyperbaric oxygen therapy. Breathing of pure oxygen at 3 atmosphere absolute pressure carries 6 ml of oxygen in 100 ml of blood in the form of physical solution, which is adequate to meet the oxygen requirements of body without dissociating oxyhaemoglobin. This soluble oxygen readily diffuses into tissues and corrects hypoxia, reduces oedema, improves blood circulation through neovascularisation and enhances wound healing by collagen matrix formation. The oxygen radicals are powerful bactericidal and controls anaerobic and partly aerobic infections. The indications for HBOT are as follows:

**(i) Accepted Indications**

- Decompression sickness
- Gas embolism
- Gas gangrene
- Carbon monoxide poisoning
- Osteomyelitis and osteoradionecrosis
- Problem Wound healing

**(ii) Experimental Indications**

- Burn injury
- Cerebral oedema
- Vascular insufficiency
- Leprosy, Actinomycosis

**$HBO_2T$ protocol**

Giving of pure oxygen at 2.8 atmosphere absolute pressure for 60 min/day for 1-2 weeks is sufficient for the above indications. However severe infections viz. Gas gangrene requires two sessions on first 3 -4 days. When oxygen is used for treatment purposes in a hyperbaric chamber at a depth of 18 m, convulsions may occur. In such cases oxygen mask must be removed and the patient allowed to breathe chamber air. The pressure is to be reduced to 12m and therapy may be restarted. Breathing of oxygen under pressure in excess of 0.6 ATA for prolonged periods can produce chronic oxygen toxicity, which manifests as pulmonary oedema, hemorrhages and fibrosis.

(d) Inert Gas Narcosis

When gases like helium, neon, hydrogen, nitrogen, argon, krypton etc are breathed, they dissolve in the body and produce narcotic effect as that of anaesthetic gases. Helium, neon and hydrogen are least narcotic, whereas krypton and xenon are highly narcotic. Narcotic effect is depth related i.e. it occurs immediately on reaching the depth and independent of time. In fact the diver develops acclimatisation after prolonged stay. The signs and symptoms of nitrogen narcosis are similar to that of alcoholic intoxication. One atmospheric pressure of air produces the effect equivalent to intoxication of consuming of 1 oz of Martini. The symptoms that occur at shallow depth upto 50m are euphoria, talkativeness and laughter. Breathing of air at more than 50m depth results in delusions, stupefaction and unconsciousness. Prevention is by avoidance of using air as breathing medium beyond 50m depth.

(e) CO Poisoning

CO poisoning occurs due to breathing of gas which is contaminated with CO. This occurs due to charging of air bottles in polluted atmosphere or near engine exhausts. The symptoms are shown in Table - 5. The treatment of carbon monoxide poisoning is quick removal of the patient from further exposure to CO and breathing 100% $O_2$. Definitive treatment is hyperbaric oxygen therapy.

(f) Carbon Dioxide Toxicity

In diving, carbon dioxide retention occurs mainly because of the malfunctioning of the sets i.e. non-functioning of

Table - 5 : Symptoms of CO poisoning

| Carbon monoxide in air (as PPM) | % of Caboxy-haemoglobin | Symptoms |
|---|---|---|
| 400 | 7.2 | Nil |
| 800 | 14.4 | Headache, nausea, dizziness, breathlessness |
| 1600 | 29 | Confusion, visual disturbance, increased pulse rate & respiration, collapse |
| 3200 | 58 | Unconsciousness, intermittent convulsions |
| 4000 | 72 | Profound coma, cardiovascular |

valves of the air bottles, inefficient $CO_2$ removal or accumulation of foul gases in the breathing bag. Excess $CO_2$ also may be produced due to over exertion. In chronic form of poisoning there is a stage of compensation, which is followed by decompensation and ultimately failure; if the toxicity is sufficiently prolonged. In the acute form compensatory stage may be totally absent.

**(i) Clinical Picture**

The signs and symptoms during various stages are as under: -

- Latent Hypercapnia (0.2-0.5% of $CO_2$). Perception of smell improves. There may be euphoria and feeling of stiffness.
- Compensated Hypercapnia (0.5-3 % of $CO_2$). Memory and attention are affected. There is hyperventilation and acidic secretion. Peptic ulcer may get aggravated from increased gastric secretion. There is increase in secretion of acidic urine and sweat. Hypotension may develop after 3-4 days.
- Marked Hypercapnia (3-6% of $CO_2$). Sharp deterioration of general condition, lack of confidence and self-control. Lack of orientation of space and time. Euphoria and deterioration of critical judgement.
- Uncompensated Hypercapnia (6-10 % of $CO_2$). There may be drowsiness, loss of consciousness, constriction of Pupils, convulsions and depression of adrenal cortex leading to collapse.
- Narcotic Stage (>10% of $CO_2$). Deep narcosis with respiratory depression leading to death.

**(ii) Treatment**

Flush through the counterlung, breathe deeply or signal for more air, according to the equipment in use. If this brings no relief, the diver must surface. Give the diver fresh air or oxygen. Allow the diver to rest. Recovery should be rapid.

**(iii) Prevention**

Ensure that the $CO_2$ absorbent is fresh, dry, dust free and. correctly packed. Do not exceed the endurance of the canister. Ensure that breathing is correct, i.e. long, deep breaths with all equipments. Periodically, the stale air in the Bell / Chamber must be replaced with fresh air without causing a change of pressure.

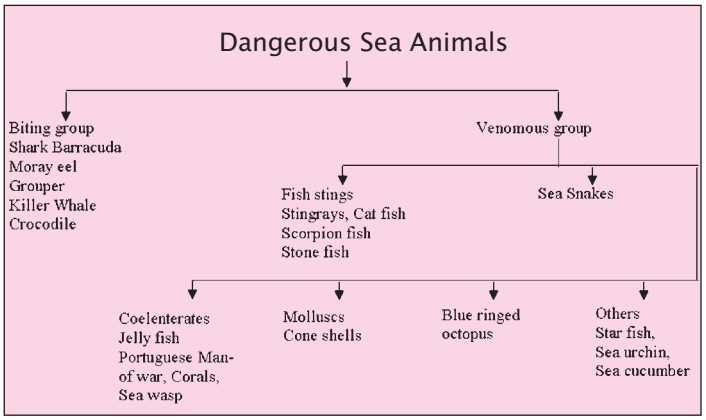
### Hypothermia

The Indian Navy personnel are not usually subjected to cold. They may sometimes suffer from hypothermic reactions following the diving operations in cold water with temperature below 15°C, as the body heat is lost very rapidly in the compressed cold atmosphere. The initial defensive response produces a constriction of blood vessels, increased heart rate and blood pressure and shivering. Generalised pathological hypothermia of adynamic phase occurs, when the core body temperature falls below 33°C resulting in hallucinations, delusions and cardiac arrythmias. When the core temperature falls below 30°C, paralytic phase sets in, which manifests as unconsciousness, stoppage of cardiac and respiratory activity. Most of the ship wreck victims die of hypothermia leading to drowning.

### Hazardous Marine Animals

Certain forms of marine life pose a threat to humans.

Table - 6 : Dangerous Sea Animals




Generally man gets hurt or killed by encountering the self-defence armament of the sea creatures or by trespassing on their property; only rarely he is threatened by unprovoked attacks. Dangerous sea animals are classified as shown in table 6.

(a) Biting Group

Sharks are the best known and most feared sea creatures. These predators are most vicious when a group is in the 'feeding frenzy' mood, usually when there is lot of flesh

and blood in the water. At such times they will attack and bite at any object in the vicinity. At other times unprovoked shark attacks are as frequent as commonly believed. Flesh blood, noise and irregular vibrations commonly attract sharks. Preventive measures include avoiding known shark infested water, avoiding water in which food and animal products has been thrown. Carry shark repellant while swimming and diving. If shark is spotted .do not panic, stay motionless or try to move away using slow strokes while watching the shark, which will probably go away. If it approaches too close hit it on the snout or eyes with any object. Emergency treatment is for hemorrhage and shock and secondary infection. Bites by Barracuda, Moray eel, crocodile, killer whales and grouper fish are rarely encountered in this part of the world.

(b) Venomous Group

The important venomous marine animals are:

**(i) Sea Snakes**

Out of the 40 species of sea snakes in Indian waters 39 species are poisonous. Sea snakes are 2-10 times as poisonous as that of cobra. But, because of its poorly developed fangs, they can deliver only 25% of the poison. The venom is neuro and myotoxic and usually causes acute tubular necrosis. In addition to first aid, treatment for shock, antihistamines and polyvalent anti snake serum are used.

**(ii) Fish**

Catfish stings are common and painful. Stingrays are found in mud and can deliver a fatal sting. Scorpion and stone fish stings can also be lethal but are uncommon. Numbness and respiratory paralysis, nausea and vomiting, dizziness may occur. Myonecrosis is common.

**(iii) Sea Wasp and Box Jelly Fish**

The sea wasp is the most venomous animals in the sea and its poison can kill within ten minutes. It has a balloon like float and long, very fine tentacles with the poison sacs. The sting causes a line of wheals on the skin and can cause local paralysis and respiratory paralysis if severe. The Jelly fishes normally cause painful pruritic local lesions. Cone shell sting and octopus bite may be lethal.

### Drowning

Drowning is asphyxia due to immersion in water and is the fatal termination of a sequence of preventable events. Among the many causes of drowning, the most common is hypothermia. The victim of immersion, both inhales and swallows water. However in the majority of cases comparatively little water enters the lungs due to spasm of larynx i.e. constricting the air passage (dry drowning). Whether it does or not, the result is the same: breathing stops. It is unimportant whether immersion occurs in fresh or salt water. Drowning causes lung damage and failure of oxygen transfer. Congestion of the lungs can occur very quickly, but may be not apparent for hours.

(a) Signs and Symptoms

The main clinical features are difficulty in breathing with increased rate and depth, noisy breathing, frothing from mouth, blueness of lips and finger tips, confusion, possible unconsciousness and death. Death usually occurs within about 8 minutes.

(b) First Aid

Remove any obstructions from the mouth of the casualty. It may be possible to start artificial respiration while still in the water. If in deeper water give the occasional breath of air while towing the casualty ashore. Place the casualty on a firm surface, check his pulse and respiration. Victims tend to swallow large quantities of water distending their stomach. No time should be wasted in trying to remove water from inside the casualty's body. Immediate Cardiopulmonary resuscitation is to be started and continued till the patient revives or medical help arrives or upto a minimum duration of 45 mins. If the casualty has been immersed in cold water for sometime there is also a danger of hypothermia. So he should be kept warm, wrapped in blankets. Occasionally survival may be prolonged by profound hypothermia. People have recovered after being totally immersed and without breathing for 40 minutes. Arrange to remove to hospital. Even though the survivor of near drowning may appear to have recovered, he should not be allowed home as complications may develop rapidly during the next day or so. No patient with Hypothermia is to be declared dead till fully warmed.

### Investigation of Diving Accidents

Diving accidents are not uncommon and almost all of them are preventable. There are various contributory factors, which may lead to a diving accident. Majority of diving accidents, however are due to human error or carelessness. Hence a high standard of physical fitness and good, continuous training of the diver are essential for the survival of the diver under water. All diving accidents, both fatal and non-fatal, should be investigated thoroughly to prevent their recurrence. When diving accident occurs, the diving set used by the diver should be inspected meticulously. The position of all the valves, pressure gauges and the external appearance of the set should be examined and noted down. None of the valves are to be operated. Gases filled in the cylinder/ breathing bag and $CO_2$ absorbent are to be sent for analysis. Statement of the diver, his buddy, the diving attendant and any other witness are to be taken as early as possible. All this information compiled together will lead to the cause of the accident. In cases of fatal accident, postmortem examination of the body is a must. The concerned Unit should render a report on a prescribed proforma (Diving Accident/ Incident Report) so that appropriate action is taken to prevent such accident in future.

Management of the casualty and investigation into the cause of the accident are both equally important steps in Diving accidents. Investigation of a fatal diving accident is a fact-finding mission. The intentions are to establish the cause of death and to take corrective steps to prevent recurrence of the event. Autopsy of a dive fatality includes the findings of a post-mortem examination and toxicology studies. A thorough external examination

including signs of trauma, animal bites and evidence of subcutaneous emphysema or envenomation should be carried out. Radiograms of the head, neck, thorax, and abdomen will reveal free air. An initial "I" shaped (modified "tent" incision) over the chest is made and this area filled with sterile water. A large bore needle is inserted into the second intercostal spaces bilaterally and escaping air can be captured in an inverted, water filled, graduated cylinder. As sternum is removed, any gas escaping from vessels should also be noted. The pericardial sac is opened under water to look for pneumopericardium. A needle is inserted into both the ventricles for capture of escaping gas. After an under water examination of the mediastinum, heart, and great vessels, the water may be evacuated and a standard autopsy is performed. The lungs are carefully examined for bullae, emphysematous blebs, and haemorrhage. Evidence of cardiovascular disease especially inter-atrial or inter-ventricular septal defects and any changes that would compromise cardiac function is looked for. Prior to opening the skull, all of the vessels in the neck are to be tied off. Once the skull is opened the vessels at the base of the brain are tied. Bubbles in the major vessels are significant. Carboxyhaemoglobin, $PO_2$, $PCO_2$ and electrolytes on aortic blood should be considered for toxicology. Investigation of a diving accident is a composite effort of specialist diver, marine medical specialist and pathologist. A study of circumstances leading to event, diving set analysis and autopsy findings contribute equally to indicate the probable cause.

### Survival at Sea

In case of shipwreck, the crewmembers who survive the initial impact should resort to abandonment (ditching) of vessel at sea. It is therefore necessary that prior training be imparted to the crew to familiarise with all procedures to safe and prolong life at sea. Forced immersion in water, after abandonment of vessel, is the primary hazard to life. In water there is increased heat loss leading to decrease in body temperature (i.e. generalised hypothermia) which can lead to abnormalities in heart rhythms or even cardiac arrest & death. This loss of body heat depends upon ambient water temperature and length of exposure in water.

(a) Warm clothing to be worn before ditching. If immersion suit is available it should be worn over the warm clothing. If immersion suit is unavailable, then put on a life jacket.

(b) It is always better to avoid jumping into the water from a height more than 5m as the sudden immersion in water can result in drowning or death. As far as possible climb on the life boat or life raft.

(c) After jumping it is important to orient oneself and try to locate ship, lifeboat or other survivors.

(d) In cold waters person will have violent shivering and feel great pain. While afloat, do not swim too much, as needless exercise will increase the rate of body heat loss. Hence it is important to remain as still as possible, however painful.

(e) In life boat/ life raft, shield yourself from the wind as wet clothes on the body causes a wind chill effect and further increase heat loss.

(f) It is very important to have a positive mental attitude and the will power to survive. There are many amazing cases of people who have survived with just will power.

(g) DO NOT CONSUME ALCOHOL before abandoning ship, as alcohol causes vasodilatation & thus heat loss.

(h) For further details refer to the Chapter on Survival at Sea

### Medico Legal Aspects of Death at Sea

In case of a sudden or unnatural death afloat, where circumstances do not permit the help of shore authorities for the postmortem of the body and the body cannot be preserved until arrival of the ship in harbour, the medical officer may under written orders from his Commanding officer, conduct the postmortem to ascertain the cause of death. If the dead body can not be preserved due to any reason, then it should be packed and sealed in the manner as to ensure its immediate sinking. In case of a natural death, the medical officer may, if he considers it necessary or advisable, conduct postmortem on the body with the prior consent of the commanding officer in the absence of consent from next-of-kin. Should there be any appearance of a suspicious case, he shall retain evidence in accordance with the normal medico-legal requirements. He shall also inform the Commanding officer of his suspicion. The commanding officer shall thereupon take appropriate steps to investigate the case and report the same to the senior officer present or the administrative authority who shall thereupon convene a board of inquiry .If the ship is near an Indian port, the commanding officer may, if considers it advisable, inform the coroner or other appropriate civil authority ashore so that an inquest may be carried out. Where, however, the body is to be cremated or buried ashore, the Commanding officer shall inform the coroner or other civil authority of the case. In case the death occurs at a place outside India, unless the local law requires otherwise, it is not necessary to inform the local civil police and the inquest may be held by the commanding officer of the ship to which the deceased belongs. If the death occurs during the day onboard a ship within port limits, the ensign and house flag if any, shall immediately be lowered to half mast and kept in that position from sunrise till sunset as long as the dead body remains onboard; and if death occurs between sunset and sunrise, one red light shall be hoisted at the peak, half mast high. Special provisions relating to the carriage of dead bodies and cremated remains: No person shall bring into India any dead body or human remains of persons who may have died of yellow fever, plague, Anthrax, glanders or such other diseases as may be notified by the Central government for this purpose.

## Health Problems in Naval Aviation

Health problems of aircrew and the supporting ground crew of Naval Air Arm are the same as for those of other naval personnel. Over and above, they also face the

problems encountered in aviation. The naval aviation is not limited to shore bases alone. The problems of take off and landing present different situations while flying from an aircraft carrier or another ship carrying different types of helicopters. It is very much essential that a Naval Medical Officer should acquaint himself with the aviation personnel so as to know the types of duties an aircrew has to perform. He should also know the types of aircraft flying in the Navy, their capabilities, and the types of jobs the ground supporting crew have to perform. He should establish himself as a member of the flying crew so that he develops a rapport with them and thus knows the problems faced by them in day to day life. The following conditions need close attention and medical evaluation for flying fitness: -

(a) Loss of flying efficiency.
(b) Physical and mental fatigue.
(c) Fear of flying or phobia during conversion.
(d) Increased indulgence in alcohol/tobacco.
(e) Frequent near miss, incidence and accidents.

## Water Supply

### Sources and Responsibilities

Safety of water supplies on naval vessels is very important for the prevention of waterborne diseases. Potable water must be provided for drinking and cooking purposes. As far as possible it should also be available for washing, bathing & laundering. However, due to storage difficulties afloat, it is not possible to supply water at the same liberal scale as on shore. The engineers are responsible for supply of water, and medical services advise on the treatment to render the water fit for human consumption. Constant vigilance by regular periodical examination of the water supply is essential to ensure that the quality of water on naval vessels conforms to the established standards. The source of potable water supply on naval vessels is mostly from potable water systems ashore or by distillation of seawater. Over board, sea water is normally utilised for fire fighting, flushing systems and cleaning of decks.

### From Shore

Before accepting any fresh water from shore, it is good to investigate the source of supply. If time permits, the bacteriological examination of the port water should also be carried out. Information regarding quality of the water is generally available from the local Port Health Authority. Water for ship's supplies is normally clarified and chlorinated, and the Port Health Authorities all over the world conform to the international requirements of the quality of water. Therefore, if proper precautions for transportation, storage and distribution are taken, there should be very little danger of dissemination of waterborne diseases. However, the fact that water has been purified earlier at port does not necessarily assure its continued safety. Rechlorination of water supply on board the ship ensures added safety, especially when water is of doubtful purity or when it is likely to get contaminated during the process of transportation. The following precautions while loading water should be taken: -

(a) Water should only be taken after the competent authority has determined and assured that the source of supply is safe.
(b) Generally, potable water is available from a common source of supply ashore for both domestic purposes as well as for fire fighting and flushing systems. In some ports there is a dual system and unfiltered water is supplied for fire fighting and in flushing system. The hydrant should be properly identified, specifically when they are not distinctly marked. This information must be passed to the individual who makes the connection between the shore supply and the ships system and operates the hydrants.
(c) The fresh water hose should always be kept separate from others. When taking it to shore for attachment to hydrants, precaution must be taken to ensure that no part of the hose falls into the harbour water. The hose should be thoroughly flushed with fresh water before it is connected with the water system of the ship.
(d) It is necessary to test the water for the residual free chlorine by the orthotoludine test.
(e) While filling the fresh water tanks, it should be ensured that no cross-connections exist between the fresh water system and fire-fighting or flushing systems.
(f) After the operation of loading is completed, the hose should be disconnected, drained and washed if necessary, and then stored away in the locker specially reserved for that purpose.
(g) If facilities are available, bacteriological examination of water from each tank may be carried out. This is not obligatory, specially when the water from the harbour is considered to be safe. As a further precaution the potability can be ensured by adequate rechlorination of the water.
(h) Sometimes the water is transferred to the vessel from a watership or a tanker. This water may have been purified before loading at the base or might have been distilled on board the ship. Arrangements for chlorination often exist in such vessels. If not, it will have to be carried out after receiving the delivery.
(j) Water barges are also sometimes used for transportation of shore water to the ship specially in harbour. The precautions mentioned above must be observed in transferring water from these vessels.

### Distilled Water

Distilling plants of various types for water supply to the fresh water system and boiler feed water system are provided on naval vessels. The distillation of sea water often leaves a considerable quantity of ammonia in the water, resulting in deviation of a considerable amount of chlorine. An adequate quantity of free chlorine is thus not available for sterilising purposes. Free chlorine in water should be estimated by the orthotoludine test. The 'flash

point' reading after 5 sec shows the free chlorine contents and the reading after 5 min indicates the combined chlorine.

### Overboard Water

The water in harbours or off-shore near habitations and around fleet concentrations is highly contaminated and should not be used for any purpose. When conservation of fresh water or fuel is important or when it is impracticable to provide fresh water for all purposes it may be necessary to use overboard water when away from contaminated areas. On naval vessels, seawater is ordinarily used out at sea for fire fighting and flushing purposes. At times overboard water has to be used in the laundry, showers, and washing of decks. This source should only be used when it is approved by the medical officer and when out at sea away from shore.

### Storage of Fresh Water

From water safety point of view, detached tanks for storage of fresh water are ideal; but in order to fully utilise the hull space, fresh water is often stored in the inner bottom and outer shell tanks. The ship's bottom is subjected to maximum external pressure and can also get damaged from under-water explosions or when grounded. Should the tank develop a leak, there is likelihood of the contamination of the fresh water in such tanks. Considerable care and regular maintenance are essential to keep the water free from contamination. Use of sounding rods for gauging the depth of water in storage tanks can be a source of contamination; therefore, their use should be strictly restricted. All tanks should have watertight covers, which are to be kept locked at all times. When it is absolutely necessary to enter the tanks for repair and maintenance, these should be properly disinfected before being taken into use. Only hose lines reserved for fresh water should be used and all cross connections to other systems eliminated while filling the tanks. Water tanks should be painted only with authorised paints; otherwise there will be a risk of unpleasant taste and odour or even poisoning by toxic chemicals. After treatment, the tanks should be cleaned, thoroughly flushed and decontaminated.

### Water Purification

Water on board the ship when obtained from shore should have been already treated. The medical officer should see that potable water on board the ship conforms to the bacteriological standards laid down for urban supplies. At least 0.2 ppm of free chlorine should be available in drinking water at all times. Sterilisation of water with chlorine may be carried out when necessary. In large ships chlorine gas in solution is sometimes used when automatic chloronome is available but in most of the smaller ships field methods have been employed. Every medical officer should be familiar with the use of case water sterilising (Horrocks' box). Free and combined chlorine can be estimated easily by the use of a chloroscope (Lovibond comparator).

### Distribution of Water

Naval vessels have two primary water systems which serve the entire ship; the fresh water storage and distribution system, and fire fighting and flushing system. An independent system of water supply is provided for special requirements of engine rooms. The fresh water distribution system delivers potable water to galleys, sculleries, pantries, sick bays, laundries, deck showers and to drinking water taps throughout the ship. The fresh water and salt water systems are generally independent of each other. Otherwise, precautions must be adopted to avoid danger of cross-connections and back siphonage between salt and fresh water systems. The fresh water system should be physically disconnected, preferably by removal of a section of the corresponding connection pipe, before installing a connection between the overboard water and the salt water system. The same precaution must be adopted in the case of the fresh water system. The following general rules should be observed as precautions for protection of fresh water on board the ship :

(a) The fresh water system should be kept entirely separate and disconnected from all other systems on board the ship.

(b) The fresh water tanks and all parts of the fresh water system must be disinfected at least annually or whenever there are reasons to suspect that it has been contaminated.

(c) Cross-connection between fire fighting and flushing systems on board and the potable water system ashore should not be permitted unless back flow preventers are used on the potable water outlets. If this is not done, there is risk of contaminating the drinking water on shore.

(d) It should be ensured that when there is a dual system ashore, the fresh water tanks aboard are filled from drinking water hydrants and not from the fire main.

(e) When fresh water is introduced into any piece of equipment that may contain contaminated water, it should only be admitted through a non-floodable air gap.

(f) Salt water for shower, laundry or flushing decks should not be used when the ship is anchored in polluted areas.

(g) As an added factor of safety, water stored in fresh water tanks should be re-chlorinated, especially when the ship is operating in polluted waters.

### Protection of Water

Cross-connection between two separate water supply systems causes water to leak or flow in either direction between the systems. The potable water to all tanks, pipes or other water connections likely to contain contaminated water should therefore be delivered through non-floodable air gaps. The air gap protection should be provided for galley and pantry sinks, scullery equipment, laundry machines, lavatories, hospital sterilisers and fixtures of all types. All drainage outlets to sewers, drains, or the bilge, should be protected from flooding by the use of air gaps. All fresh water pumps should be air tight and

should have air tight suction lines free from cross-connections. For priming of water pumps, only good quality water must be admitted to the pump casing through an air gap. All pumps after they have been dismantled for repair should be decontaminated after reassembly and before they are put into use. All faucets, hydrants, and other outlets on any system not carrying potable water should be clearly marked as "UNFIT TO DRINK". Hydrants and other connections used for loading water should also be stencilled for proper identification. In order to trace and identify the various water and other pipe systems and to prevent improper connections, all pipes are stencilled with the name of the fluid carried or are painted with distinguishing colours. The identification colours used are light blue for potable or drinking water, orange for sanitary water and red for fire services.

### Water Requirements

The normal minimum allowance of fresh water for all purposes on a naval vessel should be about 55 L / day, out of which about 1/5 is required for drinking and cooking. Economy in the use of water is essential but a liberal allowance is desirable as it helps in the prevention of diseases. At times drastic restrictions in the use of fresh water may have to be enforced, but even under these circumstances an allowance of 10 L / man / day for drinking and cooking purposes is considered to be the absolute minimum. Under such conditions sea water can be used after desalination and decontamination, in showers, waterclosets, laundries. The quantity of water required for drinking will depend upon the ambient temperature and physical activity.

### Use of Salt Water

Seawater on board ships is used primarily for fire-fighting and sanitary purposes (for flushing of toilets etc). Seawater is also used in condensers (Heat exchangers) for cooling of machinery, for anchor cleaning and for pumping out oil and grease bilge eductors. In the event of a NBCD fall out, certain types of ships have a sprinkling system on upper decks which form a "water curtain" to prevent against such biohazards from contaminating the ship. Now a days, most ships are fitted with reverse osmosis plants, the purpose of which is to convert sea water to fresh water thus drastically reducing the need for water storage on board during long sailings. The RO plant functions on the principles of reverse osmosis which prevents the free passage of solutes through a semi-permeable membrane thus letting out only fresh water which is checked for conductivity and salinity. If saline content is more then the permeate is recycled to further reduce the saline content till it reaches acceptable limits.

### Emergency Water Supplies

A 1000 L tank for vessels with a total complement of over 500, and a 500 L tank for vessels with a total complement of 300 to 500 should be provided at the forward and after battle dressing stations. Destroyers and other similar ships should have a 200 L tank. The mid ship battle dressing station should be equipped with a 500 L tank. Prior to action, buckets, tubs and other containers should be filled, and placed at the battle dressing station for use if connections to fresh water system tanks are damaged or destroyed. Arrangements for emergency drinking water should also be made in turrets and other action stations. Lifeboats and rafts must at all times carry a supply of drinking water. All emergency supplies should be regularly examined in order to ensure that safe water is available at all times.

### Cleaning of Storage Tank and Distribution System

On board the ship, in addition to thorough cleaning and disinfections of the tanks, the pipes, hose and pumps also require proper decontamination. For this purpose, after thorough cleaning by scrubbing and brushing, the tanks and the system are filled with water with a high chlorine concentration, which after an hour's contact is flushed through the system. All personnel employed for cleaning the tanks should be free from infectious diseases, and are required to bath and wear clean clothes before entering the tanks. After scrubbing and cleaning of the tanks, the pipes and other parts of the system are flushed with clean water. Tanks and pipes are then filled with water super chlorinated by adding 60 g of WSP / 1000 L of water. The capacity of the tank and system should be determined to know the quantity of water required to completely fill the system and the amount of WSP required. The total amount of WSP is first made into a thin paste, by mixing 1 kg in 10 L of water, and added to the tank when it is full and then filled. Circulation of water through the rump and back to the tank ensures proper contact with the superchlorinated water; taps and outlets nearest to the tank are allowed to flow until the highly chlorinated water appears in them. This process is continued outward from the tank until all outlets have been flushed. The outlets are then closed and after one hour's contact, the water is let out. The system is then washed and filled up with potable water.

## Food Supply and Food Inspection

The special problem encountered afloat is the preservation of fresh rations during prolonged sailing periods. Most ships of the fleet are equipped with cold rooms for preserving meat; but only some ships have a separate room for storage of fish. Fish should not be stored in the same room with meat as it imparts a fishy smell to the entire meat in store. Failure of power or a mechanical breakdown of the cooling plant may cause putrefaction of meat and fish. The thawing of the meat should be done gradually. Tinned milk is issued in lieu of fresh milk. Ships not having their own bakeries have to use bread baked many days before their consumption. There is a shortage of leafy vegetables during prolonged sailing. A daily inspection of fresh rations issued to the galleys is necessary during any prolonged sailing programme. Strict vigilance should be kept for detection of deficiency diseases amongst the ship's company. The medical officer serving afloat should ensure that the stored perishable foods are safe for consumption. He must inspect meat daily after it has been taken out of the cold room, particularly during prolonged sailing when frozen meat is often stored on board for over 2 months, as due to occasional power or mechanical failures it may become unfit for human consumption. The same applies to other

perishable foodstuffs stored in the cold room. Arrangement for cooking and serving of food should be on the same hygienic lines as on shore. Wastage of food should be avoided.

### Sewage Disposal

Ships, in most cases, discharge their sewage over the side without treatment. Disposal by this method presents no problem when a ship is underway, except that of providing adequate seawater to ensure flushing of the troughs and the effluent line, since sewage requires 1 to 40 dilution ratio. On some vessels, the construction is such that drainage from the plumbing fixtures cannot be discharged overboard by gravity flow because they are below the level of the waterline or because openings would weaken the armour of the ship. In such instances the liquid wastes flow into a sump tank equipped with a float-device which, when the sewage rises to a certain level, automatically starts a pump that lifts the sewage up and over the side. Inspections must be made to ensure that the pump is in working order and there is no leakage or overflow. The tanks should be cleaned, scraped and painted when the ship is in port for refit.

Disposal of all wastes from submarines when operating under water is achieved by forcing them out by use of compressed air. Some times the wastes are collected in a tank and ejected at specified intervals. This method requires special equipment and education of personnel in its use to avoid blowing the wastes back into the ship's compartment. Tanks require periodic cleaning, scraping and testing during dockyard refit periods to prevent fouling and leaking. Any cross-connection aboard presents a special problem due to the frequent variation of the water pressure and the subsequent back siphonage created, especially in the fresh water system. Because of necessity, fresh water, salt water, and flushing system lines are located in close proximity to one another. These conditions require special attention to prevent any accidental contamination of the fresh water supply by polluted harbour water or sewage wastes. Due to the problems involved in a ship's construction, it is often difficult or impossible to prevent sewage and other waste lines passing through food-service or food-storage areas. Under such conditions the lines must be marked distinctly, and frequent inspections should be made to determine their freedom from leaks that might contaminate food.

### Pest Control

Rodents, cockroaches and bed bugs are constant sources of nuisance on board. Rodents particularly pose a menacing problem by their wanton destruction of valuable stores and equipment. In modern ships burrowing from one compartment to another is impossible, but they can always find enough of hiding and nesting places, especially within panels between decks. They get on to the ships from the shore or from other ships alongside. Having gained access to the ship they multiply rapidly. It is, therefore, important that the medical officers should have adequate knowledge of rodent control to advise the executive officers. Knowledge of habits and characteristics of various species of rodents is helpful in instituting the control measures. In general, rodent control on ships is achieved by denying them access to the ship, denying food, water and shelter for them and active destruction by trapping, poisoning and fumigation.

#### Prevention of Access to Rodents

Rodents gain access to the ship over shorelines, gangways, cargo nets, electric and water lines and palletised cargo, which has been undisturbed for a month or so. Port health authorities normally enforce the regulations regarding the use of rat guards and these must be complied with. All lines connecting ship with decks should be protected with rat guards in such a manner as to prevent rats travelling from line to line. Bow, stern and spring lines should be illuminated during the hours of darkness. All landing ramps and gangways not in use should be removed and those in use should have adequate lighting between the hours of sunset and sunrise. Cargo nets should be lifted on board the ship when cargo is not being transferred. The following precautions should be observed when placing the rat guards :

(a) The lines should completely fill the central hole of guards so that no gap is left for rats to pass through.

(b) If several lines are enclosed by any one guard, they should be lashed together and the interstitial spaces stuffed with cloth.

(c) Guards should not be placed too close to the docks i.e. less than 1 m, as rats can jump from the dock to the rat guard or to the line beyond the guard.

(d) When the lines of different ships cross each other, the guards should be placed in such a way that they cannot be bypassed by the rodents.

(e) Rat guards should not be less than 1 m in diameter. There should be no sagging of the guards as this reduces their effective diameter.

(f) Guards with small central openings should not be placed on several lines as there is a tendency for the seams to gape and thus allow access to rats.

#### Rat Proofing

The object of rat proofing is to deny rats, by constructional fortifications, enclosed spaces for the purpose of hiding, nesting and breeding and also the opportunity of obtaining an adequate food supply. Being thus deprived of these biological necessities for existence and propagation even if rats manage to enter a rat-proof ship, it will be difficult for them to live and propagate for any considerable period of time on such a ship. Under conditions of food scarcity, rats even kill each other; and under conditions of semi-starvation and thirst it is easy to trap them and they also readily accept poison baits. The storerooms for provisions should invariably be made rat

proof by closing all openings around pipes and conduits with metal sheeting and by screening other openings. The proper turnover of the stores every month will reduce rat infestation. Food stuff should be stored in rat proof containers. Refuse and food scraps from galleys and mess decks must be deposited in raptor containers pending disposal. All cooked and left over food must be stored in proper rat proof lockers.

### Rodent Control

The most important place where active rodent control measures should be adopted are the docks and harbours. Destruction of rats ashore should be carried out. Trapping and poisoning can be practised on board the ships also.

(a) Trapping

This can be employed while ships are alongside or in dry dock or wet-basin. Rat traps are normally not authorised on board the service ships; these are obtained on loan from Station Health Organisation. Traps will be effective for the first three days, provided sufficient number of traps are laid on the rat runs which are usually along the borders of the cabin spaces and the air trunkings.

(b) Poisoning

This can be carried out even while the boat is on its run. The standard poison now used is Zinc Phosphide mixed in the proportion of 1 part to 19 parts of wheat flour. Bait can also be prepared with tinned fish.

### Control of Cockroaches

Good sanitation and housekeeping in kitchens, pantries and dining halls prevent cockroach breeding. The most effective aid to control them is by spraying of 1% Baygon or Malathion-pyrethrum mixture. These chemicals are not normally supplied on board the ships, and spraying is carried out by the staff of Station Health Organisations of the Navy. Newer agents like Goliath Gel are also useful.

## Prevention of Communicable Diseases

The scientific principles for prevention and control of infectious diseases afloat are in no way different from those on land. Ships, however may call at ports of the countries where specific infectious diseases may be prevalent. There is often a greater chance of spread of some of the communicable diseases on ships than on land due to overcrowding and adverse environmental conditions. Therefore, the medical officer has to be constantly on guard to prevent any importation of such diseases on board the ship and thereby to the country. The control of infectious diseases, disinfection and disinfestation are described in relevant chapters.

## International Health Regulations

International Health Regulations have been drawn up by the World Health Organisation with the object of maximum possible protection against infection while causing only minimum interference with international traffic. They seek to ensure this protection by preventing infection from countries where it exists and by containing it upon arrival. These regulations for the prevention of spread of diseases by ships and aircrafts are binding on all member states of WHO. The most important provisions of the regulations are notification; health organisation at the frontiers, particularly in ports and airports; and measures authorised with regard to individual goods and means of transport. The regulations cover plague, cholera and yellow fever now designated as "quarantinable diseases". The health measures prescribed are maximum measures applicable to international traffic, which a state requires for the protection of its territory against these diseases. It has also been laid down that sanitary measures and health formalities should be initiated forthwith, completed without delay and applied without discrimination. Disinfection, disinfestation, deratisation and other health operations should be carried out without causing any undue discomfort or injury to a person, damage to the ship and its cargo, and risk of fire.

### Bill of Health and Pratique

The health authorities of a port must take all practicable health measures to prevent the departure of any infected person or a person suspected to have been in contact with such a person and to prevent the introduction of a possible agent of infection or vectors of the diseases under the regulations on board the ship. A certificate completed by custom authorities in which, in addition to the routine details of the ship, it is certified that no such disease was present at the time of sailing from the port should be given to the Captain of the ship before leaving the port. This is called the 'Bill of Health'. Except when cruising in home waters, this certificate is necessary to be obtained before leaving from the homeport to any foreign country. Any vessel coming from an infected port or with an infectious case on board must fly the yellow quarantine flag. Such ships are directed to anchor at the quarantine anchorage and withhold communications with shore or other ships by boat until after all the instructions and regulations for the prevention of the particular disease have been complied with and the ship is declared by the port health authorities as free from a communicable disease: This certificate is called the 'pratique'. For obtaining a 'pratique' the 'Bill of Health' from the previous port of call has to be produced before the port official at the next port of call. However pratique can be granted by radio prior to the arrival of the ship, if the port health authority is satisfied on the basis of the information received from the ship prior to its arrival, that the arrival of a ship will not result in the introduction of an infection.

### Health Measures on Arrival at Port

The port health authority is empowered to carry out a medical examination of any ship or person on an international voyage on arrival and determine from the conditions, which exist on the ship at the time of the medical examination and any health measures, which may be applied. An infected person on board can be removed and isolated. Any person on an international voyage from an infected area can be placed under surveillance until the end of the incubation period of the disease. However, they are not quarantined unless the health authorities consider the risk of transmission of infection by the suspect to be exceptionally serious. Health measures other than medical examination are normally not repeated at a subsequent port unless, after the departure of the ship from the port where the measures were applied, an

incidence of epidemiological significance warranting the further applications of health measures has occurred, or when the health authority for the subsequent port considers, on the basis of definite evidence, that the measures applied at the previous port were not substantially effective. A ship is not prevented for health reasons from calling at any port. If a port is not equipped for applying these measures, permitted under regulations and which in the opinion of the health authority of the port are required, such ships can be ordered to proceed at their own risk to the nearest suitable and convenient port. The provisions of these International Health Regulations are equally applicable to aircrafts on international service.

### Special Preventive Measures

Prior to proceeding on a cruise, the incidence of infectious diseases at various ports of call should be studied (World Health Organisation 'Epidemiological and Vital Statistics Report' may be helpful in this respect). If information about the occurrence of diseases such as cholera, plague and influenza becomes available, it is better to avoid the infected port altogether. If an infectious disease is present in an epidemic form in a port of call, it might be necessary to place certain districts out of bounds or to stop all shore leave, according to the circumstances. Useful information can always be obtained on the subject from the port officer who comes on board to give 'pratique'.

If a member of the ship's company comes in contact with a person suffering from an infectious disease, while ashore or on leave, he is required in accordance with the naval regulations, to report this fact at once to his commanding officer. The measures for dealing with contacts of various communicable diseases have already been described. If the infectious disease assumes an epidemic proportion on board the ship, in addition to the routine preventive measures, the following special precautions may have to be recommended for the control of the disease :

(a) Stoppage of drafting or leave.

(b) Prohibition of the ship's company mixing with others while playing games ashore.

(c) Stoppage of visitors to the ship.

(d) Disinfection of outgoing correspondence and laundry.

(e) Disinfection of the ship as described in article 1106 clause 2 and article 1109 clauses 5 and 7 of the Regulations, I.N.

## Special Responsibilities of the Medical Officers

### Elimination of the Mentally Unfit

Medical officers afloat and ashore should be constantly on the alert to notice the appearance of nervous and mental disorders among naval personnel. Incipient cases can be detected if they acquaint themselves with the prodromal signs, and early symptoms and the diagnostic criteria of neuroses, psychoses, and psychosomatic conditions. The medical officer on board the ship can often spot those who are maladjusted and likely to breakdown, by paying particular attention to the frequent visitors to the sickbay and by checking the family background of the chronic offenders. They should gain the confidence of such personnel and investigate their personal problems. The divisional officers and the Chief Petty Officers in charge of such personnel may be of great help in such situations. Anyone showing a mental disorder should at once be evacuated to a hospital. Pending hospitalisation, sedation and guards should be arranged depending on the necessity of the particular case.

### Reports of Health

The medical officer to render a monthly report to a higher medical authority.

(a) In reporting on the health of the ship, the habitability of different living and working spaces should be reported in a methodical manner. When reporting on a section or a compartment, the following information should be included :

(i) Compartment name and number.

(ii) Approximate location.

(iii) Approximate dimensions.

(iv) Principal use of compartment.

(v) Average number of persons occupying the compartment.

(vi) Other relevant data, such as heat producing machinery within the compartment or adjacent hot spaces.

(b) The ventilation system of the compartment should then be described briefly. The climatic conditions should be reported by recording the physical measurements (see chapter II).

(c) The morbidity rate of diseases including effects of heat, prickly heat, boils, the physiological readings (pulse rate, blood pressure, weight, temperature etc.) and an opinion survey are also included in this report. However, investigations for research purposes can only be undertaken by a special team of workers. The type of work is only undertaken when the report from the medical officer indicates that the environmental conditions are having adverse effects on the efficiency and output of the personnel.

## Sea Sickness

This is an acute illness characterised by heaviness in the head, mild headache, nausea, dizziness, and vomiting. The psychological effects of this illness in the highly susceptible or neurotic personnel can be quite devastating and in rough seas can temporarily knock off a large percentage of the manpower. Severe cases are prone to vomit blood stained fluid leading to signs of collapse. Principal factors responsible for this syndrome are visual, kinesthetic, and psychological. Physiologically, the chemotactic trigger zone, vomiting centre and the vestibular apparatus are involved. Those who are prone to hypoglycaemia have a history of attack in an empty stomach. The preventive measures include acclimatisation, reassurance and administration of antihistamines. Preventive measures if instituted in time are quite effective; but once sea sickness sets in,

**Surg Cdr P Gokulakrishnan, Surg Cmde MJ John &**
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# Survival at Sea

## Introduction

A situation may arise during routine sailings, training exercises or operations warranting abandoning the ship. Shipwrecked mariners also need to fend for themselves for survival at sea. It requires qualities of leadership, courage and strong will to overcome adverse circumstances. If one has the understanding of the ocean's strength, commonsense and knowledge of the use of safety equipments, survival becomes easier.

## Incidence of Shipwrecks

In an analysis of incidence of shipwrecks, it has been found that 70 % ships were lost in Atlantic and most deaths of the crew were due to exposure to cold. In contrast 24% ships were lost in tropical waters and the main cause of death in them was dehydration. The remaining 6% ships were lost in arctic water. *Titanic*, a Passenger ship, sank on 15 Apr 1912 after colliding with a large iceberg. Out of a total of 2,200 passengers and crew only 700 survived. *HMS Glorious* was torpedoed in the World War - II. Out of 1,000 personnel on board, only 400 could board life-rafts. There were only 36 survivors. *INS Khukri* was sunk during Indo Pak war in 1971 in a torpedo attack. Out of 216 personnel borne on board, 149 died and 67 survived. In the peace time loss of INS Andaman in 1990, when the ship floundered in a tropical storm and sank off Visakhapatnam, 15 died and there were 92 survivors.

## Principles of Survival

Some terminologies used in this chapter are described below:

**(a) ABANDON** : The act of leaving a ship in distress.

**(b) SURVIVAL** : The ability to take to sea with the intention of getting rescued by external assistance.

**(c) RESCUE** : The act of providing assistance to shipwrecked mariners with the intention of saving their lives.

Successful survival depends on many conditions prevailing at the time of abandoning the ship viz. day or night, temperature of water, visibility, calm or stormy sea, presence or absence of enemy forces or friendly ships in the vicinity, the preparedness of the crew and their ability to lower the boats and rafts quickly. Three most important principles of survival are as under :

### (a) The will to Survive

God helps those who help themselves. A survivor should stay where he is. When the situation demands, one should help himself by taking following actions.

(i) Abolish all fears of mind

(ii) Decide on a course of action quickly

(iii) Check all safety equipments

(iv) Show leadership qualities

(v) Always avoid overexertion

(vi) Start rationing food and drinking water at once

### (b) The knowledge of expected hazards and use of commonsense

A person should acquire knowledge of the hazards expected and apply commonsense regarding the following: -

**(i) Protection**

Protection implies to application of first-aid, finding of suitable shelter and use of suitable clothing.

**(ii) Location**

One should do everything to assist search and rescue (SAR) organization to locate oneself by using the items in survival pack and the natural resources available.

**(iii) Water and Food**

Both water and food are vital for survival. Knowledge about what to drink and eat and in how much quantity is essential for survival.

### (c) Effective use of Safety and Survival Equipment.

(i) The Life Raft

The life raft is made from gas-tight, rubber proofed, high strength fabric. The various parts are rings, the floor, the arch or column supporting the canopy, and the canopy itself [Fig 95(a)]. The canopy will stay up even if one of the buoyancy rings is damaged or deflated. The following types of life rafts are available in Indian Navy:

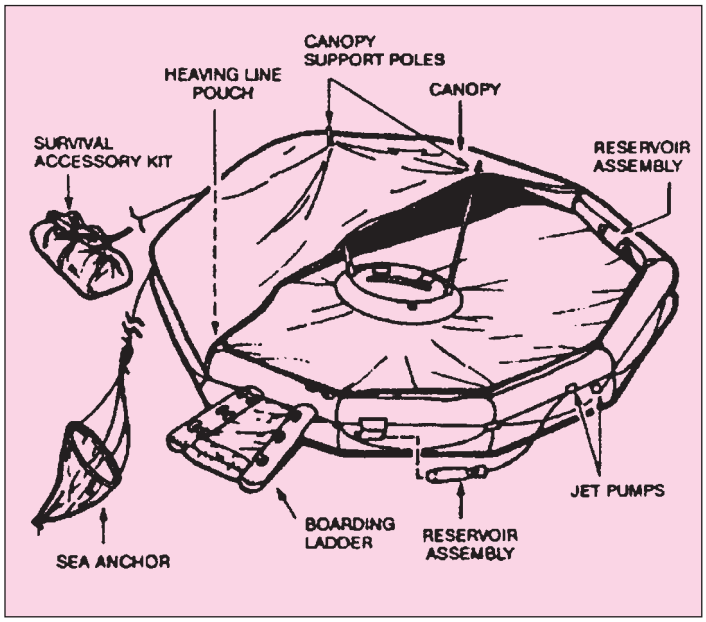
- Life-rafts (ships)
  - 25 men life-raft
  - 20 men life-raft
  - 10 men life-raft
- Life-rafts (air Crafts)
  - 12 men life-raft (TU)
  - 8 men life-raft (IL)
  - 4 men life-raft (Chetak & Sea King)
  - 1 men life-raft (Sea Harrier)

**The life raft should be handled as follows :**

**Charge of the Raft**

One person should be nominated to take charge of the safety responsibilities on the raft. All survivors must follow his directions without any reservation. The person-in-charge must maintain a log over the entire period spent in the raft. The first entry must include all details of the accident e.g. date, time and position of the wreck, names of survivors, weather conditions, details of rations

Fig - 1 : Twenty five men life raft




available etc. Later entries must over all details of stay in the raft, the physical condition and morale of the people on board, the rations issued, weather, sighting of ships and aeroplanes etc. The survival pack is likewise to be in the personal care of the person-in-charge and he should personally distribute water, rations, medicines etc.

**Topping up**

All parts of the raft must be checked regularly. From time to time the pressure in the buoyant rings, arches or column should be checked. DO NOT INTERFERE WITH THE DEFLATION VALVES.

**Leaks in the raft**

Any leaks in the raft that have been temporarily plugged with leak stoppers should be repaired properly at the first opportunity.

**Routine Duties**

Routine duties include checking of raft every hour or two, collection of rain water and care of the injured.

**Watcher**

A lookout must be kept throughout 24 hours without a break. The heliograph, Aldis or morse lamp and the distress signals should always be kept within reach. At least two men should be kept for each watch. One keeps a look out for rescue craft and the other is responsible for checking the collection of water in the raft.

**Weather Protection**

In cold weather, the floor of the raft must be kept inflated. In hot weather, the floor is to be kept deflated for cooling by seawater from below.

**Co-operation and Confidence**

The inmates of the raft should never lose hope. The raft offers excellent protection. It is important to keep the will to live and to maintain discipline.

(ii) Life Jackets

The following types of life jackets are available in the Indian Navy :

- Hazardous Duty Life Jacket
- General Service Life Jacket - supplied to all on board IN ships. It has to be orally inflated by means of the nylon mouth piece and inflation tube.
- MK 27-H (Sea Harrier)
- MK 6 & 6A (Other air crafts)
- KAPOK (In Sailing Boats)

**Care and maintenance** : Life jacket to be fully inflated and left for 24 hours to check for any leak. After submerging in sea, to be cleaned with fresh water, dried and preserved with chalk powder.

(iii) Life Buoy

Standard life buoy is made of polyurethane foam and covered by orange polyvinyl chloride. The ship's name should be written in 50 mm black letters.

(vi) Man over board smoke and light marker

It is attached to life buoy by a PP rope and secured on mounted bracket on the guard rail. It produces orange smoke for 15 minutes and white light for 2 hrs duration, when exposed to sea water.

(v) Survival Pack

The items described below are provided in Survival packs in rafts.

- **Drinking Water** : Water is supplied in cans or plastic bottles. If sufficient drinking water cannot be provided, desalination tablets may be provided for preparing drinking water from sea water.
- **Food** : Barley, sugar or glucose and rations in concentrated form providing a total of 2,500 calories food value per person is ideal for survival. A typical survival ration is rich in carbohydrate and contains only negligible amounts of fat and proteins.
- Calibrated mugs for measuring water rations for each person.
- Can openers for opening water and food cans.
- **Distress signals (Pyrotechnics) :** Two parachute rocket signals, hand held, rads. Six hand held flares red.
- **Signalling torch:** It has provision for signalling by morse code.
- Heliograph for signalling in daylight.
- Signalling whistle to attract the attention of people in water or on other rafts in the water or ships.
- Fishing tackle consisting of fishing line and hooks.
- First aid kit
- Anti sea sickness tablets.
- Deflation plugs
- Leak stoppers, Topping-up pump, repair kit
- Hand book for survivors
- Sponges, Baler

- Floating knives
- Drogue/ sea anchor
- Mittens, thermal protective aid
- Radar reflector
- Paddles

### Eating and Drinking

Drinking water is a more vital physiological need than food intake. One may tolerate hunger for three weeks whereas lack of water intake can be fatal in a few days.

Water

(a) No water should be given to healthy people in the first 24 hours; their bodies still have sufficient fluid. If time permits, drink as much water as possible before abandoning the ship Sick and injured may be given water in the first 24 hours, if they are thirsty. The daily ration of water must be given in several small portions soon after eating food.

(b) In drinking, the lips must be moistened, mouth and throat must be wetted by rolling the water around before swallowing; drinking should be slow and in sips.

(c) Rain Water

Do not overlook any chance of collecting rain water even if in very small quantities. Use plastic bags in the survival pack for this purpose. Empty water cans may also be used to collect rainwater. Even if abundant rain water is collected water is to be rationed prudently.

(d) Sea-Water

Seawater or even if diluted with fresh water should never be drunk even in small quantities as this leads to salt overload. The body will need large quantities of water to excrete the salt that is taken. DRINKING SEA WATER EVEN FOR A SHORT TIME IS FATAL

(e) Preserve water balance with proper sleep and rest, avoiding exertion, sweating, alcohol, smoking and highly proteinous food.

(f) Thirst can be allayed by increasing saliva e.g. by sucking on a piece of cloth or a button.

Food

(a) Food rations must be distributed sparingly. In the first twenty four hours no rations should be issued. The rations should be issued judiciously on subsequent days.

(b) Sea Weeds

Some types of sea weeds are edible. Fresh good sea weed is odourless and feels smooth and firm. Algae on the sea weed should be removed before it is eaten. Long sea weeds of a fibrous nature should not be eaten as they cause inflammation or irritation. Sea weeds contain salt and may be eaten only if sufficient water to dissolve or wash away the salt is available.

(c) Fish

Sea fish are generally edible and as much angling should be done as possible. Moreover, fishing is a good pastime, which keeps up morale. Fish contains some salt, hence if it is eaten, additional drinking water should be available. In temperate waters, all fish are edible. In tropics, fish caught in the open sea outside the sight of land are generally edible. In shallow tropical waters, however, there are some poisonous species. Fish with spikes and those which smell are poisonous. Fish with brushes or spikes but no scales SHOULD NOT EVEN BE TOUCHED, since there is danger of poisoning even in holding them. When handling such fish, hands must be protected, otherwise small injuries produced by handling them may lead to inflammation.

(d) Sea Birds

All sea birds may be eaten even raw if the oily taste can be overlooked.

### Preventive Measures

The following preventive measures are recommended:-

(a) Avoid perspiration as far as possible, as any loss of water from the body is dangerous. Cut down body movements to a minimum. It is very important to cut down sweating by protecting the body from sun and if necessary by wetting clothes with sea water.

**(b) Sea Sickness**

It can become dangerous if it continues over a long period as it causes loss of body fluids. Every one must be protected by taking the tablets provided in the survival pack.

**(c) Frost Bite**

It is caused by intense cold or icy wind and appears mostly on the face, hands and ears. Indications are numbness and intense pallor of the parts affected. The affected parts should be covered with protective clothing. These parts should never be rubbed or exposed to sudden heat.

**(d) Sea-Water Injuries**

If the skin is covered with salt and the pores are blocked, it is particularly sensitive and easily inflamed. Such inflammations should be covered with ointment and loosely wrapped in bandage.

**(e) Sun Burn**

Sunburns should be prevented by protecting the body from the direct rays of the sun which might result in boils and later in inflammation. Ointment is useful in treating the sunburns.

### Attracting Attention

Under normal conditions, a life-raft may be seen with the naked eye from a distance of 4 miles and in a good weather, it can be picked up by radar at more than 2 miles. In clear weather, pyrotechnic distress signals can be made out at a distance of 25 miles. The following instructions must particularly be observed when one is not sure whether rescue has been alerted and ships or planes are engaged in a search for survivors.

(a) Distress signals should be fired only when you are convinced that a distant ship whose attention is to be drawn is NOT coming any nearer. If it is seen

approaching, wait until you are sure that the distress signal can be seen from the ship before setting off the signal. For aeroplanes, the distress signals can be fired in the daytime only when you can actually see the plane. Generally fire the signal holding it out as far away as possible from the raft.

(b) The mirror heliograph is used to help search at sea and signals can be seen by ships and planes upto 20 miles depending on the sunshine and atmospheric conditions. It is a reflector with whose aid you can signal to search vessels and indicate your own position.

(c) At night the water proof signalling torch can be used to send blink signals or messages by morse code.

**Rescue**

The rescue teams should follow the guidelines as given below:

(a) If a life raft is sighted by a ship, rescue is immediate and the survivors are picked up by the ship. Even if the raft is sighted by a plane, rescue is absolutely certain. The plane will indicate by circling round, that the raft has been noticed, and call up a ship, sea plane or helicopter to pick up the survivors.

(b) Some search planes are equipped with a "Rescue-Supply" kit which is dropped into the sea near the life raft to keep the survivors supplied until final rescue. The kit consists of a number of containers connected to one another. One of these containers hold a life raft which inflates automatically on hitting the water and the other containers hold drinking water, food, clothes, medicines etc.

(c) To mark the life-raft and also ascertain wind direction, the search plane will first send out a smoke signal. The plane then flies at fixed height, obliquely to the wind in the lee over the raft and throws out the container. When the containers strike the water, a sea-anchor is released automatically from each one of them and the life-raft in the middle container inflates rapidly.

(d) The raft with survivors should then take in its sea-anchor and strike out towards the life-raft dropped from the plane. Some of the survivors should then board the air dropped raft, distribute the water, food, etc. and then wait for ship to come and pick them up.

(e) **Rescue by Ship:** The rescue ship will come as close as possible to the raft and make lee. As a result of the ship's height, which catches the wind, its drift is greater than that of the life-raft and it can therefore come quickly up to the raft. Take care that the sea-anchor of the raft does not tangle with any part of the ship e.g. the propellers. If necessary take the anchor in. Wait for a line to be thrown from the ship to the raft. When this is done and the line is caught, tie fast to the painter or the mooring of the life-raft. Thereafter, follow the instructions given by the rescue ship. If necessary, they will send a life boat and the rescue action will be directed from it.

(f) After the survivors have been rescued, the raft can be taken on board the rescuing vessel and deflated.

(g) Rescue by helicopter is easier than by sea-plane. The survivers are fished up from the water by a net. Naturally they must leave the raft and get into the water first, and care should be taken that not all the inmates of a raft leave at the same time. Generally the weakest ones should be sent first, as it will then be possible for the others to give them assistance. The survivors can also be picked up directly from the raft by a rescue sling. The sling is pulled over the body of the man and lies against the small of the back and under the armpits. The distance between the hoisting point and the chest of the person being lifted is adjusted by a safety slip-knot. If a survivor cannot help himself, a member of the helicopter crew may be let down and then the survivor can be helped into the sling for hoisting up.

## Glossary of events during survival at sea

**Boat stations**

(a) Muster all personnel as per their life-raft numbers.

(b) Ensure life-raft cord secured to strong point.

(c) Rig all, ropes & ladders, scramble nets to the ship side.

(d) If time permits, drink as much water as possible before abandoning ship.

**Abandon ship**

(a) Prior to abandon ship, all life-rafts must be manually launched.

(b) Put on life jacket and fully inflate.

(c) Board the life-raft with the help of ropes and ladders with out getting wet.

(d) Do not jump into life-raft. Avoid jumping from more than 3m height.

(e) If ship is drifting - jump from weather side.

(f) If ship is listed jump from bow or stern.

(g) If ASW weapon fired in the area swim back stroke, try and lift yourself clear of water line if any u/w explosion take place.

(h) Swim together.

(j) If oil burning on water:- Deflate life jacket, swim under water, come up, splash water, take breath and swim under water.

**Abandon ship: actions after boarding**

(a) Cut the painter line.

(b) Get away from sinking ship.

(c) Look for and rescue survivors.

(d) Stream the drogue.

(e) Open survival pack and read through survival instructions (INBR 1329).

(f) Close entrances in cold weather.

(g) Issue anti-seasickness tablets as soon as possible.

(h) Keep rescue rafts together.

(j) Appoint someone in charge.

(k) Familiarise yourself with the survival pack.

(l) Keep floor of rafts dry.

(m)Check raft lighting outside as well as inside.

(n) Attend to injured survivors.

(o) Appoint watch system and look outs.

(p) Ask survivors to pass urine within 2 hrs of boarding life-raft.

(q) Keep up the morale of the survivors.

(r) Never dangle limbs in the water, swim or bathe.

(s) Do not smoke in life-raft.

(t) Do not drink sea water.

(u) Do not refuse any dose of water or anti-seasickness tablet.

(v) Do not remove life jacket.

(w) Use only the safety knives which are provided in the rafts.

(x) Keep the rafts fully inflated at all times.

**Drinking water**

Allow 500 ml of water per person per day. Fortify with rain water, body fluids squeezed out of fishes, squids, crabs. Collect rain water in plastic bags. Daily water is rationed in three doses, issued soon after food intake.

**Food ration**

Allow one item/ person every 8 hrs (chew well).

Avoid salty or sweet foods taken from ship: both increase thirst and salty foods speed up the dehydration process in the body.

**Action in hot climate**

(a) Preserve body water: Do not spit. Deflate floor.

(b) Ventilate the raft. Keep out side canopy wet.

(c) Treat sunburn: apply ointment from first aid kit.

**Correcting an overturned liferaft**

(a) It is most unlikely that a life-raft will overturn.

(b) If it does, do not panic.

(c) Survivors are safe to come out through doorways.

(d) One man standing on the gas cylinder and pulling steadily on cross straps can correct the raft.

**Partial deflation of life-raft**

If already boarded

Close entrance securely as quickly possible to keep out of sea water.

If noticed before boarding the raft

Life-raft is still useful and should be boarded as quickly as possible. Do not abandon a life-raft that is swamped or being swamped; stay with it. Close both entrances immediately, even if the life-raft is full of water. Ensure drogue is streamed. Bale out life-raft.

**Rescue by helicopter**

Ascertain the wind direction. Do not use parachute/rocket flare in the presence of helicopter. All personnel except those assisting in the lifting operation should lie down keep still. Lifting strap must not be attached to any part of the raft. Ensure lifting device not entangled with any part of life-raft. Stretcher should be detached from lifting device during strapping procedure. Ground the lifting strap in seawater before taking it on board.

Wg Cdr (Ms) Renuka Kunte

# Medical and Other Aspects of Nuclear, Biological and Chemical (NBC) Warfare

## Nuclear, Biological and Chemical (NBC) Warfare

NBC warfare relates to both the employment of Nuclear Biological or Chemical munitions to cause large scale casualties, destruction and damage, as also the ability to fight in such an environment. The mass casualty/ damage producing effects of these weapons has given a new dimension to modern warfare. There is a possibility of these weapons being employed in future wars. NBC warfare is distinct from conventional weapons because of -

(a) Effect - The magnitude of the effect of NBC weapons is far more than that of conventional weapons.

(b) Mass casualties - The no of casualties is many times more than that in conventional warfare.

(c) Contamination - Large areas and casualties are likely to be contaminated with NBC agents making it necessary to decontaminate.

(d) Complex casualties - The casualties may suffer from conventional injuries and from the effects of different chemical agents, biological agents or from effects of radiation.

(e) NBC weapons have a marked psychological effect leading to severe stress.

(f) Unlike conventional weapons, these weapons have the potential to have a residual effect.

### NBC Defence - Constituents

NBC defence is central to fighting in a battle field wherein NBC weapons have been employed or there is a threat of such weapons being employed either by the enemy or by own forces. Survival in such a environment demands a capability to detect the presence of NBC agents and thereafter adopting protective measures. NBC defense thus includes -

**a) Detection**

The ability to detect any type of NBC contamination.

**b) Protection**

This is required when contamination cannot be avoided. It is broadly categorized as

(i) Individual protection

(ii) Collective protection

**c) Decontamination**

It includes all the measures adopted to remove, destroy or neutralize Nuclear, Biological or Chemical contamination.

**d) Damage control**

This includes mitigation, restoration activities and management of casualties due to effects of NBC weapons at different levels in the battlefield.

NBC weapons are weapons of mass destruction and the casualties caused to men and equipment will be colossal. In addition to the tremendous psychological effect on the personnel, the type of casualties would also pose a challenge to the medical personnel. It is important to elaborate the effects of Nuclear, Biological and Chemical weapons to understand the medical aspects of NBC warfare.

## Radiation

### Nature of Radiation and its Action on Living Cells

Transfer of energy from sun to earth by radiant heat and light is a well - known phenomenon. This radiant heat and light can be stopped by opaque objects, which are interposed in the path of these radiations. These radiations form only a small region of the whole spectrum of electromagnetic radiations - ultraviolet - visible light - infrared region.

The knowledge of the biological effects of ionizing radiation has been built over the past, through experience in the fields of early X-ray workers, luminous dial painters, patients who have been administered radium salts and high doses during radiation, uranium miners, atomic bomb survivors in Japan, victims of reactor accidents and children of mothers who received radiation exposure during pregnancy.

### Types of Radiation

Several kinds of ionizing radiations are known of which common types are the following :

**(a) Alpha Particles**

These nuclei of helium atom are swiftly moving particles of high energy, carrying a positive electric charge. They have little power of penetration, passing into soft tissue upto only fraction of a millimeter, and thus irradiation of the body from outside with alpha particles is of little significance. However, they may affect living tissues when released by radioisotopes within the body.

**(b) Beta Particles**

These are fast moving energy carrying particles (electrons) with a negative charge. The amount of energy carried varies and their penetrating power will also vary accordingly. In general beta particles are more penetrating than alpha particles and can traverse distances up to a centimeter or more in soft tissues. For this reason these are valuable therapeutically, and radioactive substances emitting beta radiations are used for the destruction of superficial tumours. However, heavy doses from outside the body can damage the superficial tissues, and if beta emitting substances are ingested, destructive effects within the body may be produced.

**(c) Gamma Rays**

These are electromagnetic radiations of high energy emitted by atomic nuclei. Like alpha and beta particles,

these are produced in the process of natural or artificially induced atomic disintegration. Gamma rays have great penetrating power in comparison with alpha & beta particles and the more energetic gamma rays can traverse the whole body with relatively little absorption. As a result, almost the whole thickness of the body may be irradiated by gamma radiation and this is the deciding factor in producing the general illness, which may follow this type of irradiation. The properties of gamma rays are essentially similar to those of X-rays but in general gamma rays have more energy and penetrating power compared to X-rays.

**(d) X-rays**

These are also electromagnetic radiations, which are usually produced artificially by electrical machines and their origin is from the electronic structure of the atom. These are widely used both diagnostically and therapeutically in medicine, varying considerably in their penetrating power according to the electrical potential used in their production. The biological effects of X-rays are brought about by high - energy electrons, which are liberated in the tissues during the passage of the rays, thus the biological action of X-rays and beta particles is essentially the same.

**(e) Neutrons**

These are primary constituents of atomic nuclei, and may be liberated with considerable energy. These carry no electrical charge and are therefore not repelled by the charged nuclei of atoms. These enter into the atomic nuclei to build up unstable structures, which often disintegrate with the production of artificial radioactivity. Fast neutrons act mainly by collision with the hydrogen of water and of other compounds which the tissues contain. The resultant recoiling hydrogen nuclei are called protons. The fast neutrons are gradually slowed down in the tissues and may then bring about biological effects by interaction particularly with nitrogen. They may also be captured by the hydrogen nuclei, thereby releasing energetic gamma radiation.

**Ionisation**

Ionizing radiation loses its energy in the medium by knocking out an electron and sharing part of its energy with the electrons. This results in a number of electrically charged atoms, molecules and electrons along the path of ionising radiation, which are called ions. For this reason this is called ionising radiation. Every radiation is characterised by the power of penetration as well as the ionizing capacity. It is the production of these electrically charged particles or ions, which is mainly responsible for initiating the physicochemical changes in the living tissue that lead to the production of radiation damage or biological effects.

The biological effects of radiation are closely related to its dose, the period of exposure and the type of radiation. The intensity of a beam of X-rays or gamma rays is simply the measure of quanta striking a particular area in a given time, the radiation being regarded as consisting of small units of energy called quanta. The radiation dose may be described as the energy, which is absorbed in the small mass of tissue upon which the radiation impinges. Living tissues are not inert. After damage by radiation, repair processes take place, and the rate at which the dose of radiation is given becomes an important factor in determining the biological effects. Thus, if a dose of radiation is spread out over many years, the response may be very much smaller than or even quite different from that which would occur if the same amount of radiation were given in a very short time. On the other hand with some forms of biological damage produced by radiation (like gene mutations) recovery does not occur.

**Measurement of Radioactivity**

Biological effects of radiation depend upon the amount of energy absorbed in the tissues. An atom emits certain amount of energy in the process of disintegration. The total rate at which the tissues are irradiated therefore depends upon the rate of disintegration. In assessing the effects of radioactive material within the tissue, the use of radioactivity units, which depend upon the number of atomic disintegration per second, is necessary. Based originally on the rate of atomic disintegration of radium, the unit of radioactivity is called the Curie and represents the amount of an element in which $3.7 \times 10^{10}$ disintegrations occur per second. This is too large an amount of radio - activity for most biological work and it is customary to measure the amount of radioactivity in the body in microcuries i. e. $3.7 \times 10^{4}$ disintegration per second. The present SI Unit is "Becquerel". The conversion factor from SI Unit to present unit is $2.703 \times 10^{-11}$ and present unit is 37 kilo Becquerel = 1 microcurie

The method of measuring the disintegration of a radioactive substance is in terms of half - life. The time taken for activity to decrease to half its original value is known as half - life, and is also called physical half - life (Tp). When isotope is administered into man, it is excreted out. The time required by the administered activity to excrete to half is termed as biological half - life (Tb). The effective half - life of radioactive substance in the body is as follows :

$$\frac{Teff}{Tp + Tb} = Tp \times Tb$$

## Measurement of Dose

### Roentgen

Roentgen is a unit of measure of exposure. It was only in 1951 that International Commission on Radiation Units (ICRU) clarified that Roentgen is the unit of exposure dose. Exposure at a point is a measure of the radiation at that point based upon its ability to produce the ionisation in air. Thus the unit Roentgen (R) is defined as the quantity of x or gamma radiation such that the associated corpuscular emission per 0. 001293 gram of air (i. e. 1 cc of air at NTP) produces ions carrying one electrostatic unit of quantity of electricity of either sign. In the matter of assessment of biological effects, the energy absorbed by the medium from the exposure of radiation is an important factor. One Roentgen corresponds to the absorption of 87. 7 ergs /gm of air. The Roentgen is unit

of exposure, which applies only to x - or gamma radiations with air as medium. SI Unit for exposure is measured in coulombs per kg.

**(a) Rad**

As mentioned earlier, Roentgen is a measure of exposure and is used in assessing the biological effects in tissues due to radiation exposure. The measurement of the energy absorbed in the tissue has become a necessity, which is called absorbed dose or simply dose. A measure of dose is called rad (radiation absorbed dose). This measure of dose includes all types of radiation irrespective of particulate or non particulate matter. The rad is defined as an energy deposition of 100 ergs per gram. This was first defined by ICRU in 1954. SI Unit for absorbed dose is Gray with 1 Gray equal to 100 rad.

**(b) Kerma**

Kerma (Kinetic Energy Released In Matter) is a unit just like Roentgen which is meant for all media and includes all indirect ionizing radiation (X-rays, gamma rays and neutrons). It is measured in energy / unit mass.

**(c) Rem**

Even though rad is a useful unit, it transpires that in biological system the same degree of damage is not necessarily produced by the same absorbed dose of different types of radiation. In order to account for this, a factor known as Relative Biological Effectiveness (R. B. E) or Quality factor (Q. F. ) has been introduced, which reflects the ability of the particular type of radiation to cause damage. The quantity obtained when absorbed dose is multiplied by R. B. E. or Q. F. is known as Dose equivalent, the unit of which is rem.

**(d) Relative Biological Effectiveness**

| Types of Radiation | QF or RBE |
|---|---|
| X-Ray, or B particles | 1 |
| Thermal neutrons | 3 |
| Fast neutron | 10 |

Relative Biological Effectiveness depends upon the density of ionisation caused by radiation. The values of RBE or QF for different types of radiation are given in the box:

In SI units of dose equivalent is measured in Sieverts (SV).

One Sv = 100 rem.

Certain measurements, which were preferred in exposure quantity and expressed in its special unit the roentgen, have now been replaced by air kerma measured in free air. An exposure of 1 roentgen is equivalent to an air kerma of 8. 7 milligray (mGy). Specific gamma ray constants are now replaced by air kerma rate constants, expressed in units such as wGy h - 1, GBq - 1. at 1m (Table - 1).

**Action on Living Tissues**

The radiation acts primarily upon the cell and its constituents, and upon the complex chemical processes occurring in these, rather than upon the fluids in which the cell is bathed. The processes associated with the formation of ions during the passage of radiation lead to changes in some of the highly organised molecular systems within the cell. These changes are probably brought about by highly reactive chemical intermediates liberated within the cell subsequent to the physical process of ionisation.

Table-1 : International system of units

| Radiation Quantity | SI Unit | Special unit |
|---|---|---|
| Adsorbed dose | 1 gray (Gy)<br>1 Centigray (Cgy) | 100 rad<br>1 rad |
| Dose equivalent | 1 Sievert (Sv)<br>10 millisievert (mSv)<br>10 microsievert (μSv) | 100 rem<br>1 rem<br>1 millirem |
| Radioactivity<br>1 disintegration<br><br>(μCi) | <br>37 Kilobecquerel (KBq)<br>37 megabecquerel (M Bq)<br><br>37 gigabecquerel (G Bq) | 1 becquerel (Bq)<br><br>per second (dps)<br>1 microcurie<br><br>1 millicurie(mCi) |

All living tissues are killed when exposed to large doses of radiation. Different types of organisms, tissues and cells vary greatly on the amount of radiation, which they can withstand. Among the mammals, the dose of X-rays to the whole body, which will kill 50 % of an animal species varies from 200 - 1000 R (2 - 10Gy) depending on the species (for man it is thought to be between 400 and 500 R (4 - 5Gy). There is also a wide variation in sensitivity between different animal tissues. For instance, in man, the most sensitive tissues include the lymphatic glands, the epithelium of small intestines, and bone marrow, whereas adult nerve and muscle tissues are less sensitive. Variations in the sensitivity also occur at different stages in the life cycle of a cell; for example cells about to divide are often more sensitive than those in the resting stage.

**Repair Processes**

In case tissue damage is less, the situation is modified by a process of repair, but a distinction must be drawn between true recovery in which the damaged cells return to normal form and function, and the replacement of injured cells by those coming from outside the field of radiation. The latter is a more conspicuous form of repair after heavy radiation damage in the higher animals and leads to the original tissues being replaced by simpler and unspecialised material or scar tissue. Repair processes within the individual cell are not yet well understood and still a matter of speculation. An understanding of such repair processes plays an important role in low - level radiation effects.

**Effects of Radiation on Health**

The effects ionizing radiations on human beings are based on four main sources; uses of X-rays and radium in the treatment of disease, mainly concerning knowledge of occupational hazards of medical radiologists, workers in luminising industry and miners of radioactive ores; study

of the victims of atom bomb explosions and from animal experiments. Observation of patients receiving radiotherapy has yielded information on the general effects of radiation and on the effects produced in different tissues by external radiation, and the therapeutic use of radioactive isotopes has provided data on the effects of radioactivity within the body i. e. internal exposure. The second source of the radiation provided data on :

Radiological worker exposed to external radiation, by X-rays and gamma rays leading to skin cancer or bone marrow damage resulting in blood dyscrasias.

Luminising dial painters who used radium, mesothorium and radiothorium in paints, developed bone tumours. This is due to their ingestion and retention in the skeleton.

Miners who worked in an atmosphere containing high concentration of radon developed lung cancer. The study of different hazards has contributed to the knowledge of harmful effects of radiation and has helped to formulate safety standards. Atomic bomb explosions over Hiroshima and Nagasaki brought wide spread destruction to both the cities. About 15 to 20 % casualties were caused by the gamma and neutron radiation emitted during the explosion. The observations of these casualties regarding immediate and delayed effects of radiation have given baseline information on this subject.

Radiation hazards may be external or internal. The external hazards arise from the exposure of the whole body or its parts to penetrating radiations (like gamma ray or X-ray or neutrons) from sources outside the body. Alpha ray emitters are not an external hazard since alpha rays cannot penetrate even a fraction of a millimeter into the tissue. Beta rays will not normally be a significant external hazard either since clothing will act as a barrier but beta emitters in contact with the skin can produce some harmful effects like loss of hair and skin burns. Internal hazards originate through the incorporation into the body of radioactive materials. This may arise through inhalation of radioactive dusts and vapours, from ingestion of active material through eating and drinking or through cuts and wounds. Depending upon the nature of the isotope, the radiation it emits, its half - life - physical as well as biological, the critical organ in which the isotope concentrates etc. , even extremely minute amounts of internally deposited radioisotopes may be hazardous. The effects also depend upon the rate at which the radiation dose is received. 'Acute' exposure (received in a short period) is more injurious than protracted or chronic exposure. This is because cells have a certain capacity for repair and recovery from the radiation injury. Thus a whole body exposure to 600R(6Gy); would be lethal if received as a single exposure. The same dose spread over a period of 20 years should not cause appreciable clinical effects.

Biological effects can be classified as somatic and genetic. Somatic effects are manifested in the person exposed to radiation. These may be manifested soon after exposure (within a few days) while certain other effects exhibited after a latent period of several years. Genetic injury does not affect the exposed persons but their progeny. The exposure to radiation of sex cells of a person damages the genetic material causing "gene mutations. " During reproduction one of the damaged cells may take part in the fertilization process, the fertilized cell carrying the defect and repeating itself during successive divisions. This leads to a defective offspring. Biological effects can also be classified into immediate and delayed effects. Immediate effects are mainly due to acute exposure whereas the delayed effects are due to chronic low exposures. On the basis of mechanism of induction, radiation effects are broadly classified into Deterministic effects and Stochastic effects. Deterministic effects are sure to occur at high doses and do not occur below a particular threshold dose. Severity of the effects is proportional to the dose. Stochastic effects do not have a threshold dose and are probabilistic in nature and include induction of cancer, leukaemia and genetic effects. (1 - 6).

Immediate Effects of Radiation

A summary of the immediate effects in human beings related to radiation dose when the exposure is acute and to the whole body is given in Table - 2.

**Acute Radiation Effects on Individual Systems**

**(a) Central Nervous System**

An acute dose of 1600 R (16Gy) or more will cause brain damage with severe oedema causing unconsciousness within three to four days followed by certain death. The higher the dose, the more rapid is the onset of unconsciousness. Loss of sphincter control may be a sign of central nervous system involvement.

**(b) Gastrointestinal Tract**

A dose of 400 R and higher will cause radiation sickness with nausea, vomiting and diarrhoea. The higher the dose the more quickly the symptoms appear. Where vomiting comes on immediately and persists for several days without interruption, the dose received will probably prove lethal. Vomiting may also be induced by psychogenic factors. Denudation of gastro - intestinal tract with haemorrhages will follow doses of 900 -1000 R (9 - 10Gy) and is lethal within one or two weeks. The G-I tract is hyperactive initially but later on atony sets in.

**(c) Bone Marrow**

Depression of the haemopoietic activity of the marrow will be caused by doses as low as 200 R (2Gy). Even after 200 to 300 R (2 - 3Gy) improvement may occur without any symptoms, unless complications such as pre - existing illness, pregnancy, trauma and thermal burns are also present. Doses of 400 to 600 R (4 - 6Gy) may result in total aplasia of the bone marrow. Restoration may occur spontaneously by proliferation of primordial cells, provided the period of acute cellular depletion of the blood is tided over. Irreversible aplasia results from doses of 700 to 900 R (7 to 9Gy).

**(d) Lymph Nodes**

The lymph nodes become atrophic and depleted of cells after doses of 400 to 500R (4 - 5Gy). This condition becomes irreversible if 700 to 900R (7 - 9 Gy) have been

Table - 2 : Acute whole body exposure

| Acute Dose | Effects |
|---|---|
| 5,000R (50 Gy) | Immediate and persistent non-effective mass until death |
| 1,000 R(10 Gy) | Initial sickness appears in 1 hour or less. There may be no latent period. No survivors are expected. |
| 650R(6.5Gy) | Initial sickness appears in all personnel within 4 hours and lasts for about one day. The latent period is one week. Death ensues in about 2 weeks in about 95% of the cases. Survivors are non-effective for 6 months. |
| 450R (4.5Gy) | Initial sickness appears in all personnel during first day. The latent period is 2 weeks. About 50% deaths may be expected but can be reduced by giving adequate medical treatment. Survivors are non-effective for 6 months. |
| 300 R (3Gy) | Initial sickness during first day in all personnel. After about 3 weeks of latent period, about 25% deaths may be anticipated but this may be reduced by giving adequate medical treatment. Survivors are non-effective for 3 months. |
| 200 R (2Gy) | Initial sickness during first day in about 50% of personnel. Second period of sickness appears after about 3 weeks and lasts for 1 to 2 weeks. No deaths anticipated unless recovery is complicated by poor health, other injury, or infection. |
| | |

received.

(e) **Skin**

Following 400 to 500 R (4 - 5Gy) hair will usually be lost in bunches within 12 to 14 days. Alpha particles cause damage only if inhaled or ingested.

Delayed Effects of Radiation

Delayed effects of exposure to radiation may occur at any time after the end of the second month. Disorders of the skin and underlying soft tissues and bones may occur. There may be subsequent development of cancer. Cataracts, severe anaemia and leukemia have been caused. There is evidence from animal experiments that exposure to radiation may cause death at a prematurely early age. There may be inhibition of immune response. Radiation exposure may be harmful to the genetic material, which may be transferred from one generation to the other.

**Leukemia**

Leukemia is a disease in which there is an uncontrolled over production of white blood corpuscles. Experiments on animals have shown that the incidence of leukemia is increased by irradiation. Clear evidence that the same is true of the man, comes from two main sources; a study by the Atomic Bomb Casualty Commission of the incidence of leukemia in Hiroshima and Nagasaki, and a survey of the incidence of leukemia among patients treated by radiation for ankylosing spondylitis. The latent period, that is the average length of the period between exposure and the first appearance of symptoms of leukemia was about six years. The conditions of exposure to radiation in Hiroshima and Nagasaki and in the treatment of ankylosing spondylitis are not comparable with the irradiation in small doses over long periods which might be received by persons engaged in work with a possible radiation hazard i. e. in radiologists mainly. Some evidence has been presented suggesting an increased death rate due to leukemia among radiologists.

All evidence indicates that the incidence of certain types of leukemia increases in children as a result of prenatal irradiation at high dose rate of 5 - 50rads (5. 50cGy). Radiation induced leukemia's tend to occur most frequently within a few years (six years) after exposure, and, after 25 years, the frequency tends to return to levels expected in the absence of irradiation.

**Cancer**

Two characteristics of cancer induced by radiation are noteworthy:

(a) The tendency of tumours to arise in tissues already severely damaged by radiation

(b) The long latent period, 20 years or more, before they appear.

Studies of people exposed to internal irradiation include workers and patients contaminated with radium, mesothorium, plutonium and radioactive strontium and also miners exposed to radon gas. Radium, plutonium and strontium are accumulated and retained in the bone thereby irradiating bone - forming cells continuously at a decreasing rate for decades after being absorbed into the body and give rise to bone tumours.

Studies of pitchblende miners suggest that the inhalation of the radioactive gas radon may lead to cancer of the lung. The frequency appears to rise in proportion to the level and duration of exposure. The latent period has been about 20 years and the dosage to lungs over this period may be about 1000rads (10Gy) due to alpha radiation. Lung dosimetry is extremely difficult and the role of other carcinogenic factors such as smoking habits is very difficult to assess. In theory, the inhalation of radioactive particles in the fallout from atomic explosions or in the vicinity of nuclear reactors could also lead to cancer of lung. But the hazard due to fallout from atomic explosions in peacetime is extremely unlikely and steps are always taken to ensure that such incidents do not occur. Lung cancers appear to have been induced at Hiroshima by doses estimated on the basis of crude assumptions to be equivalent to some 30rads (30cGy) of external gamma

radiation and to have increased with dose upto about 100rads (1Gy). The data indicates that from 10 to 40 cases of cancer per rad (cGy) per million exposed (at 200 rad to 300 rad (2 - 3Gy) respectively) develop during the first 25 years after exposure to high dose rate gamma radiation.

Information is also available on the induction of thyroid and breast cancers. Breast cancer mortality at Hiroshima suggests a risk of 6 - 20 cases per million per rad (cGy) in the first 25 years after irradiation among women exposed to between 60 and 400rads (0. 6 and 4Gy). This is probably an underestimate of the situation. For thyroid cancers, an average of about 40 cases per million in the same range of irradiation over the same period of time is obtained. The estimate has large uncertainities due to small number of cases observed. Cancer of the thyroid gland in children has been a sequel to irradiation of neck for enlargement of the thymus gland. This form of cancer is distinguished by its short latent period (about 7 years) and comparatively low dosage of radiation required to induce it. There is a possibility of other factors also involved in addition to the direct effects of irradiation.

Cancer of the skin was the earliest form of radiation - induced tumour to be described in man. By 1911, before the adoption of proper safeguards, fifty four cases have been described among the pioneers of radiology. The doses of radiation which have led to the formation of skin cancers must have been high - - in the order 1000 rad (10Gy) and above (partial body exposure).

**Other Delayed Effects**

There may be other delayed effects like aplastic anaemia, cataract formation and temporary loss of hair. Miscarriage and stillbirth may be a consequence of irradiation during pregnancy. But they do not constitute a problem unless the dose of radiation is large. A number of different developmental abnormalities have been described in the children whose mothers were treated by irradiation during pregnancy, the most conspicuous defect being microcephaly, a partial failure of the development of the brain. Number of cases so classified are recorded in children with irradiation, before birth in Hiroshima and Nagasaki.

**Genetic Effects of Radiation**

The genetic material consists of chromosome (microscopically visible structures within cell nuclei) and genes (functional units being the chromosomes, which cannot be distinguished microscopically). These structures are present in all the body cells. But only those in the reproductive cells are transmitted to the fertilized ovum. Where the reproductive cells are irradiated, changes may be produced in the genes or in the chromosomes of these cells and subsequently transmitted to the descendents of the individual. These genetic changes are of different kinds:

(a) Gene - mutation i. e. alterations in the function of individual gene.

(b) Chromosomal aberrations resulting from breakage and reorganisation of chromosomes, and

(c) Changes in the number of chromosomes. Some of these changes result in offspring suffering from abnormalities, which may range from mildly detrimental to severely disabling lethal disorders.

Spermatogonia in the male and oocytes in the female are the two reproductive cell stages, which are most important for assessment of genetic risks. At high acute doses of radiation, the risk of mutation in females conceiving shortly after radiation exposure will be about twice as high as in males, whereas at low doses the risk will be reduced to one third and with chronic exposure to about one twentieth of that expected after acute exposure to high doses. If the human ovary responds to irradiation as it does in that of mouse, which is by no means certain, it can be expected that, if conception occurs after a sufficient interval following irradiation, the resulting frequency of mutations in the descendants of irradiated females might be zero. Dominant gene mutations are expressed in the first generation of an irradiated population.

Chromosomal Aberrations

Spontaneously occurring chromosome aberrations are a source of considerable hardship since they are responsible for a large fraction of all spontaneous miscarriages, congenital malformations and mental and physical defects. The possession of an additional chromosome (Number 21) leads to Down's syndrome which is associated with severe mental retardation.

Another type of aberration is known as translocation. This involves the exchange of parts between two different chromosomes. This may lead to malformations similar to those associated with the presence of additional chromosomes, or may lead to early pre - natal death. These effects are associated with the presence of translocation in the unbalanced form, in which there may be loss of one of the exchanged segments and gain of the other. In its balanced form, a translocation usually has no detrimental effect for the persons carrying it, but half of his or her offsprings are likely to have the translocation in unbalanced form. Many of these unbalanced zygotes will die at such an early stage in pregnancy that they will lead to a missed menstrual period. The proportion surviving will be abnormal babies. An estimation of such abnormal babies is very difficult.

There may be other forms of aberration in chromosomes. For instance there may be gain or loss in chromosomes in addition to translocation. Very few of these aberrations are transmitted to the next generations after irradiation of the male because the reproductive cells carrying them will be eliminated before they mature. In female, some are transmitted. Most of these cases will die before birth. Those surviving will be sterile and will have certain other symptoms (Turners' syndrome).

Genes on chromosomes form an important component of the human genetic burden. Gene mutations are induced at higher frequencies than chromosomal aberrations. Furthermore chromosome aberrations will be eliminated after a few generations whereas gene mutations may permeate through many more generations thereby

'affecting a larger number of individuals (3 - 7).

### Changes in Immune Response

Immune system provides the main defence mechanisms of the body against infective agents or their products. The system recognizes what is foreign to the body and responds by destroying or neutralizing it whereas it does not distinguish between "foreign good" and "foreign bad". It can stand in the way of medically desirable objectives, such as the acceptance of needed tissues or transplants. Some net effects of immune reaction are themselves undesirable, as in allergic and other immunological disorders where the system reacts to body's own components producing auto - immune diseases.

Because of the many values associated with the immune system, affecting it by irradiation has great human significance in numerous contexts. For example, depressing immune responsiveness by irradiation reduces the ability to acquire resistance to bacterial, rickettsial and parasitic infections or to neutralize bacterial toxins and is therefore an undesirable effect of radiation. This is the situation in atomic warfare.

Depressing immune responsiveness by some means is desirable, even necessary, if organ transplants are to be accomplished. Suppressing or controlling allergy, hypersensitivity, immunopathological disorders and autoimmune diseases are other important medical objectives.

In cancer, the malignant cells are recognised as foreign by the individual's own immune system and the lymphocytes in the host may be directed against tumour cells. The existence of specific serum factors, which react with cancer cells has also been recognised and in some instances these may protect cancer cells from the action of potentially lethal lymphocytes. In some situations, it is clearly observed that radiation induced immune depression permits an increased rate of growth of cancer. A more critical question arises as to whether immune suppression may be an important factor in radiation - induced cancer.

The immune system has large built - in factors of safety so that it can withstand substantial injury and recover from damage. Even then effects on human lymphocytes in culture have been noted at doses of 10rads (cGy). The observable damage to the immune systems such as changes in antibody formation resulting from the whole body dose of the order of tons of rads is unlikely to be the effect causing the greatest concern. A dose in the range of 100rads (1Gy) to the whole body and damage to the immune system leads to an increase in susceptibility to infection. When whole body doses approach and exceed 200rads (2Gy), it leads to increased risk of mortality from infection.

### Social and mental health aspect of radiation

The large - scale use of atomic power in the field of industry, medicine and agriculture is inevitable, and more people will have to live and work in intimate contact with ionizing radiation. The prospects of dangers to health of the people and genetic effects on their descendants would cause apprehension and since dangers of radiation cannot be seen or felt, emotional unrest and confusion are bound to occur in course of time. This new technological advance is therefore, bound to create a number of social and mental health problems involving the industrial and scientific workers and also the population in general. Added to these the real and imagined horrors of the nuclear bomb and weapons hang like the sword of Domocles'. A better understanding of these problems by the people, and more so by the medical profession, is necessary in order that they get a clear perspective of the real hazards, and know the efficient preventive and remedial measures that can be taken when need arises so that the people are confident of the preparedness of the medical profession to do so. The social and mental health problems can be divided into the ones that may occur among workers and the ones that may occur among the general population.

The mental health problems that may occur among workers in atomic reactors, chemical plants and allied nuclear industries are of immediate importance. Under vigilant management, the occupational hazards will not actually affect most workers; but a certain extent of fear and anxiety will be present in them. Radiophobia may arise in certain neurotic workers who may suffer from irrational and groundless fears of over exposure and may produce a serious mental derangement, which may also influence others around. The usual prevalence of anaemia, leukaemia, cancer, psychosexual aberrations such as impotency and male sterility, abortions, foetal abnormalities, sterility in women workers and so on, may all come to be ascribed to the occupational radiational exposure. In the event of an accident in the reactor, a few may be actually exposed to an overdose of radiation, although no immediate illness may occur, but some of the others actually not exposed to an overdose may constantly be haunted by the fear of development of late effects of radiation. A regular periodical medical examination is an excellent method of restoring confidence and removing anxiety and fear. Industrial Physicians will be able to remove and rationalise many of the apprehensions by explanation and assurance.

Concern, misgivings and anxiety may also arise in the minds of the people living in the vicinity of the reactors. The workers in the reactors knowingly and willingly submit themselves to the occupational nuclear hazards for vocational, financial or scientific interest. These factors, a correct knowledge of the real hazard, and observance of and confidence in precautionary measures help to maintain their mental balance and health. The people in the vicinity of a reactor on the other hand have no knowledge or interest in the reactor and have apprehensions. The usual incidence and outbreaks of disease may come to be attributed to radioactivity. A reactor accident, should it happen, may constitute a hazard to a wide area and may necessitate evacuation of people. This may lead to anxiety and tension in the population and resentment against the authority responsible for locating the factory in their vicinity. The education of the people regarding radiation, its hazards

and the observance of safety precautions may rationalize their attitude. An organisation to carry out monitoring of the surrounding areas of the reactor and to reassure the population regularly should be established and doctors and nurses will have to check the health of the surrounding population from time to time and inspire confidence.

**Food and water contamination by radioactive 'Fallout'**

Food and water are not spoiled by radiation, but contamination by radioactive material from accidents in a reactor or fallout from nuclear bursts makes them dangerous for consumption. The crops in areas highly contaminated with fallout build up radioactivity. The animals grazing on contaminated herbage pick up radioactivity. This when excessively absorbed, may cause hypothyroidism, or the bone seeking isotopes such as strontium - 90 may cause leukemia and anaemia. The edible parts of the animals do not concentrate radioactive materials to the same extent as the thyroid and ash bone, except that the milk may contain radioactivity. Consumption of such milk and its products will introduce strontium - 90 inside the human body resulting in the possibility of bone cancer and leukemia. Fish from water contaminated by a fall out, meat from exposed slaughter houses, fresh vegetables from fields contaminated with fallout, cereals from such crops, flour and bread from such cereals and also when directly exposed are dangerous for consumption. When water in lakes and reservoirs contaminated by a radioactive fallout is consumed, the gastrointestinal mucosa may be ulcerated and on absorption the contained radio - active material may get deposited in the bone, liver, muscle etc. and produce internal irradiation like strontium - 90, causing bone tumours and leukaemia. Casualties, however, may not result immediately from drinking moderately contaminated water.

**Monitoring techniques**

For ensuring that the precautions taken are adequate, monitoring should be done by ascertaining from time to time the total dosage to which workers have been exposed to in a given period. Personal monitoring with a pocket dosimeter or film badge gives better assessment of the total dose received by the workers than the routine six monthly blood examination. Because the minimum exposure of 25 rem (250 mSV) required before effects on the blood count are noted occurs only as a result of an accident or gross negligence, and rarely occurs in a radioisotope laboratory.

(a) For external radiation, monitoring is done by studying the TLD, dosimeter or the film badge, which is continuously worn on the front of the body, on the breast pocket, or attached to a finger ring or wrist by each person exposed to radiation. Intensity of radiation incident on the badge is shown by a proportionate blackening of film on its development. A fountain pen type dosimeter can be read by the wearer himself at any time but it requires expert maintenance. The developed film badge serves as a permanent record of the individual's exposure (physical monitoring).

(b) If an internal hazard is suspected, testing of urine, faeces, nasal smear, or sputum may be helpful depending upon the metabolism of the particular element involved (Biological monitoring).

(c) Measurements over the thyroid may be used to estimate the body burden of radioiodine where it is being used. A monthly thyroid count of the workers would show whether the radioisotopes have been inhaled or ingested.

(d) Hands and shoes, floors, tabletops, gloves and other items are checked for contamination by the Gieger - Muller portable survey instruments.

(e) For larger radioisotope units, a 'count rate' meter is also essential according to the nature of the radiation exposure.

(f) Intensity of radiation due to radioactive materials, which have entered the body by inhalation, ingestion or through skin can be estimated through Biological monitoring by a 'scintillating counter'.

(g) The total body burden can be estimated by assaying the amount of radioactivity excreted in the urine, faeces or exhaled air and by a direct measurement of radiation from the 'critical organ'.

**Protection of workers in industry**

In addition to the various measures described earlier, general protection is provided by measures described as under, the actual details varying with the nature of the hazard.

**(a) Protection Against External Radiation**

All techniques used for providing protection against the exposure to external sources aim at increasing the distance of the subject from the source of exposure, decreasing the exposure period, shielding from exposure and use of various remote control devices. The tissue - penetrating gamma - rays obey the inverse - square law just like light. Therefore, if the distance from the source is doubled, the intensity of radiation falls to a quarter. When it is necessary to work in fields of intense radiation, the dose received can be reduced by limiting the period of exposure and shielding the subject from exposure to radiation. The thickness of the shield is determined by types and intensities of radiations and the rate at which the shielding material attenuates the radiation. Alpha radiations are stopped even by a sheet of paper, clothes on the body and by horny layer of human skin. Beta rays penetrate into the tissues for about 3 mm and can be stopped by an aluminium foil, thick clothing or plastic overalls. For protection of hands, plastic or rubber gloves are enough. The use of protective clothing made of serial materials like plastics, aluminium, fabric or other synthetic fabric are important protective measures. Gamma rays are however, highly penetrating and can only be attenuated by lead and cement concrete. The shielding power against gamma rays is proportional to the specific gravity of the material. Therefore, 2. 5 cm

thickness of lead, which is about 4 times as dense as aluminium has the same shielding as 10 cm thickness of aluminium. In addition to shields of lead - bricks, a variety of 'remote control' implements are used while dealing with high intensity radio - active matter in industry and the working is reduced so that the permissible radiation exposure limit is not exceeded.

**(b) Protection Against Internal Radiation**

Smoking, drinking, chewing, taking snuff or eating in areas where there is a possibility of contamination, and pipetting of radioactive solutions by mouth is forbidden; rubber bulbs for aspiration are used for this purpose. Rubber or plastic gloves are worn for handling radioactive material. When a risk of air - borne contamination is present, appropriate devices to mechanically suck and carry the fumes, mists, dusts or vapours away from the worker, and respirators or special hoods are used. Fixed radioactive contamination is not a source of internal hazards as it cannot be inhaled or ingested, but loose contamination leads to hazards. The scrupulous cleanliness, protective clothing, washing of hands and mouth, prohibition of eating, drinking, smoking or application of cosmetics in work rooms will give considerable protection against internal radiation hazards. For ensuring that the precautions taken are adequate, monitoring should be done by ascertaining from time to time the total dosage to which workers have been exposed in a given period.

**(c) Prevention of Exposure to Radioactive Material**

In industries such as radium dial painters where the material comes in intimate contact is prevention of exposure affected by providing the workers with :

(i) Glass screen booths and efficient exhaust ventilation.

(ii) Adequate facilities for washing hands before meals.

(iii) Wearing of rubber aprons.

(iv) Use of paper handkerchiefs, which are collected daily and destroyed. Workers should not use their own handkerchiefs.

(v) Special separate rooms for eating and smoking. Food, tobacco, drinks and cosmetics must never be introduced into workrooms.

(vi) Special solvents to remove paints should be rubbed on the hands and removed with soap and water. The hands after drying thoroughly must be examined in a darkened room under ultraviolet light, which may reveal some residual luminescent material. Electroscope and Geiger - Muller counters can more accurately detect radioactive substances. A breath radon estimation may also be helpful, if facilities are available

(vii) Cleaning of floors must be done by employing the wet methods.

(viii) Mechanical painting process should be employed and brushes must not be licked for pointing.

(ix) Employees should be medically examined within seven days of employment and thereafter at monthly intervals. The first sign of finger damage is a reddened glazed appearance of the fingers tips commencing with the erasure of the finger impressions, followed by cracking of the nails. At this stage with complete stoppage of exposure, the fingers will revert to normal. A total WBC count below 4500 with reduction of polymorphs and relative lymphocytosis shows ingestion of large doses.

**(d) Medical Examination**

(i) A preplacement medical examination is necessary to eliminate individuals, physically and mentally or temperamentally unsuitable to work with radiation and also to get basic blood counts for future comparison during the employment. The preplacement medical standards are laid down in the ILO publication on 'Protection of Workers against Radiation'.

(ii) Periodical medical checks of persons who are continuously exposed to ionizing radiations are necessary. A complete medical record of such periodic or special examinations should be maintained. This should include information regarding preplacement state of health, the radiation hazards exposed to, details of clinical examination and any special investigations relating to the critical organs or tissues.

(iii) Examples of special investigations are: haematological examination in case of external whole body irradiation; skin examination in case of external irradiation or contamination; ophthalmological examination in case of exposure to neutrons and to heavy corpuscular radiations; examination of the 'body burden' in case of an internal radiation hazard; pulmonary examination in the case of inhalation of radioactive aerosols and gases.

(iv) Haematological examinations should include RBC, WBC and thrombocyte counts, a search for abnormal cells, haemoglobin estimation, and an assessment of the bleeding and the coagulation time. The skin examination should be carried out for detection of epilation, dermatitis, cancer and also slight changes such as the disappearance of the finger ridge details. The ophthalmological examination should be done for changes in the crystalline lens. The 'body burden' examination should define the nature and degree of the internal contamination assessed by means of measurement or analysis directly on the body or indirectly on the excreta, urine, faeces, inhaled air and so on. The pulmonary examination should be done for detection of the complex effects (mechanical, chemical and radioactive) of radioactive aerosols and gases.

**(e) Health Education**

(i) Health Education to Workers exposed to ionizing

radiations and internal changes should be watched for. Precautions should be taken where necessary as carelessness may lead to harm to themselves and others. They should immediately report to their doctor if any abnormal signs detected on the skin or any other unusual ailment develops, without becoming unduly alarmed. However, exposure beyond a permissible level can occur for a long time before any significant change in the blood count becomes evident. In planning protective measures, the emphasis should be much more on the instrument and film badge monitoring of radiation exposure than on blood counts (3, 4).

## Nuclear warfare

### Introduction

Conventional weapons contain chemical and high explosives and on detonation energy is released as a result of chemical changes. In chemical changes or reactions, only the outer electrons, which are revolving round the nucleus take part. The amount of energy released in a chemical reaction is of the order of few electron volts per atom. The atoms of carbon, hydrogen, oxygen and nitrogen originally combined in the high explosives are released uncharged but recombine with other partners to form the waste products of the explosion.

In the atomic weapons, the energy comes from the inner core or the nucleus of each atom. In nuclear explosions, measurable quantities of matter are converted into energy. This energy is of the order of few million electron volts. Only a few of the known elements have atoms capable of releasing large amounts of nuclear energy. Weight for weight nuclear explosives release greater amounts of energy than conventional explosives.

### Fission Weapons

Nuclei of heavy elements like uranium - 235 (naturally available), plutonium - 239 and uranium - 233 (made artificially in nuclear reactors) can be split into nearly equal parts in a process called fission by the addition of a neutron bringing an imbalance in the nucleus. This is the process that takes place when fission weapons are exploded.

### Fusion Weapons

Another process by which nuclear energy can be released is called fusion because isotopes of hydrogen can fuse together at high temperatures of the order of millions of degrees centigrade releasing large quantities of energy. Such hot atmosphere is available only at the centre of the sun and stars. But such temperatures can be obtained in the detonation of an atomic fission weapon. Fusion or hydrogen weapons therefore need a small atomic or fusion charge as an initiator and for this reason, these are some times known as 'fission - fusion' weapons. In fusion reaction, large number of fast neutrons of the order of 1014 are released and these can be utilized in fission of uranium - 238 in fast fission reactions. Such a bomb where a third stage is incorporated is called 'fission - fusion - fission' bomb or thermonuclear weapons. Conventional weapons explosive power is expressed in terms of tons of trinitro toluene (TNT). High explosives have maximum yield of the order of 1000 tons TNT explosion but atomic weapons exploded over Hiroshima and Nagasaki had yields of the order of 20,000 tons of TNT or 20 KT (TNT).

At present there are wide range of nuclear weapons ranging from sub kilo tons to few mega tons power i. e. mini nuclear weapons (Mini nukes), Nukes, tactical weapons, atomic weapons and thermonuclear weapons. There are also different varieties of weapons enhanced radiation weapons, another type of weapons where radiation is suppressed and blast effect is improved. The third type of radiological weapons where radioisotopes are used deny the enemy an area for certain period.

### Principles of Fission

The practical exploitation of nuclear energy becomes feasible with the discovery of nuclear fission in 1939. When $U^{235}$ (an isotope of uranium which occurs to the extent of 0. 7% in natural Uranium) is bombarded by a neutron, it splits into two nearly equal fragments with the release of a large amount of energy. In addition, 2 to 3 neutrons are also released, which under suitable conditions can be made to bombard further $U^{235}$ nuclei and sustain a chain reaction. In a nuclear reactor, the chain reaction takes place in a controlled fashion whereas in an atomic bomb, the chain reaction takes place in an uncontrolled fashion releasing all the energy in one millionth of a second in a confined space leading to an explosion. For an atomic bomb the elements required are:

(a) Uranium - 235

(b) Plutonium - 239 and Uranium - 233.

Uranium - 235 is naturally available whereas the other two are to be obtained from nuclear reactors. Ten to twenty kg of U - 235 (90% enriched in U235) is required for a 20 KT atomic weapon, which is of the same power as Hiroshima or Nagasaki bomb. The fuel must be kept in sub critical bits or in a sub critical shape before the explosion and suddenly made critical at the time of explosion. The other nuclear fuel, plutonium - 239 is a man - made element and obtained in a reactor by the absorption of a neutron by uranium - 238 nucleus. This is produced in a reactor after several months of operation. Since uranium and plutonium are chemically different these can be separated by chemical means.

### Chronological Development of An Atomic Burst in Air

The first indication of a nuclear burst is blinding flash of light (many times brighter than the sun). An intensely hot luminous sphere of compressed gases (containing vapourised fission products of the uranium or plutonium, bomb casing etc), called the ball of fire, is formed. It expands and rises like hot air balloon. At one second it reaches its maximum diameter of 300 M. By 10 seconds it cools to such an extent that it is no longer visible as a ball of fire. As the temperature falls, the smoke cloud rests on top of a column of dust and debris sucked from the surface of the earth by the force of the explosion. The smoke cloud rises to a height of about 8 Km in 10 minutes;

then the top spreads laterally for several kilometers giving the characteristic mushroom shape. About a thousandth of a second after the explosion, a high - pressure wave develops and moves out - ward from the ball of fire. This is the shock wave, which is the cause of the destructive blast. The high - pressure front of the shock wave initially travels at about 5 times the speed of sound (330 m/sec). When the shock wave strikes the earth it is reflected; the reflected and incident shock waves fuse at some distance from the explosion site to form the Mach Stem, which is extremely destructive to the structures. Gamma rays and neutrons are emitted from the ball of fire and smoke cloud. They are very intense for the first one - minute. The fission products that are formed during the explosion due to the fission of the uranium (i. e. the material used in the bomb) get mixed up with the dust sucked in and constitutes the radioactive cloud. This radioactive cloud travels down wind and settles down either in the immediate vicinity or over long distances in an area or circulates round the globe in stratosphere. Depending upon the height of the explosion, this fall of radioactive dust is called local fallout or global fall out. This radioactive fall out is responsible for the delayed radiation effects - high level as well as low level.

### Effects of Nuclear Weapons

The effects of nuclear weapons depend primarily on the

Fig. - 1

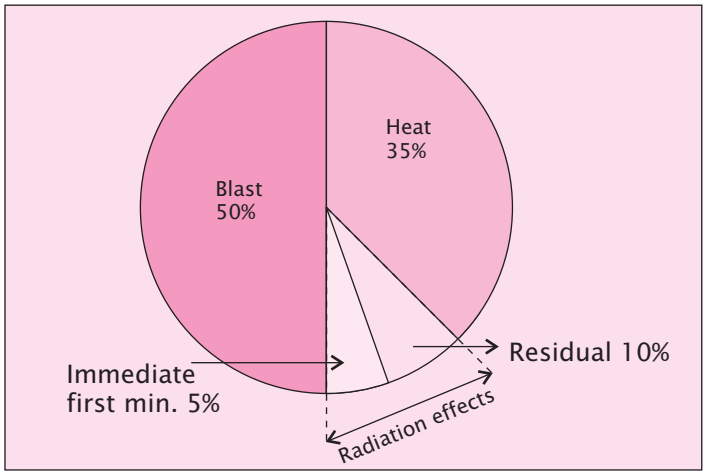



Table - 3 : Distribution of energy released 121012j by a nuclear bomb exploded in the troposphere

| Energy Form | Energy Released 12 1012j | % Total |
|---|---|---|
| Blast (Shock) | 41.9 | 50 |
| Heat | 29.3 | 35 |
| Nuclear Radiation 1st min | 4.2 | 5 |
| Nuclear Radiation Residual | 8.4 | 10 |

yield and type of the burst (high air, low air, surface, under ground and under water). For knowing the effects of any particular type of burst for a given yield (power) say for 20 KT, there are simple sealing laws which enable the effects from any other yield to be predicted. The effects are of two types (7 - 12) :

(a) **Immediate** (occurring within one minute of the explosion)

(b) **Delayed**

Immediate effects are of three categories - blast, heat and nuclear radiation. (Fig. - 1) Delayed effects are due to fall out. The distribution of energy released by a nuclear bomb of 20 KT yield exploded in the troposphere. (Table - 3)

### Effects of Thermal Radiation

Thermal radiation or heat flash consists of visible and invisible light rays - ultraviolet rays of shorter wave length and infrared rays of longer wave length. It is already mentioned that 35% of the energy released in the detonation is emitted in the form of light and heat radiation which will produce temporary or permanent blindness, burns on exposed parts of the body and set fire to combustible material. Substances will scorch, char or even burst into flames as a result of the heat radiation from the fireball. The intensity of the direct heat radiation received at any place may be enhanced, in a way similar to that of visible light, by reflection and scatter from clouds or from fog and dust particles in the atmosphere or it may be reduced by the absorption in passing through thick or heavy atmospheric pollution. Thermal radiation like visible light is reflected by light colours and absorbed by dark ones so that dark coloured objects are more likely to catch fire than the white ones. Paper, wood, rubber and dry grass are easily charred and may catch fire. Fortunately, wool and the material for the dress given to the soldiers are relatively resistant to heat. The primary inverse square law in determining the heat radiation at a point does not hold good, since the atmosphere consists of many pollutants like dust, fog, clouds etc.

Table - 4 : Range of heat effects on people exposed in the open : radii in km for ground burst weapons

| Weapon power | 20 KT | 1 MT | 10 MT |
|---|---|---|---|
| 3rd degree Burns | 2.25 | 13.0 | 35.5 |
| 2nd degree Burns | 2.8 | 14.5 | 40.25 |
| 1st degree Burns | 4.0 | 13.25 | 56.00 |

Table - 5 : Range of heat effects on people exposed in the open: radii in km for air burst weapons

| Weapon power | 20 Kt | MT | 10 MT |
|---|---|---|---|
| 3rd degree Burns | 1.4 | 6.5 | 21 |
| 2nd degree Burns | 1.6 | 8.85 | 23 |
| 1st degree Burns | 2.4 | 13.25 | 34 |

### Skin Burns

Skin burns can vary in severity from a mere reddening (first degree) or a more painful blistering (second degree) to a much more charring of the skin (third degree). But in considering the severity, it is necessary to keep in mind three important factors; total amount of heat; the area on which it falls and the duration of application of this quantity of heat to the surface.

Table - 4 gives ranges in Km at which people in the open would suffer various degrees of skin burns from the ground burst weapons of different power. Table - 5 gives similar data for airburst weapons.

### Personal Protection from Thermal Radiations

To protect oneself from the thermal radiation it is necessary to get out of the direct path of the rays from the fireball and any kind of shade will suffice to protect in an emergency. People caught in the open should dive far behind any available cover. While so doing one should cover one's body as far as possible so that the extent of the burns is kept to a minimum. Loose clothing offers some protection compared to tight clothing.

### Fire Protection and Precautions

Primary fires result from the heat flash through windows, open doors etc igniting the combustible contents in the houses, offices and stores. One precaution would be to rearrange the furnishings or equipment to remove all inflammable material out of the direct path of any heat rays that might enter through windows or other openings, Another precaution would be to white wash windows as this would keep about 80 % of the heat radiation.

Secondary fires might be the consequences of blast damage, scattering of domestic fires, rupture of gas pipes, or short - circuiting of electrical wirings. These risks could be reduced if ordinary common precautions were taken on receipt of warning such as shutting up stoves, covering open fires with sand or earth and turning off gas and electricity at the mains.

### Fire Storms

The chief feature of a fire - storm is the generation of high winds, which are drawn into the fire area to feed the flames. These inrushing winds prevent the spread of fire outwards but ensure almost complete destruction by fire of every thing within the affected area. A firestorm increases the number of causalities since it becomes impossible for people to escape by their own efforts and they succumb to the effects of suffocation and heat stroke. The 20 KT Hiroshima bomb caused a firestorm. A fire storm occurs in a heavily built up area of substantial size with plenty of combustible material and where at least every other building in the area had been set on fire by the heat flash.

### Effects of Damage From Air Blast

The enormous pressure produced in the detonation of a nuclear weapon gives a violent push to the surrounding air with the result that a wave of high pressure is transmitted outwards through the air; in addition, a strong wind is caused by the bulk movement of the air. The pressure wave is followed by suction wave that is a partial vacuum, which then causes a wind in a reverse direction towards ground zero. Initially the pressure wave is transmitted at a speed five times that of sound and then slows down to the speed of sound. The effect of a shock wave on any structure is an initial shock thrust and sustained push over it.

### Mach Wave and Mach Effect

When the shock strikes the earth, it is reflected. The reflected shock wave travels in a hot medium so it travels with a greater speed than the original shock front. After some time the two shock fronts (original and reflected) fuse together to form Mach wave. The effect due to this Mach wave is called Mach effect. The peak pressures in the Mach Wave are almost double that in the original wave.

### Relation Between the Blast Effects of Air and Ground Burst Weapons

The range of blast damage is substantially greater for an. air burst than for a ground burst weapon. For most practical purposes, the damage radii for the ground burst would be increased by as much as 30 % if the weapon were airburst at about the optimum height.

### Effects on Human Beings

Human beings run little risk of being killed outright if the static pressure is about 200 psi but ear drums may burst and lung damage may start at 35 Psi. For people in the open, the main risk (apart from other risks) is being blown over by the blast wind. A person standing in the open would be blown over at a distance of about 14 Km from a 10 MT ground burst. He would be moved bodily if lying prone in the direction of the blast at about 6. 5 km.

### Effects of Initial Nuclear Radiation

Nuclear radiations are emitted continuously from the moment of detonation of a nuclear weapon and for long periods thereafter. They are emitted from the fireball, from the radioactive particles in the cloud as it is dispersed by the winds, and finally from the radioactive fallout material deposited on the ground. The division between initial (some times called flash) nuclear radiations and residual radiations, therefore, has been chosen arbitrarily at one minute after detonation. Initial radiations consist of neutrons and gamma rays, followed by gamma radiation from the newly formed and intensely radioactive fission products in the fireball. Most of the neutrons are captured by the material of the weapon but some escape.

Neutrons being neutral particles, pose indirect problems by way of induced activity. In an airburst, these neutrons are absorbed by the atmospheric nitrogen and become radioactive emitting highly energetic gamma rays. This gamma radiation intensifies and extends the range of the initial gamma flash. For some distance around the point of detonation, the neutron dose may be higher than the gamma flash dose, but beyond a certain point the gamma hazard predominates. This point is always well within the zone in which storm blast and radiation protection are needed. Thus, it may happen that the neutron hazard is greater in shelters quite close to the detonation of tactical weapons with light cases, which permit a higher proportion of neutrons to escape. Otherwise a shelter, which gives reasonable protection from gamma radiation also gives good protection against neutrons.

### Initial Gamma Radiation

Gamma rays can penetrate considerable thickness of

Table - 6 : Radial distance (in km) of initial gamma effects on people exposed in the open to all ground burst weapon

| Weapon power | 20KT | 1MT | 10MT |
|---|---|---|---|
| 50 percent survival (450R) (4.5 Gy) | 1.2 | 2.5 | 3.5 |
| No appreciable risk of sickness (75R) (0.75 Gy) | | 1.6 | 2.8 |

matter for example the roof and walls of a building but they are attenuated in doing so. They can also be scattered back by the medium i. e. by the atoms of oxygen and nitrogen in the atmosphere causing an additional hazard even though one takes protection behind heavy obstacle. This is called invisible sky shine. So protection behind a heavy obstacle in the line of sight only will not be sufficient. One has to have a cover all around under a heavy shield for good protection.

**Weapon Power and Range of Effects**

Table - 6 shows the radial distance at which 50% lethal dose of 450R(4. 5 Gy) and a wartime emergency dose of 75R (0. 75 Gy) would be received by the people exposed in the open to initial radiation from a ground burst.

**Personal Protection from Initial Nuclear Radiation**

Inspite of extensive research in many parts of the world, no satisfactory drug is available yet for self injection or oral administration immediately after exposure to a lethal dose of radiation. Only protection against initial radiation is to remain under adequate shielding when the flash occurs (to escape both the direct and the scattered radiation). Protective clothing does not provide any protection against gamma radiation. It only prevents radioactive dust from getting on to the skin or into the body.

**Effect of Residual Radiation from Fall Out**

The radioactive fission products from a nuclear weapon, burst on or near the ground, would condense on debris and dust lifted by the explosion and would be deposited around the creator or dropped from the cloud, more or less slowly, as if swept over a broad area, the extent of which depends upon the power or yield of the nuclear explosion. Particles of size more than 20 microns would be deposited over a 'hide area' as a local fallout and particles less than 20 micron size would have been carried high into atmosphere or even into stratosphere in the case of air burst, and these would take more than weeks or even years to be deposited on the ground. This constitutes the global fallout.

**Residual Radiation**

Residual Radiations are those emitted later than one minute after the detonation of a nuclear weapon and come from the radioactive fission products. These fission products are deposited around the point of detonation of weapon. Depending on the prevailing winds at the time of detonation, the fall out pattern takes an oval shape extending in the down wind direction. Typically the region of severe fall out from a 20 KT low air burst may extend 5 km up wind, 8 km cross wind and 25 km down wind.

About 200 isotopes or different radioactive species of atoms of about 35 elements are released in a nuclear fission detonation. The half lives of these fission product isotopes vary from a fraction of a second to thousands of years. The rate of decay of the mixed fission products is very rapid. Starting from 1 hr after detonation to 200 days,

Table - 7 : Seven, Tenth rule

| Time after burst | Time factor | Dose rate per hrs | Dose rate factor |
|---|---|---|---|
| 1 hr | 1 | 100 | 1 |
| 7/4 hr | 7/4 | 50 | ½ |
| 7 hr | 7 | 10 | 1/10 |
| 2days (49hrs) | 7x7 | 1 | 1/100 |
| 2 weeks | 7x7x7 | 0.1 | 1/1000 |
| 14 weeks | 7x7x7x7 | 0.01 | 1/10000 |

the rate of decay follows the formula RT = R, t12 where RT is the activity at any time 't' and R is the activity at one hour after the detonation, t is time when RT is being assessed.

**Seven, Tenth Rule**

The use of this formula in the field conditions becomes a tedious process for fission product decay. For many civil defence purposes, the seven tenth rule enables one to make a quick approximate mental calculation of the radiation level at any time from a single measurement at a known time. This rule is that the intensity of radiation falls by a factor of 10 as the time lengthens by a factor of 7. Its application is illustrated in the Table - 7 for a dose rate of 100 Roentgens measured at one hour after a nuclear detonation at any point.

**Different Hazards Presented by Fall Out**

The radioactive fission products emit alpha, beta and gamma radiations. These have different penetrating and ionizing powers. The hazards due to these radiations can be assessed only when it is known as to what kind of problem the radioactive fallout possesses. There are three distinct situations in which radioactive fallout can be hazardous.

(a) The radioactive dust has already settled and personnel are to work in the area. In such a situation a person can have protective clothing so that the dust particles that

Table - 8 : Isotopes for critical organs

| | |
|---|---|
| 131 I | Thyroid |
| 239 Pu | Lungs, Bone and Bone Marrow |
| 90 Sn | Bone |
| 40 Ca | Bone |
| 137 Cs | Muscle (whole body) |

would be rising are not inhaled or contaminate the human body. This is an external hazard in which gamma rays irradiate the whole body and the other two radiations are not important.

(b) Fallout may contaminate the body, for example fallout on clothing, hair or skin.

(c) The fission products may get into the body through inhalation, through cuts or contaminated food and water.

131 I, 137Cs, 90Sr, 45 Ca and 239 PU are the more important isotopes as internal hazard. These are selectively absorbed in certain organs and irradiate the organs. This results in greatest damage to a particular organ or system in the human body called critical organ. Table - 8 gives the isotope and the critical organs.

Special protective clothing with a head gear and filters would protect a person from internal hazards and give temporary protection against the contact hazard. But these should be removed and decontaminated or replaced at the earliest opportunity. These do not provide any significant protection against gamma radiation. Personal cleanliness is essential to remove radioactive fallout from the clothing or skin and to prevent its entry into the body.

**Hazards to Food Stocks, Animals, Crops and Water Supplies**

Uncovered food, water, live stock and crops may be contaminated and through these they may find their entry into man via the food chain which will be harmful to human beings. Tolerance limits of contamination must be specified but their application requires advice of the radiological experts. The limits will depend upon how long it would be necessary to exist on the contaminated food or water supplies. ICRP had recommended maximum permissible concentrations (MPC) of various isotopes in water and air. These depend upon intake throughout lifetime. ICRP has also given guide lines to arrive at maximum permissible concentration in water, air and food when there are more than one radioactive isotopes present.

**Monitoring Organisations**

The first line of defence for the protection of the public and defence personnel would be the organisations for monitoring the degree of contamination and for controlling and distributing the available supplies of acceptably pure food and water. Civil defence personnel should co - operate with these organisations. So there should be teams even in civil defence organisation who have some knowledge of the problems involved and of possible protective measures.

These monitoring organisations should have a knowledge of the various fission products, solubility of these products, food chains, retention mechanisms in the body, critical organs in the body, significance of internal contamination, monitoring drinking water and decontaminating water to make it drinkable under emergency conditions, monitoring food stocks, crops and live stock for contamination. Milk consumption is associated with special problems. Iodine - 131 may get into the milk through the grazing of contaminated grass. This concentrates in the thyroid and consumption of this milk by children poses a problem in the long run.

**The Threat of Epidemics**

Post attack survivors suffering from exposure, malnutrition, heat, blast and radiation injuries are an ideal feeding ground for epidemics. Typhus, dysentery, tularemia and plague may appear in epidemic forms. Insects (especially flies, mosquitoes, ticks and mites which are of importance in transmitting diseases) are highly resistant to radiation. LD 50 for man is 400 - 600R (4 - 6 Gy) whereas LD 50 for insects is 10, 000 to 20, 000R (100 - 200 Gy). Their number increases enormously as there are uncleared human and animal carcasses with poor sanitation. This problem is enhanced in the poor tropical regions. Public Hygiene should be a part of the radiation hygiene. As in the event of a nuclear war these two cannot be separated, medical teams should educate in peace time the consequences of nuclear war.

**Protection Against Atomic Explosion**

(a) Against explosive blasts, flashes and fire

The distance from the point of explosion, reinforced concrete buildings, deep shelters, tunnels, caves and trenches afford protection to some extent. Inflammable material like wooden structures catch fire easily. Concrete brick and earth have greater protective value.

(b) Against ionizing radiations

The greater the thickness of the wall of the shelter the lesser are the chances of exposure to penetrating external radiation. To avoid internal radiation by inhalation of radioactive air and dust in the contaminated area or by ingestion of contaminated food or water, no person should enter a contaminated area without a respirator or touch food or water unless it has been declared safe by a monitoring team. To summarize, the protective measures are :

(i) Suitable underground shelters with thick non - inflammable walls and roofs.

(ii) Monitoring of all suspected areas and subjects

(iii) Avoidance of entry into the contaminated area

(iv) Use of suitable clothing i. e. respirators, overalls, gloves, gum - boots or strong leather boots

(v) Prohibition of the consumption of suspected food, water, fruits, milk and vegetables

(vi) Decontamination of personnel and equipment at decontamination centers

(vii) A periodical medical examination of rescue workers and cases likely to have been exposed to small doses of radiation

(c) Individual Protective Clothing and Equipment

Different types of protective equipment and clothing are available :

**Facelet**

The facelet mask affords marginal protection to personnel against low concentrations of chemical agents and protects personnel temporarily when threat is imminent. It also provides protection against radioactive dust being

inhaled. It can be worn for prolonged duration without physiological stress.

**Respirator NBC**

Respirator NBC provides protection against field concentration of most chemical agents, biological agents and radioactive dust in vapours and aerosol form. It does not provide protection against ammonia vapours and CO and must not be used for fire fighting. The respirators may be broadly classified based on the type of cannister being used viz; the filtering type and closed circuit types. The filtering type filters the contaminated air whereas the closed circuit type has compressed air/oxygen or oxygen which is regenerated within the system when desired. The respirator is also referred to as gas mask, protection mask or simply as mask also.

**Protective Clothing**

The protective Clothing Utility NBC, is the nomenclature of the more commonly used clothing items; the other is Clothing Isolating NBC. The clothing protects the wearer against effects of WMD including to some extent, from fire and incendiary. It causes physiological stress on the wearer and reduces his ability to operate. The clothing is of two types, namely the permeable and the non permeable. These may be further classified into disposable, reusable and non - reusable. The disposable, non, non - permeable are the plastic cape or over garment which provide the most immediate but temporary protection against liquid agents. The reusable permeable are those based on rubber and vinyl materials. The permeable layered cloth clothing cannot be reused in battle and has to be discarded.

**Gloves**

Gloves provide protection against liquid chemical agents and vapor hazards, as well as against radioactive dust and vectors. Each glove consists of an outer and an inner layer. The outer is usually made of butyl rubber or neoprene and the inner of cellulose fabric. If either glove is damaged, the glove set must be replaced.

**Boots and Overboots**

Exclusive boots for operating in NBC environmental are clumsy and difficult to use. An overboot may take a form of a boot or even fish tails and is used only when NBC threat is imminent.

**Haversack**

The haversack is designed to prevent contamination of items carried in them. Its usual contents include the respirator, face mask, liquid chemical agent detection paper, self aid kits etc. The haversack, when carried on man is anchored well to prevent damage to the respirator and the cannister.

**First Aid Treatment of Atomic Bomb Casualties**

(a) Multiple Injuries

Multiple injuries like fractures and wounds of different parts of the body will require conventional surgical and supportive treatment. In addition, decontamination of these patients should be borne in mind as they might have received sublethal doses of radiation.

(b) Treatment of Burns

Burns caused by 'flash' and 'fire' will always constitute a large %age of casualties. In order to reduce fatalities and disfiguring disabilities these cases will require special treatment. It is, therefore, important that special 'burn centres' with adequate accommodation, equipment, staff, laboratory and monitoring facilities are made available. Burns may also be produced by beta particles received in fallout; therefore, exposed patients should be thoroughly and quickly decontaminated under a shower with soap.

(c) Treatment of Radiation Injuries

Decontamination of all likely to have been exposed to radiation is the first essential procedure. Thorough training to make it a drill is necessary. A shower bath with soft soap is the initial requirement. Cases of actual radiation injuries may only constitute a small %age of total casualties. However, many of the wounded or burn cases will also be suffering from the effects of ionizing radiations. Early treatment of shock, maintenance of water, and an electrolyte and acid base equilibrium is essential. Later infection and anaemia will have to be combated.

(d) Prevention of Delayed Effects

This will need constant vigilance. Usually the central nervous system and gastro - intestinal denudation syndromes are lethal within two weeks. Patients who develop intractable nausea and persistent vomiting soon after exposure will probably have sustained a lethal dose in which case, medical care will not change the course. In others, however, these symptoms may well be of psychogenic origin and require only mild sedation and anti - emetic drugs, although sometimes fluid replacement may also become necessary. The major problems among the survivors will be those associated with bone marrow depression. The critical period will be within the 10th to 30th day after exposure. There is no specific form of therapy for severe bone marrow aplasia; treatment must therefore be largely symptomatic with good nursing care, maintenance of scrupulous cleanliness, an adequate fluid intake, and a high calorie and protein diet rich in vitamins. The leucopenia results in an increased susceptibility to infection. Therefore, the best nursing care possible should be provided. The mouth, nares, anus and vulva should be taken care of. Meticulous care should be taken of all minor cuts and abrasions of skin and mucous membranes. Antibiotics should not be used prophylactically but should be administered when signs of infection occur. Thrombocytopenia may result in haemorrhagic diathesis. Transfusion of fresh blood or platelet rich plasma will be needed. Since pooled and preserved whole blood does not contain platelets, it should be reserved for traumatic cases and for patients suffering later from persistent anaemia.

The chief difference between an atomic disaster and other heavy explosions are the suddenness and magnitude of the former event. 40, 000 to 50, 000 casualties, excluding the dead may occur as a result of one detonation. Most of the casualties may be similar to other type of explosions except that about 10 to 30 % of the wounded in an

explosion would have received ionizing radiations as well. Hence medical aid for sudden occurrence of a large number of casualties, their evacuation to safe areas and further special surgical and medical treatment needs to be planned, developed, and organized much earlier in the pre - strike period. Immediately following the incident, sufficient medical personnel and equipment enough to give minimum essential early treatment and preventive medical supervision would be required. As a practical consideration all casualties have to be regarded as radiation victims unless proved otherwise. In addition to attending to the wounded and sick there will be the enormous task of dealing with residual contamination. Monitoring and decontamination of the residual radioactive contamination and that of food and water supplies and of a substantial proportion of injured population is a task of such magnitude that cannot be relegated to a medical organization alone. Medical services may be able to deal with relatively easy procedures; monitoring and decontamination shall have to be done by a special team of monitors and decontamination centers and squads. Monitoring squads should be located near large cities and industrial areas. Their main duty is to assess the degree of contamination of any area, amongst uninjured population and that of stores and equipment.

Most people within a 15 km radius from the detonation of a megaton bomb will be killed by blast and heat, unless they are in a blast resistant shelter, where they should stay for at least 48 hours as it will probably be so hot from induced radiation and fallout that any efforts to reach survivors within this period would be risky or even fatal. Further out in the 15 to 30 km radius and beyond, it may be possible to remove patients with injuries and burns to sheltered areas for treatment, provided sufficient time is available before the expected arrival of fallout. Principal decontamination centres will have to be established outside the periphery of contaminated area and no individual should get in or out of the contaminated areas without passing through these centres. Decontamination of clothing and the bodies of casualties and refugees and workers who enter contaminated areas will have to be arranged. Washing and bathing arrangements and laundry facilities will have to be provided in these centres.

Additional medical support could be organised by the help of specialized medical units assigned on a regional basis as required, under centralized control. These will be casualty treatment units organised in advance and manned by a team of physicians, surgeons and trained para - medical staff. These units should also have decontamination staff. Such units must be capable of operating for short periods without communications. Each unit should be capable of caring for about 100 casualties. There will also be the need for airborne (helicopter) casualty treatment units to give medical help to isolated regions, where ground units may fail to approach. Airborne as well as ground evacuation units will have to work in close co - operation with the medical treatment units. Airborne units carrying dispensary, laboratory, preventive medical services, dental services, etc. , would also be needed. Special monitoring teams on the wings' to check the water, food and drug contamination need to be organised; so also ground monitoring at all levels of medical organisation. There is need for the organisation of decontamination units which should be able to take up the responsibility of personnel decontamination and laundry services for contaminated clothes.

Training of the general public and dissemination of information regarding atomic disaster must be carried out in peace time to create a sense of confidence in them. The dispersion of relief organisations and stores is absolutely necessary. The construction of shelters, protection of vital services and communications, training of monitoring teams and positioning of essential medical stores and

Effects of nuclear explosion

| Event | Effect | Protection |
|---|---|---|
| Flash | Flash blindness | Close eyes |
| | | Protective posture |
| Heat | Thermal burns | Protective clothing |
| | | Protective posture away from path of light |
| | | Shelter |
| Blast | Fractures and injuries Rupture of hollow viscera | Protective posture Appropriate shelter |
| Radiation | Acute and delayed effects | Protective clothing |
| | | Shelter |
| | | Avoiding entry in contaminated area |
| | | Avoiding eating / drinking in contaminated area |
| | | Decontamination |

equipment must be planned before the disaster. Medical and nursing officers and other staff shall have to be specially trained. Surgical teams and burn centres are essential medical units in any plan and should be raised in all civil and military hospitals. Fire fighting services must be fully organised. Emergency hospitals shall have to be opened in existing buildings or tents and located away from large towns and industrial areas. Large reserves of antibiotics, resuscitation fluids and medical stores will have to be arranged for dispersal over a wide area. Other relief organisations to evacuate and care for the victims, monitoring, emergency health services to deal with contamination of food and water supply and to decontaminate areas, stores and personnel are required. Similarly, the relief organisations for the supply of food, water, clothing and amenities of life to the victims of the exposure are also required (7, 12).

## Biological Warfare

### Definition

Biological warfare is the military use of living organism or their toxic products to cause death, disability or damage to man, his domestic animals or crops. As a conscious and planned form of waging war in an non - explosive but equally deadly manner, this form of warfare is still largely unknown and its true potential remains untested. However, there is ample evidence to show that active programmes of research have been in existence in various countries since 1930.

Biological weapons are fundamentally different from nuclear and chemical weapons for the following reasons

(a) Ability of the agents i. e. microorganisms to reproduce within the host after dissemination thereby causing infection.

(b) Ability of some of the agents to be transmissible from one person to another.

(c) Distribution of small quantities of agents in suitable wind currents could result in vast areas being affected.

(d) Difficult detection - it is virtually impossible to detect biological warfare agents until it is too late. There are no BWA detectors similar to the capabilities of CWA detectors now in use.

(e) Biological warfare agents can be produced quite easily and at low cost.

(f) Dissemination of these agents can be in many forms - aerosol form by bombs, release of vectors, covert methods.

(g) Delay factor - These agents take time varying from hours to days depending on the incubation period, to produce their effects.

(h) New disease agents i.e. genetically developed microorganisms or virulent variations of otherwise harmless microorganisms could be introduced almost any time.

(j) Potential weapons for terrorists.

### Types of Biological Agents

A biological warfare (BW) agent is any living organism which can be used to produce disease or death in an enemy, his animals or crops. An enemy would select an agent which is highly infectious, easily produced and stored, stable and suitable for use in the field and able to produce a disease for which there is minimum immunity in the target population.

According to the medical point of view, these are classified as under (Table - 9) :

(a) Bacteria : Cholera, anthrax, plague etc

(b) Rickettsia : Typhus, Rocky Mountain spotted fever etc

(c) Viruses : Small pox, Dengue, JE etc

(d) Fungi : Aspergillosis etc.

### Characteristics of BW agents

A majority of agents employ microorganisms which will only grow and reproduce under suitable conditions. The most important characteristics of micro - organism is that they are living. The essential characteristics are :

(a) Infectivity

(b) Virulence - This signifies severity of disease caused.

(c) Incubation period i. e. , time between the infective penetration of sufficient microorganism into the body and appearance of symptoms.

(d) Transmissibility

(e) Lethality

### Operational Classification

The classification of BW agents is in accordance with their operational effects :

(a) Lethal and transmissible (Small pox, Pneumonic plague)

(b) Lethal and non - transmissible (Anthrax, Epidemic Typhus)

(c) Incapacitating and transmissible(influenza, Typhoid)

(d) Incapacitating and non - transmissible (Tullaremia, Dengue Fever)

### Routes of Entry

To cause disease there are several routes of entry of BW agents into then human body.

#### (a) Respiratory route

This is the most important route and besides, in this way the infective dose required may be smaller and onset of symptoms more rapid than normal. The most effective delivery is by inhalation of an aerosol containing agent particles that are in the range 1 to 5 microns in size. Larger particles fall out of the aerosol or are trapped in the upper airway. Smaller particles are breathed into the lungs and expired out. In addition this route it has the following advantages :

(i) The delivery of BW agents by aerosol is one of the most practical methods.

(ii) The natural rhythm of breathing provides a continuing susceptibility.

(iii) Personnel are reluctant to wear respirator continuously.

#### (b) Skin

Penetration through damaged skin and mucous membrane may occur, particularly if the surface is damaged. Some protection will be afforded by the IPE (Individual Protective Equipment).

#### (c) Digestive Tract

This provides a route of entry of BW agents which have contaminated food and drink. This route, however, has some limitations :

(i) Many BW agents are destroyed by digestive process.

(ii) The drinking of deliberately contaminated water is a possible method but an unknown dilution factor, chlorination and boiling, all serve to reduce the

Table - 9 : Biological agents and their characteristics

| Disease | Symptoms | Incubation period infective dose | Man to Man txn |
|---|---|---|---|
| **Bacteria** | | | |
| Anthrax | Cutaneous form : Sores or blisters form on hands or forearms<br>Pulmonary form : Non specific respiratory symptoms followed by respirator distress, fever shock , lead to death.<br>Intestinal form : Intense stomach pain, bowel obstruction, dehydration, diarrhea, fever septicaemia and death. | 2 to 7 days(48 hrs)<br>8000 to 50,000 spores | No |
| Tularaemia | Sudden onset of fever with chills, headache, muscle pain, fatigue , dehydration, ulcers on skin, lymphadenopathy | 2 to 10 days<br>10 to 50 organisms | No |
| Plague | Bubonic plague- High fever headache, painful lymphadenopathy, haemorrhages on skin<br>Pneumonic plague High fever, cough, blood tinged sputum, respiratory distress ,death | 2 to 8 days<br>2 to 3 days | No<br>High |
| Cholera | Severe watery diarrhea with vomiting, muscular cramps, dehydration and death | Few hrs to 5 days | Rare |
| Diphtheria | Sore throat, low grade fever, respiratory obstruction | 2 to 5 days | |
| **Rickettsia** | | | |
| Q Fever | Sudden onset of fever, chills, weakness, profuse perspirstion, respiratory symptoms, muscle and joint pain | 2 to 3 weeks<br>1 to 10 organisms | Rare |
| Rocky Mountain spotted fever | Fever, chills headache, arthralgia, muscle pain, skin rash, neurological complications | 3 to 14 days | Rare |
| Typhus | Headache, high fever generalized bodyache, rash | 6 to 14 days | Rare |
| **Viruses** | | | |
| Encephalitis | Fever headache, drowsiness, stupor, convulsions, severe prostration, occasional paralysis | 2 to 15 days | |
| Dengue fever | Fever with severe headache, retro orbital pain joint pains, petechial rash, spontaneous bleeding, circulatory collapse and death | | 3 to 15 days<br>No |
| Yellow fever | Fever with chills, prostration, headache, backache, myalgia, nausea, vomiting, jaundice from liver damage. Bleeding from mucus membranes | | 3 to 6 days<br>No |
| Small pox | Fever with centrifugal rash, typically multilocular umbilicated with erythematous base, septicaemia, blindness and death. | 7 to 17 days<br>10 to 100 organisms | High |
| **Toxins** | | | |
| Botulinum toxin | Vomiting, Paralysis , muscle cramps | 1 to 5 days | No |
| Ricin | Fever, constipation, thirst and dizziness | 18 to 24h | No |
| | | | |

chances of success.

(iii) Cooking at high temperatures kills almost all microorganisms.

**Biological Agent Dissemination and Delivery Techniques**

**(a) Aerosols**

(i) Explosive bomblets

(ii) Generators

(iii) Spray tanks

**(b) Vectors**

**(c) Covert means**

These include direct placement of BW agents of liquids, powders or spray form into food chain at harvest, processing, distribution and preparation points, or by placement of BW agents into points of water reservoir /distribution chain.

**Techniques of biological attack**

**(a) Multiple point source**

Biological bomb lets or containers can be distributed over a large area as follows :

(i) Missile delivered warheads

(ii) Aircraft delivered bomblets

(iii) Aircraft released bombs containing clustered bomblets.

**(b) Line Source**

Biological munitions can be delivered in a linear fashion to disseminate the agent over a large area, downwind of release line :

(i) Elevated line source

Can be released from spray mounted on aircraft.

(ii) Ground line source

Can be released from bomblets that are ejected from dispensers of aircraft or missiles at a controlled rate. Agents can also be released along the ground from a vehicle - mounted generator.

**Medical Aspects of Biological Warfare**

There is nothing mysterious about the medical problems that would be created by a successful biological weapon attack. It would lead to an outbreak or epidemic of the disease with clinical features caused by the disseminated disease agent. The potential for causing devastating casualties is high for certain biological agents especially if genetically modified strains are used or if the disease is transmissible. In addition to affecting the general population, biological warfare agents also affect the healthcare system and cause mass panic ultimately affecting a nations' economy as a consequence.

The situation would require medical management on a mass basis rather than the administration of individual cover. But the basic principles of medical therapy would apply. Firstly every attempt should be made to make a definitive diagnosis by sending appropriate samples to appropriate laboratory facilities. While awaiting laboratory confirmation, a preliminary diagnosis must be made on clinical grounds. A firm diagnosis can only be made by a trained epidemiologist with good laboratory backup. Prompt treatment must be instituted Prompt treatment must be instituted based on preliminary diagnosis since it is in the initial phase of the diseases that therapy is most likely to be effective. Standard precautions for infection control for prevention against most diseases should be practiced, (14).

**Prevention & control measures for Biological Warfare.**

Prevention and control in case of Biological Warfare would include :

(a) Physical Protection.

(b) Chemo prophylaxis

(c) Immuno Prophylaxis

(d) Diagnosis

Physical Protection

It can be personal protection or collective protection for personnel. Simple measures to be adopted are - If out doors keep head covered. Wear a scarf or wrap a cloth/handkerchief around nose. Keep hands in pockets. If possible, take refuge in a closed shelter. Use personal (individual) protective equipment like:

**(a) Protective Mask**

The NBC mask offers protection against aerosol agents. The main functional part of the mask is the air filter which filters out particles of size 1 - 5 microns.

**(b) Protective Clothing.**

Protective clothing employed against chemical agents is also effective against biological agents. Even if this is not available standard uniform clothing of good quality affords a reasonable protection.

**(c) For Collective Protection**

(i) Personnel must be housed inside a shelter with an efficient air filtration system.

(ii) In case troops are in barracks at the time of attack, close all doors and windows of the barrack.

(iii) Reduce the ventilation rate as much as possible by shutting off any ventilation system (unless it contains a filtration unit) and by putting out the fire.

Chemoprophylaxis

Chemoprophylaxis should be used only under the conditions where an attack is known to have occurred and organisms identified.

Diagnosis

In an event of a biological attack, the all important factor in providing adequate medical management will be rapid establishment of an accurate specific aetiologic diagnosis.

In evaluating problems from a practical stand point one must assume that the enemy would employ an organism other than the ones commonly encountered in every day medical practice.

Plan for immediate movement of small number of representative cases to one or more previously designated

medical facilities.

How to recognise biological attacks? The number of people affected, the time relationships, the similarity of clinical picture, the sharply defined geographical boundaries will produce an epidemiological picture that can be explained only by an infection due to an artificially disseminated aetiological agent as in aerosols.

It must be remembered that success or failure in organising the medical defence may well depend on the rapidity and accuracy of diagnostic efforts.

Detection of Biological Warfare Agents

The detection of these agents in the environment is virtually impossible or difficult The first indication of a biological agent attack would be an increased no of patients showing up at hospitals with clinical features of the disease agent used. It is difficult to recognize the outbreak of an endemic disease from an outbreak stemming from a biological attack. The disease pattern that develops may be an important factor in differentiating between a natural and a terrorist or warfare attack. Some epidemiological clues of a biological warfare or terrorist attack are :

(a) The presence of a large epidemic with similar symptoms, especially in a discrete population.

(b) More severe symptoms than are usually expected for a specific disease, or failure to respond to standard therapy.

(c) A disease that is unusual for a given geographic area or transmission season.

(d) Multiple simultaneous or serial epidemics of different diseases in the same population.

(e) Unusual routes of exposure for a disease, such as the inhalational route for diseases that normally occur through other exposures like exposed skin.

(f) A single case of a disease by an uncommon agent (small pox, viral haemorrhagic fevers)

(g) Unusual strains or variants of organisms or diseases that resist normal treatment.

(h) Intelligence of a potential attack or claims by a terrorist of release (13).

Immune Prophylaxis

Most effective method against biological warfare would be the use of specific active immunoprophylaxis. Most of these vaccines are not available through commercial channels and have been developed mainly for protection of laboratory personnel or for possible protection of military personnel who might be required to operate in areas of the world in which specific diseases are endemic.

Problems associated with immunoprophylaxis are :

(a) Requirement of large amount of vaccine

(b) Development and production of vaccine against exotic diseases

(c) Logistic burden

(d) Requirement of multiple doses and limitations on the number of vaccines which can be administered at one time.

Single or polyvalent vaccines may be used. Polyvalent vaccines have the advantage of preventing multiple diseases by a single injection. For reducing time in mass vaccination programmes jet injectors can be used effectively. However active immunisation takes time for producing an immune response and is hence ineffective in a war like situation. Passive immunoprophylaxis might also be employed in biological operations situation when rapid protection is desired and agent used by enemy is known.

Public Health Aspects

A Biological attack can breakdown public health systems including disrupting of existing disease control programmes. Every precaution should be taken to prevent these consequences.

Medical aspects of biological warfare

| | |
|---|---|
| Epidemiological Indicators of biological warfare<br><br>diagnosis | Personal protection<br>Collective protection<br>Early detection and<br><br>based on features and lab diagnosis<br>Antibiotic stocks<br>Isolation<br>Prompt treatment<br>Infection control<br>Information to higher authorities |

The following measures may be instituted :

(a) Proper inspection and thorough cooking of food

(b) Institution of water surveillance, water chlorination/ superchlorination and/or boiling water for 15 mins.

(c) Frequent change of clothing, daily baths, washing of mouth by water/ normal saline.

(d) Strict control of rodents and insects is of immense importance following a biological attack as they may be a source of propagation of an epidemic (21, 28).

## Toxins as Warfare Agents

### Introduction

Toxins are poisonous substances usually produced by living organisms or extracted from the cells of these organisms. Toxin warfare agents or toxic weapons are toxins used for hostile purposes. Toxins are faster acting than biological agents, they are of potentially greater military utility.

Types of Toxins

**(a) Bacterial Toxins**

These can be broadly divided into exotoxins and

endotoxins. Few important bacterial toxins which are of military interest are :

(i) Botulinium toxin
(ii) Staphylococcal toxin
(iii) Tetanus toxin

**(b) Mycotoxins**

Mycotoxins are toxic compounds produced by moulds. Some of the important mycotoxins which are of military interest are :

(i) Alphatoxins
(ii) Trichothecenes
(iii) HT 2 toxins
(iv) T 2 toxins

**(c) Snake Toxins**

Out of many toxic components in snake venom the following are important :

(i) Neurotoxins
(ii) Necrotic toxins
(iii) Haemorrhagic toxins

**(d) Ricin**

Effects

Toxins, depending upon their type, can cause death or incapacitation in human beings and animals and are thus classified as :

(a) Lethal
(b) Incapacitating

Dissemination Techniques

Toxins can be delivered on the target area by all available means similar to those used for delivering chemical agents. In Laos, Cambodia and Afghanistan wars, the following means were reported to have been used for dissemination of mycotoxins :

(a) Aircraft
(b) Bombs
(c) Rockets, artillery
(d) Mines

Conclusion

Many toxins have turned out to be more toxic than orgonophosphorous compounds and other chemical poisons e. g. Ricin. Progress achieved in the field of microencapsulation might make aerosol distribution of toxin warfare agents more feasible technically. Modern method of genetic engineering, cell techniques, protein engineering and immune techniques makes it possible to produce large amounts of toxins.

## Chemical Agents and Chemical Warfare

### Definition

Deliberate use of chemicals against humans, animals or crops with the primary intention of inflicting casualties or to decrease combat efficiency of the enemy during war is called as chemical warfare. A weapon that owes its destructive power entirely to the toxicity of one or more of its constituent chemicals rather than the energy of the chemical interaction between them is called as a chemical weapon. A chemical agent is a compound which when suitably disseminated produces incapacitating, lethal or damaging effect on men, animals, plants or materials.

**Salient features of Chemical agents are**

(a) Most chemical agents are powerful organic solvents and able to penetrate into polymeric materials.
(b) Depending upon its physical properties and the method of application chemical warfare agent may present itself as liquid, aerosol or vapour.
(c) Chemical warfare agents may be thickened to increase their persistency.
(d) Chemical warfare agents present a dangerous contact risk and are difficult to decontaminate.
(e) These agents have a much more immediate effect than biological agents when used on the battlefield.

### Methods of Dissemination of a Chemical Agent

Chemical agents may be disseminated in one of the following ways :

(a) Liquid droplets or spray like rain
(b) Liquid aerosols like fine mist small enough to be inhaled
(c) Solid aerosols like smoke
(d) Vapour or true gas.

Chemical Warfare agents may be delivered in many different ways from aircrafts, spray tanks, containers, aerial bombs, artillery shells, rockets, grenades, missiles from air or ground or from aerosol generators.

### Classification

Chemical agents may be classified in one of the following ways

(a) Classification based on their military use

The chemical agents are further classified as:

**(i) Lethal agents**

Also called as killing agents, they are delivered with the primary aim of killing maximum number of men e. g. , nerve agents.

**(ii) Incapacitating agents**

Make an individual temporarily unable to perform his duties.

**(iii)Riot control agents**

They are selected and approved for use while giving aid to civil authorities.

(b) Classification based on Duration of Effectiveness:

This is based on the duration for which the agents are effective over a target. They are classified as follows :

**(i) Non - persistent agents**

Such agents disperse rapidly as they are highly volatile. They affect the body through respiratory route. Examples include Phosgene and G. agent.

**(ii) Persistent agents**

Such agents continue to present a hazard over the target for considerable period after delivery. Example V agent.

(c) Classification based on Effect of the agent on the body:

**(i) Nerve agents**

Interfere with the working of the nervous system e. g. , Tabun (GA), Soman (GD), Sarin (GB).

**(ii) Blister agents**

Also called as vesicants, they cause inflammation, blistering and superficial destruction of contaminated tissues such as lining of breathing passages. Examples include distilled mustard, nitrogen mustard and lewisite.

**(iii)Blood agents**

They prevent body tissues from using oxygen e. g. , hydrogen cyanide (AC), cynogen chloride (CK), arsine (SA).

**(iv)Choking agents**

Phosgene, diphosgene, chloropicrin.

**(v) Vomiting agents**

Diphenylchloro arsine, adamsite.

**(vi)Mental incapacitators**

These are further classified as

- CNS depressants e. g. , marijuana
- CNS stimulant e. g. , LSD

Chemical weapons have been tried out and their effects are known more or less thoroughly (22 - 27). General and medical defences against these agents are well developed and if instituted early can save large number of lives. Effects, sign and symptoms and the treatment of a few important chemical agents is given below:

**Effects of Nerve Agents**

These are a group of highly toxic organophosphorus compounds and constitute one of the deadliest chemical agents. High exposure may lead to death without any reaction time. Broadly they are divided into G group agents such as GA (tabum) GB (sarin), and GD (soman).

**Absorption**

Entry is through respiratory route usually. They can act through the eyes, skin and penetrate ordinary clothing rapidly. They can be easily removed from the skin using Fuller's earth or soap water. They act by inhibiting cholinesterase enzyme. Signs and symptoms resemble Organophosporous poisoning. Treatment consists of termination of exposure, and decontamination. Atropine and oximes are used whereever indicated, severe cases may require ventilatory support. NAPS or nerve agent pre - treatment set consisting of 30 mg pyridostigmine bromide is available. NAPS can be used 8 hourly before an anticipated attack. Self - aid consists of use of protective mask and hood. Eyes should be irrigated. Combopen auto injector with 2 mg of atropine and 220 mg of oxime can be used every 15 minutes. In case of soman, diazepam can be added with combopen.

**Effects of Blister Agents**

These are absorbed through the skin, conjunctiva and respiratory tract. They are rapidly absorbed if they are ingested. Repeated exposure leads to cumulative effect. These agents are cytotoxic and mutagenic. Their effect resembles that produced by ionizing radiations. They interfere with DNA synthesis and cellular division process. Eyes are blistered after a heavy exposure and may lead to blindness. Mild exposure leads to lacrimation and foreign body sensation. Self aid consists of washing the area exposed with normal saline or water. Antibiotic eye drops may be used. Exposure of the skin leads to erythema, vesication and necrosis, depending on the dose. Treatment consists of decontamination with Fuller's earth and use of bland lotions. Beclomethasone can be used on blisters and erythema. Analgesics can be used when required. Four to six hours of exposure leads to effects on the respiratory system. These include nasal secretion, burning pain in the throat, hoarseness of the voice and aphonia. Repeated exposure leads to pulmonary fibrosis and chronic bronchitis. Secondary infection may lead to pneumonia. Treatment consists of cough syrup, steam inhalation and antibiotics. Exposure to the GIT leads to vomiting, bloody diarrhoea, prostration and shock. Large number of similar cases with GIT symptoms should lead to a suspicion of exposure to blister agents. In such a case close examination of food should be done. Treatment consists of use of atropine, analgesics and IV fluids.

**Effects of Choking Agents**

These agents affect the lung tissue leading to pulmonary oedema. Best known example is phosgene. This is a colourless gas with suffocating odour reminiscent of mouldy hay. Maximum oedema occurs after 92 hours of exposure. The gas may be inhaled in vapour or aerosol form. Exposure to the eyes leads to lacrimation. Irrigation of the respiratory passages leads to cough and choking along with feeling of tightness in the chest, nausea and vomiting. Increasing quantity of frothy white or yellow sputum is expectorated which later may become blood tinged. Circulatory collapse and cardiac failure may occur. Death may occur within 48 hours of exposure. Diagnosis is ascertained by history of exposure and a large number of cases occurring at a particular time. The initial symptoms of choking, coughing and lacrimation disappear to reappear after one to six hours. Treatment consists of use of mask, protection from exposure, bronchodialators and antibiotics. Decontamination is not required.

**Effects of Blood Agents**

These include hydrocyanic acid and cyanogen chloride. These are absorbed by inhalation. These agents act by combining with cytochrome oxidase enzyme and lead to death due to respiratory failure. Cyanogen chloride leads to symptoms of upper respiratory system. Acute poisoning is characterized by dizziness, headache, palpitation, anxiety, dyspnoea, ataxia, paralysis and coma. Severe cases may show collapse, convulsions and respiratory arrest. History of exposure, typical signs and symptoms and peculiar odour, like bitter almonds, point to the diagnosis. Treatment consists of use of mask, and smelling amylnitrite. Crush 2 ampoules close to the nose.

In case the individual is in a contaminated atmosphere, crushed ampoules are inserted inside the protective mask. Two crushed ampoules can be used every 4 to 5 minutes to a maximum of 8 ampoules. Ventilatory support may be required.

**Detection of chemical warfare agents**

Detection and identification of chemical agents is extremely important for taking protective action since chemical agents have different mechanisms of action. The detection of chemical agent (compound) is defined as the determination of its presence in a qualitative and often In a quantitative way. Sometimes especially if the agent is highly toxic, it is also important to determine the hazard which a combination of its presence, its concentration its form and its toxicological properties.

Detection can be carried out on site and off - site both by detection in its vapour or liquid form by using physical and other automated techniques. Some of the Detection methods are

(a) Residual vapour detection kit
(b) Detector tubes
(c) Three colour detector paper forliquid blister and nerve agents
(d) CAM (Chemical agent monitor) for mustard and nerve agents
(e) Portable gas chromatography
(f) Mass spectrometry

**Protection against chemical agents**

In a situation of chemical warfare agent use, physical protection of the individual is the most important measures to counteract the toxicity of the agent. Physical protection for an individual is known as individual protection and if for a group of individuals is known as collective protection. In either of the cases the twin aspect of physical protection are creation of an artificial barrier between the chemical warfare agent and the 'subject' and the provision of breathable air.

Individual Protection

Protective equipment which is used by an individual to achieve protection is termed as Individual Protective Equipment. This includes protective clothing such as trousers, jacket with hood, overboots and mask or respirator. Respirable air is provided through a source connected to thr face piece which can be a pure air cylinder or a canister which detoxifies the contaminated air.

Collective Protection

In case of collective protection, locations such as shelters, tanks, ships buildings, vehicles etc are suitably modified e. g. by a ventilation system to protect against the chemical environment. Collective protection reduces the discomfort of wearing the individual protective equipment.

Medical management of chemical casualties

Chemical warfare agents are weapons of mass casualties, with casualties having features specific to the toxic effect of the agent.

(a) The effects of chemical agents are known.
(b) Chemical casualties have features specific to the toxic effect of the agent.
(c) The general defensive measures, NBC suit and face mask were primarily developed against chemical agents and are efficient in preventing the effects provided the troops are well trained in their use.
(d) Medical protection in the form of pre treatment, self aid and treatment is well developed and if instituted early can save lives.

**Medical management of Nerve agent poisoning**

Principles of treatment

(a) Termination of exposure
(b) Decontamination
(c) Assisted ventilation
(d) Anticholinergic agents eg atropine which competitively blocks acetyl choline
(e) To reactivate he inhibited acetylcholine esterase enzyme by an oxime
(f) To use adjuncts eg carbamates to augment the effects of cholinolytic agents. The carbamates bind with a portion of the body's AchE forming a weak complex thus saving this from the effects of nerve agents. Thus carbamtes eg pyridostigmine reserves upto 30 % of the body's AchE for later release. This release is facilitated by oximes. Use of pyridostigmine allow the body to tolerate larger doses of nerve agents provided post exposure treatment is given.

Management

**Pre treatment**

Pyridostigmine bromide 30 mg, also known as Nerve Agent Pre Treatment Set(NAPS) tablets are taken 8 hourly before an anticipated chemical attack. The set consists of 21 tablets.

**Self aid and First aid**

(a) The protective mask and hood must be put on immediately if any of the symptoms of nerve agent poisoning are noticed eg
  (i) Feeling of tightness in the chest.
  (ii) Unexplained running nose
  (iii) Unexplained dimness of vision
(b) The eyes must be washed with water if a splash of liquid agent gets into the eye.
(c) Atropine must be taken immediately in the form of autoinjectors. These contain 2mg of atropine and are to be injected in the outer aspect of the thigh by self or buddy every 15 minutes till a maximum of three injections are taken. Oxime injections are also to be taken in the same way in the other thigh for a maximum of three injections. The auto injectors contain 220 mg of atropine. The two can

be combined in one injection known as combopen injection.

(d) 5 mg of diazepam taken orally is also a useful adjunct in the treatment of nerve agent due to its central anti convulsant properties.

**Treatment**

The casualty must be evacuated to the hospital if there is no improvement after 3 injections of combopen. Here treatment can be continued with oxygen inhalation, artificial respiration, intravenous atropine and supportive care.

**Medical management of blister agent poisoning**

Self aid and first aid

(a) Remove the casualty from the source of the blister agents.

(b) Clothing should be removed.

(c) Wash the eyes preferably with normal saline otherwise with clean water.

(d) Decontaminate the skin with fullers earth i. e. DKP I and 2

(e) Local anaesthetic eye drops may be instilled in the eyes e. g. amethocaine hydrochloride may be instilled in the eyes.

(f) Topical antibiotics e. g. chloromycetin should be used to prevent secondary infection.

(g) For areas of erythema and minor blistering bland calamine lotion may be used.

(h) Beclomethasone dipropionate cream may be used for minor blistering.

(j) Pain relief by using analgesics, (Paracetamol).

(k) Application of antibiotic ointment and covering the area with sterile bandage.

Treatment

Blister agents require long period of hospitalization and skin care depending on the area involved. Broad spectrum antibiotics, pain relief and dressings form the mainstay of treatment. In case of GIT symptoms, atropine and IV fluids may be required.

**Medical management of choking agents**

Self Aid and first aid

(a) Protective mask should be worn immediately on suspicion of exposure to the toxic agent eg odour of cut grass, irritation of eyes or choking feeling with cough.

(b) Casualty must be removed from the source by buddy wearing protective mask.

(c) Personnel must be made to rest and provided with warmth.

(d) Decontamination is not necessary.

(e) Bronchodilators e. g. beclate in metered doses must be inhaled every 15 min.

Treatment

Rest, oxygen, bronchodilators e. g. aminophylline is helpful. Antibiotics are required to check infection and ventilatory support may be required.

**Medical management of blood agents**

Self aid and first aid

(a) Mask must be put on immediately as soon as suspicious odour is detected. Breath should be held till mask is worn.

(b) Crush two ampoules of amyl nitrate immediately and hold close to the nose. If individual is still in contaminated environment, two crushed ampoules are inserted inside the protective mask. This treatment of crushed ampoules is repeated every 4 - 5 minutes till breathing returns to normal or a maximum of 8 ampoules are used.

Treatment

(a) Oxygen inhalation and artificial respiration if breathing difficulty persists.

(b) 600 mg of dicobalt edetate is given IV over one minute. If there is no recovery, another 300 or 600 mg is repeated iv over two min

(c) Sodium thiosulphate and Sodium nitrite are given in combination as an alternative treatment. Three % sodium nitrite 10 ml along with 50 % sodium thiosulphate 25 ml.

## Principles of NBC Defense

Protection from NBC agents involves the following components

(a) Avoidance

(b) Detection

(c) Protection (individual and collective)

(d) Decontamination

(e) Medical management

**General**

An enemy may use its NBC capabilities in direct support of its attack to cause maximum casualties. He may also attempt to contaminate ground and equipment so that our troops are forced to take precautions, which may degrade their operational performance. The operations may also be hindered because of :

(a) NBC casualties.

(b) Reduction of efficiency of troops who wear protective clothing and equipment.

(c) Loss of time in performing decontamination operations.

(d) Lack of logistical support required to perform decontamination

In spite of taking measures for avoidance of contamination, and individual and protective measures, it is likely that troops, terrain and equipment will get contaminated while fulfilling the mission. It is therefore essential that the decontamination operations be carried out at the earliest to restore the combat potential in order to fight and win.

### Nature of NBC Contamination

NBC contamination will generally take the following forms :

**(a) Chemical Contamination**

Chemical agents, either free standing or absorbed, will gradually evaporate posing residual vapour hazards.

**(b) Biological contamination**

Existing in solid or liquid forms as spores, powders or live micro - organisms, may persist for long periods, posing a potential hazard.

**(c) Nuclear Contamination**

Gamma rays and neutrons are very penetrative. These cannot be destroyed and decontamination must be aimed at removal of contamination or separation of personnel from the source of radiation.

**(d) Secondary Hazards**

Fall out of military activities in areas of NBC contamination may cause a secondary local and down wind hazard areas.

### Reasons for Decontamination

(a) Contamination can be lethal to unprotected troops.

(b) It degrades performance. Contamination forces soldiers into Mission Oriented Protective Posture or MOPP - 4. This reduces efficiency.

(c) Limitations of MOPP gear will begin to reduce effectiveness of the gear as well as the soldier. MOPP also provides only minimal protection from radiological contamination.

(d) Contamination also tends to spread to the shelters and along the supply routes due to spread of troops.

### Contamination Hazards

Contaminations may take the form of solids, liquids or gases. These can take place by :

**(a) Transfer**

Anything that touches a contamination tends to pick it up and then transfer it. The aim is to limit such a transfer.

**(b) Vapour**

Vapours have the potential of being inhaled. Also they tend to settle out of the air and coat the surface they touch.

**(c) Desorption**

Any absorbed contaminant is let out as vapour. This poses a vapour and transfer hazard.

**(d) Radiation**

For decontamination purposes radiation can be thought of as solids and removing a contaminated equipment will remove the hazard.

### Locating Contamination

**(a) Radiological**

Survey meters / Radiation meters.

**(b) Biological**

Only non specific contamination can be detected in the field. For specific detection, laboratory help is required.

**(c) Chemical**

Chemical detector papers, field detectors and alarms.

### Decontamination

It is the normal removal, neutralization or reduction of hazardous level of NBC contamination from personnel and material. Its aims are :

(a) To remove the free liquid or solid agents or radioactive dust from surface.

(b) To reduce the residual vapour hazard levels to permit relaxation of full personal protection.

(c) To hasten the rate of weathering and decay.

Types of Decontamination

**(a) Emergency Decontamination**

Any thing that immediately neutralises or removes contamination from exposed skin. The technique uses DKP1 and DKP 2 kits. It should be started within a minute of exposure.

**(b) Partial Decontamination**

Neutralisation of visible contamination from individual clothing and equipment that the crew must touch to perform its mission. Techniques used are :

(i) Personal wipe down.

(ii) Operator spray down.

(iii) MOPP gear exchange.

(iv) Vehicle wash down.

**(c) Complete Decontamination:**

This aims to reduce all or most of the contamination hazards.

Principles of Decontamination

(a) Decontaminate as soon as possible.

(b) Decontaminate only what is necessary

(c) Decontaminate as far forward as possible.

(d) Decontaminate by priority.

Chemical Decontaminants

They work by destroying the specific structure of toxic chemical agents. Some commonly used chemical decontaminants are :

**(a) Super Tropical Bleach (STB)**

It is a mixture of chlorinated lime and calcium oxide. It contains 30% active chlorine. Decontaminates mustard, lewisite and nerve agents.

**(b) Decontaminating Solution (DS - 2)**

Clear solution consisting 70% active chlorine, triamine, ethylene, glycol, monomethyl ether and sodium hydroxide.

**(c) High test hypochlorite (HTH)**

Bleaching powder similar to STB and contains a higher

%age of active chlorine.

**(d) Caustic soda or sodium hydroxide**

Neutralises a nerve agent and hastens hydrolysis of lewisite.

**(e) Sodium hypochlorite (house hold bleach)**

Effective against blister and V agents.

**(f) C - 8 calcium hypochlorite.**

Acts as a universal decontaminant.

**(g) Miscellaneous decontaminants.**

Organic solvents such as gasoline, kerosene, alcohol can dissolve toxic chemicals. Absorbant materials such as earth, charcoal, coal dust, saw dust, fuller's earth or clay.

Decontamination Equipment

These are used at individual, unit or formation level. These are:

**(a) Personal Decontamination Kit - PDK No. 1**

(i) Characteristics.

- It effectively decontaminates all types of chemical warfare agents.
- It is for immediate decontamination of human skin exposed to a chemical attack.

(ii) Description

It consists of pads filled with an inert, non - irritating strong absorbent powder. Each pad is sealed in polythene laminated aluminium paper bag to protect it from moisture and contamination.

(iii) Procedure

Quickly blot affected parts of skin with the pad then dap the pad lightly on the skin so as to cover the area liberally with powder. Remove excess powder with a fine towel to be thrown away or destroyed.

(vi) Packing

- It consists of four bags (containing powder pads) wrapped and sealed in polythene coated paper folder.
- Instructions are printed on package.

(v) Precautions

- It should be stored in a dry place.
- It is used as survival kit in an emergency to be followed by medical treatment.
- Always be alert to the development of symptom even after decontamination.

**(b) Personnel Decontamination Kit - PDK No. 2**

(i) Characteristics

- PDK No. 2 effectively decontaminates all types of chemical warfare agents.
- It is used for the decontamination of clothing, equipment and small arms.

(ii) Description

- It is puff bottle with a mixture of absorbent powder and chlorinated lime.
- Presence of chlorine helps in fast neutralization of mustard and VX agents in addition to the absorption properties.

(iii) Procedure

Press puff bottle repeatedly. Spray powder to spread all over the contaminated surface, dab the surface briskly and then wipe off the excess powder.

(iv) Packing

- Its puff bottle contains 80 gms of powder.
- Instructions are printed on the package.

(v) Precautions

- It should be stored in a dry place.
- It should be used for decontamination of skin.
- It is for use as field kit by the individual in an emergency.

**(c) Radiological Decontaminant Personnel Rdp**

(i) Characterstics

- It is intended for decontamination of dry/oily skin contaminated with radiological dust particles.
- It is a dilute aqueous solution with PH value of 7. This solution is adsorbed on special paper handkerchief.
- Fine handkerchiefs are packed in aluminium coated polythene bags.

(ii) Procedure

- Contaminated skin surface is cleaned thoroughly by wiping of the dust particles with the help of handkerchiefs provided.

(iii) Packing

- Hundred polythene bags (5 handkerchief in each bag) are packed in cardboard box.
- Instructions for use are printed on each bag.

(iv) Disposal

- These handkerchiefs should be collected in container to be buried under the earth.

(v) Precautions

- This handkerchief is for single use and repeated use of the handkerchief is strictly prohibited.

**(d) Portable Decontamination Apparatus - PDC 1**

(i) Technical Description

- This is used to decontaminate surfaces of materials and equipments.
- This is designed for spraying all liquid decontaminating agents.
- PDA - 1 assembly consists of a steel container capacity 10 litres, spray gun equipped with adjustable nozzles to obtain desired spray angles, brush for rubbing the surface, hose

pipes 2 metres in length, small size air cylinder for pressurizing liquid inside the container upto 3 Kg/sqcm pressure guage and safety valve.

- Spraying range is 10 m (max).
- Total height of apparatus is 565 mm.
- Weight of filled apparatus is 20 Kg.
- Generally 9 litres of decontaminant is filled into container.

(ii) Operating Instructions

- PDA - 1 container is filled to volume of 9 litres and stoppered. Air is slowly released to get desired pressure. The spray gun is operated and directed towards contaminated area.
- In case of slurry, higher pressure would be required for its delivery.
- Maximum pressure of air in the steel container should not be more than 3 Kg/sqcm.
- Slurry is slowly rubbed over contaminated surface to ensure complete decontamination of thickened agents.
- Maximum pressure of compressed air in the air cylinder is 130 - 150 Kg/sqcm.

(iii) Maintenance of Apparatus

- After each operation the steel container should be cleaned thoroughly with water.
- Spray gun should also be thoroughly cleaned with water.
- Threadings of stopper should be greased properly.
- Safety valve should be checked periodically for its correct setting.

**Various types of first aid kits used in Chemical Warfare are described below :**

**(a) First Aid Kit CW Type 'A'**

(i) First Aid Kit CW Type 'A' is intended to be used primarily to augment first aid resources available with a small body of troops when speedy evacuation of casuality is not possible. Kit can also be used at MAP.

(ii) Contents

| | |
|---|---|
| Combopen autoinjectors | 6 |
| Beclomethasone inhaler with metered dose | 1 |
| Personal decontamination kit | 1 |
| Detector paper chemical agent | 1 |
| Sterile gauze dressing | 2 |
| Antibiotic skin ointment | 1 |
| Dimercaprol eye ointment | 1 |
| Ampicillin 250 mg capsules | 25 |
| Paracetamol 500 mg tablets | 25 |
| Codine phosphate 30 mg tablets | 15 |

**(b) First Aid Kit CW Type 'B'**

(i) First Aid Kit CW Type'B' is intended to be used primarily at RAP for management of chemical casualities flowing in from FDL by trained medical personnel. It can also be used at ADS by pooling more number of such kits for treatment of casualities after decontamination has been carried out. Kit can also be used at MAP Cl 'I'.

(ii) Contents of the kit are attached as: Appx 'A'

**Emergency and Partial Decontamination**

One must decontaminate just enough to keep fighting rather than enough to make contamination free environment. Decontamination can be:

(a) Emergency or individual survival decontamination

(b) Partial

(c) Complete / deliberate

**Individual Survival Decontamination**

**(a) Chemical**

The skin decontamination kit DKPI provides the best means of decontamination. If it is not available, then chemical contamination may be pinch - bottled from the skin with any cloth and then area flushed with water from canteen.

**(b) Biological**

No decontamination is required immediately. The best biological defence is to take action before you are attacked. Keep immunization up to date, observe basic sanitary precautions and keep skin breaks covered. Treat minor cuts or abrasions by ordinary first aid measures. A 1. 5 % sodium hypochlorite (household bleach) solution is also an effective biological decontaminant.

**(c) Radiological**

Because no immediate life threatening hazard is caused by radiological contamination, no immediate skin decon is required. If your skin is contaminated by radiological contamination, use the individual sustainment techniques as soon as possible.

**Partial Decontamination**

Unit sustenance Decontamination Technique

It is a company sized operation that consists of three techniques:

(a) The MOPP gear exchange. This removes all liquid or solid contamination from the soldier and his equipment.

(b) Equipment decontamination

(c) Vehicle wash down: The last two techniques reduce the transfer hazard. Unit sustenance should be done as soon as possible.

**Individual Decontamination Equipment**

Decontamination is done at different level. It implies degassing, deradiation and disinfection. As part of an individual's kit there are individual decontamination kits, one based on the principles of absorption and the other on neutralization. Both are needed to tackle different types of contamination of different surfaces to be encountered on

an individual. The most popular one is the Fuller's Earth using a special technique to absorb maximum toxic chemical agent from such surface. However when the surface is skin, it must be decontaminated immediately. For this, chemical which neutralize most toxic chemical agents are used. Some kits can be used to remove radiological contamination also. Both contamination and decontaminating agent must be prevented from contacting eyes, mouth and open wounds. If contamination does occur, it must be flushed with water and if symptoms appear then they require medical attention. If a soldier is incapacitated, then his buddy must perform the decontamination.

**Special Equipment**

'Special' is the term used to express the range of equipment which are not personal equipment but are unit or subunit equipment. Every individual must know how to use since any person may be required to use them. This range of equipment includes

Residual Vapour Detection Kit (RVD)

It is also known as Field Chemical Agent Detection Kit. This kit consists of different sets of detection tubes, a mechanical pump and detection papers. The detector tube will detect harmful concentration of agent in field and the extent to which the changes in the colours indicate the approximate concentration of the sample. With the detection kit, it is also confirmed that the concentration of the agent is below hazardous level and therefore unmasking may be done. It also helps in collecting samples of any novel and unknown agent used by the enemy.

Direct - Reading Personal Dosimeter

It helps in reading total radiation dose and also gives a total gamma/neutron cumulative dose. Thus it enables commanders to determine the single exposure dose and the total dose at the end of the day and maintain the Radiation Exposure State of the Unit.

Hand - Held Decontamination Apparatus

It is used to decontaminate small areas that individuals come in contact with during the perusal of the mission. It reduces the levels of hazard of such mission. It has a pressurised can, a nozzle and a handle and looks like a fire extinguisher. Examples of situations where this apparatus can be used are: steering wheel and the wind screen, the door and its handles, the foot rests and the dashboard of a vehicle, laying and siting parts of an artillery gun and mortar and the like.

Casualty Bag

It used for evacuation of casualties through contaminated areas and to control contamination while transporting contaminated casualties through clean areas. Its of two types:

(a) Whole casualty bag. Its employed for evacuation of stretcher borne cases.

(b) Half casualty bag. Its used for walking wounded cases.

**Individual Self Aid Kits**

(a) Nerve Agent Poisoning

(i) Pre treatment Set of pyridostigmine bromide tablets (20 gm), commonly known as NAPS (Nerve agent pre - treatment set). These tablets are taken every eight hours and the set consists of 21 tablets. It therefore caters for 7 days. These tablets bind about 30 - 40% of body enzyme in a reversible reaction which then is not available for reaction with nerve agent. There is however a need to administer the autoinjector after attack if symptoms are observed.

(ii) **Autoinjectors :** Should be administered as soon as possible in case of nerve agent poisoning. A set of these autoinjectors contain a mixture of atropine (2mg) and an oxime (150 mg). A set consists of three auto injectors.

(b) Vesicants

These are hazardous whether they enter the respiratory system, come in contact with skin or are ingested. Mustard will also get through the clothing, given time. Immediate emergency decontamination, hence is ideal. If vesicants have gone into the eyes, it is best treated by using distilled water provided in self aid kits

(c) Miscellaneous

Amyl nitrite (smelling salt) can be used to relieve respiratory congestion against choking agents.

**Individual Detection Equipment**

Instruments needed to help the soldier to measure radiation and detect chemical agents encountered on the battlefield, help in survival of the man in NBC environment.

(a) Personal Dosimeter

It enables to record the radiation to which the person is exposed. These are of two types:

(i) Direct reading

These provide the commanders with information on single exposure doses and daily exposure doses.

(ii) Indirect reading.

This records cumulative gamma and neutron dose received by the person.

(b) Chemical Agent Detector

In case of vapour or aeresol this is provided by the detector alarms and monitors. But they do not give indication of absence of the hazard. The detection of liquid chemical agent is achieved by single colour and three colour detector paper. Immediate self aid or buddy aid is essential to survive in case an individual has been subjected to chemical attack. Each soldier is issued a set consisting of three autoinjectors, nerve agent pretreatment tablets, oxime tablets and some anti

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## Appendix A

**First Aid Kit CW Type B**

| No | Item | Nomenclature | Auth | Qty | Pack | Potency |
|---|---|---|---|---|---|---|
| **Injections / Parenteral** | | | | | | |
| 1. | Atropine | Atropine sulphate 2 ml | Amp* | 30 | 3 | 2mg/ml |
| 2. | Dimercaprol | BAL,2ml | Amp | 60 | 10 | 100mg/ml |
| 3. | Diazepam | Diazepam/Calmpose | Amp | 30 | 05 | 10mg/ml |
| 4. | Tab cough | Codine Phosphate | Tab | 200 | 10 | 30mg |
| 5. | Corticosteroids | Prednisolone Acetate 5ml | vial | 10 | 2 | 25mg/ml |
| 6. | PAM Chloride | PAM Chloride 100ml | vial | 2 | 2 | 1gm/2ml |
| 7. | Sodium Thiosulphate | Sodium Thiosulphate 25ml | Vial | 12 | 2 | 12.5gm/25ml |
| 8. | Sterile Water | Distilled Water 500ml | Bott | 27 | 2 | 500ml/Bott |
| 9. | Sodium Nitrite | Sodium Nitrite | Amp | 12 | 2 | 10ml of 3% solution |
| 10. | Antispasmodic | Baralgan/ antispasmodic | amp | 10 | 2 | 5ml/amp |
| 11. | Frusemide | Lasix 80mg/ml | amp | 10 | 2 | 80mg/ml |
| **Oral** | | | | | | |
| 12. | Paracetamol | Tab Paracetamol | No | 60 | one | 500mg/tab |
| 13. | Ibuprofen | Tab Brufen | No | 50 | one | 400mg/tab |
| 14. | Antispasmodic/analgesic / antipyretic | | Cap Spasmoproxyvon | | | No50oneBott of 50 tab |
| 15. | Diazepam | Tab Calmpose | No | 200 | 2 | 10mg/tab |
| 16. | PAM Chloride | Tab PAM Chloride 100mg tab fast release with three 500mg tab slow release | Tube/ Sachete | 30 | 2 | Pack of four tabs having 1000mg fast release one & 500mg slow release three tabs |
| **Inhaler** | | | | | | |
| 17. | Corticosteroids | Beclomethasone,50mg dose, 200 metered doses, aerosol packing | | 2 | 2 | Each inhalation dose 50mg |
| 18. | Amyl nitrite | Amyl nitrite | amp | 100 | 10 | Easy to crush amp for inhalation |
| **Ointment / Drops** | | | | | | |
| 19. | BAL (Dimercaprol) | Eye oint VBAL | Tube | 5 | 1 | 200gm/tube |
| 20. | Atropine | Atropine sulphate oily eye drops 1% sterile single dose applicator pack of 20 | Pack | 40 | 2 | 1% conc |
| 21. | Antibiotic/ antiseptic | Skin oint.,betadine | tube | 5 | 1 | 20mg/tube |
| 22. | Antibiotic broad spectrum | Eye oint., single dose application pack of 20 | pack | 40 | 2 | Single use |

## Appendix A

**First Aid Kit CW Type B (Contd.)**

| No | Item | Nomenclature | Auth | Qty | Pack | Potency |
|---|---|---|---|---|---|---|
| **Syringes** | | | | | | |
| 24. | Syringe | Hypodermic | No | 5 | 5 | 5ml/syringe |
| 25. | -do- | Disposable | No | 5 | 5 | 10ml/syringe |
| 26. | -do- | -do- | No | 1 | 1 | 50ml/syringe |
| 27. | Needles | Needles sterile 38.1mm | No | 200 | 20 | |
| **Dressings** | | | | | | |
| 28. | Pad gauge packed | Pad gauge surgical sterile with cotton film 15cm x 15cm | | No | 50 | 50Sterile pre- |
| 29. | Wipe swab | Wipe swab 70% IPA | No | 300 | 6 | 70% IPA % |
| 30. | Three layered NBC proof 0.5% medicated cloth large | Three layered NBC proof cloth dressing. Medicated pad with Bezalkonium BP 0.5% w/w 20cmx10cm. Three layered NBC proof cloth to be provided with velcro fasteners. | | No | 20 | 20Benzalkonium w/w. The dressing to be packed in water proof sterile pack separately |
| 31. | -do-(small) | Size 15cm x 40cm | -do- | -do- | -do- | -do- |
| 32. | Adhesive plaster | Adhesive plaster non irritant | Rolls | 2 | 2 | 5m/roll |
| **NBC Kit** | | | | | | |
| 33. | Fullers earth | Puff bott(PKD-2) | Bott | 2 | 2 | 200gm/bott |
| 34. | Pers decon kit | Pers decon kit | set | 5 | 5 | -if space permits |
| 35. | Water poison testing kit | Water poison testing kit for Nerve Agent, set heavy metals(As, Cu, Pb, Mn, Hg, Cr) & coliform bacteria | set | 1 | 1 | |
| **Misc Items** | | | | | | |
| 36. | Scissor | Scissor bandage all steel with Tungston edge. | No | 1 | 1 | 177.8mm |
| 37. | Tray Instrument | Tray instrument (kidney) polypropylene | No | 1 | 1 | Medium size |
| 38. | Chlorinated lime | Chlorinated lime (hermatically sealed) 250gm packed in non corrosive packing | Pack | 2 | 2 | 250gm pack to be kept outside the kit box |
| 39. | Box | Container box for NBC kit(CW) kit type 'B' | | Box | 2 | 2Ref para 7 GSQR No 537 dt Jun 89 |
| 40. | Endotracheal tube (Disposable with adopter) | Size 9.5mm | No | 30 | 1 | Each packed separately |
| 41. | Laryngoscope | Laryngoscope | No | 2 | 1 | |
| | | | | | | |

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## Policies and Procedures for Medical Classification of Personnel Affected by Important Conditions

Tertiary prevention constitutes the final level of prevention. Theoretically it appears to be a different stage from secondary level of prevention but in practice both run concurrently. As soon as a disease is confirmed, effort of medical & health fraternity is to cure it and thereby prevent loss of tissue / function which may result in disability necessitating rehabilitation. In diseases where early / timely intervention results in complete recovery / regeneration of tissue without any loss of function the disease process halts at secondary level, in others it progresses further. The modality of practice of tertiary prevention entails (a) disability limitation and (b) rehabilitation as applied to various diseases (1).

**(a) Disability limitation**

Early identification of disease and prompt treatment remains cornerstone of disability limitation. A delay in either will lead to instituting subsequent modalities of rehabilitation. During the treatment an appreciation of complications of disease helps in preventing them. Therefore, it will now be appreciated that secondary and tertiary level are inherently interlinked and run concurrent to each other.

**(b) Rehabilitation**

As far as it is concerned main thrust of all the activities under this head are directed to make the individual a useful member of society besides maintaining the pride and dignity of a human being. A holistic approach is adopted for this purpose. Main components of rehabilitation are (i) physical, (ii) vocational (iii) emotional/ psychological and (iv) social.

(i) **Physical** : It involves measures like reconstructive surgery or artificial limbs or wheel chairs, training of other group of muscle whereby endeavor is made to compensate the individual physically for loss of Function.

(ii) **Vocational** : Individual specific jobs are identified & created to make the individual self reliant in finances so to support himself & his family. Various financial rehabilitation schemes also come under this head.

(iii) **Emotional / psychological rehabilitation** : It should start immediately as soon as illness / loss of body part / function is realized. Besides the immediate treating team, the family support plays a crucial role in over coming the physical loss by individual. An aggressive management in secondary level will reduce subsequent effects for disability limitation & rehabilitation. However, when a patient reports late in pathogenesis of disease then disability limitation follows the cycle of function impairment leading to disability and ultimately becoming a handicap.

In Armed Forces a very dynamic and robust system follows disability limitation and rehabilitation of affected individuals and the modalities are laid down in concerned Army/Navy/ Air Force orders on the subject. This is applied in the form of various medical categories, SHAPE - 1 being the highest category denoting fitness of individual for all duties any where. The SHAPE factors then increase in number to denote various restrictions being put on individual as far as his / her employment, postings, dietary habits, periodic monitoring by medical authorities are concerned. The highest number i. e. 5 in any factor of SHAPE denotes unfitness for ARMED FORCES service and individual is invalided out of Service. An individual after being downgraded can be upgraded to his / her original medical category provided during periodic reviews the medical condition commensurate with laid down standards for particular disease.

Each SHAPE factors has a corresponding employment index and it is mentioned in each individual's medical documents at the time of categorization. The guidelines for administrative authorities are in the form of these employment indices. At the time of discharge a detailed counseling of patient is conducted to explain the various restrictions being put on the patient and periodicity of follow-up to be observed by the patient.

### Disposal of cases of important diseases in the armed forces

**Diabetes mellitus**

Diabetes mellitus like many other chronic diseases, leads to systemic complications if treatment is inadequate (poor compliance) or delayed. Tertiary prevention revolves around motivating intensely the patient by health education for self-care and early identification of complications by virtue of sign & symptoms Importance of maintaining euglycaemic state with proper diet, weight control and adequate physical activity.

In Armed Forces after an initial period of three months of diagnosis and after initiating the treatment if a patient develops unstable serious complication or requires insulin for routine control or any one developing serious complications is invalided out.

All diabetic retained in service will be placed in med category P3 (T-24) following which, officers requiring insulin, will be placed in P3(P) while JCOs/OR achieving control with diet / oral drugs will be followed to check the grade of control achieved. Grade III control patient will be placed in P3 for further period of 24 weeks whereas, Grade II control patients will be upgraded to P2 (Temp). Finally if a patient maintains grade II control without drugs and without complications for a year than he / she will be upgraded to P1 with instruction to be on follow up every 3 years by Endocrinologist / Senior Advisor (Med).

Remaining cases of impaired fasting and glucose tolerance (IFG & IGT) with obesity will be placed in P3 (T-

24) with instr to reduce to normal range of ideal body weight and subject to Oral GTT being normal will be upgraded to P1 otherwise will be disposed as above. However, if Impaired Fasting Glucose(IFG) & Impaired Glucose Tolerance(IGT) incl obesity persists then they will be placed in P3 (P).

**Non obese patients of IFG & IGT :** These patients will be observed in P2 (T-24) and following an Oral GTT (in normal limits) after 24 weeks can be upgraded to P1 otherwise they will continue to be in P2 (T-24). If glucose profile continue is unchanged after a year they will be placed in P2. (2).

### Hypertension

Besides emphasizing the importance of good control with / without medicines, diet, body weight and physical activity, tertiary prevention of hypertension involves extensive patient education about early recognition of likely complications which can be Ischaemic heart disease, Cerebro vascular accident, renal insufficiency, retinopathy etc. Management in case a complication occurs, will entail huge system specific rehabilitation.

In Armed Forces all individuals with high normal blood pressure without target organ, damage will be in SHAPE 1 but will be regularly followed up by AMA. All stage 1 hypertensives without target organ damage will be placed in P2(T-24) with final disposal in P2. Stage II & III hypertensives will be initially placed in P3 (T-24) following which those displaying well controlled hypertension with grade 2 retinopathy will be upgraded to P2 (T-24) and if blood pressure remains well controlled finally will be placed in P2.

All remaining patients will be observed initially in P3 (T-24) and those with well controlled Blood Pressure incl static complications finally will be placed in P2. Rest all patient will be invalided out.

Any up-gradation to P1 will be for patient showing good control without target organ damage without medicines for at least one year. This can only be done be by Senior Advisor (Med)/ Cardiology (3).

### Problems of high altitude

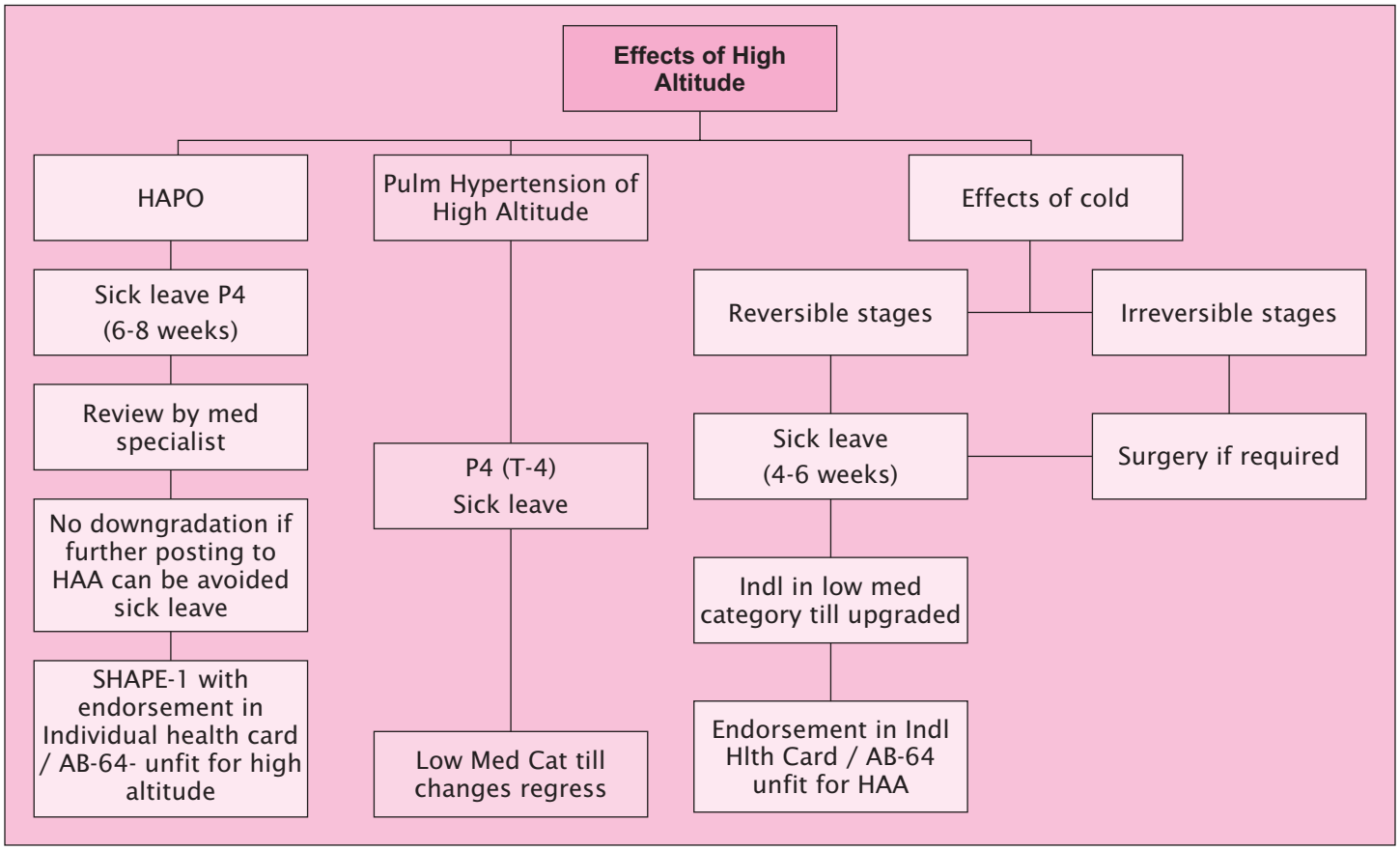
Tertiary prevention of HAPO has to take in account the possibility of recurrence in old patients of HAPO on subsequent reentry to High altitude (4).

In Armed Forces the patient is immediately brought to lower altitude so that other associated complications do not develop. Once an individual has recovered, then action in taken as per Table - 1.

### Ischaemic Heart Disease (IHD)

Disability limitation has a very imp role in IHD and an aggressive, active management of cases ensures that maximum possible individuals return to their normal duties. Armed Forces follow the protocol for tertiary prevention of IHD as given Table - 2. (5)

Table - 1



**Viral hepatitis**

Armed forces lay special emphasis on viral hepatitis especially water food borne viral hepatitis (Type A & E). All such cases are treated as indoor patients and after screening for other types of hepatitis are provided bed rest, High glucose, and low fat diet. Once the liver enzymes regress and there is improvement in general condition of patient, he is dispatched for four weeks of sick leave. Following the sick leave, if liver enzymes & general condition are found to be in normal ranges the patient is placed in low med cat for six months and is upgraded to SHAPE-1 provided liver condition is healthy otherwise low med cat continues.

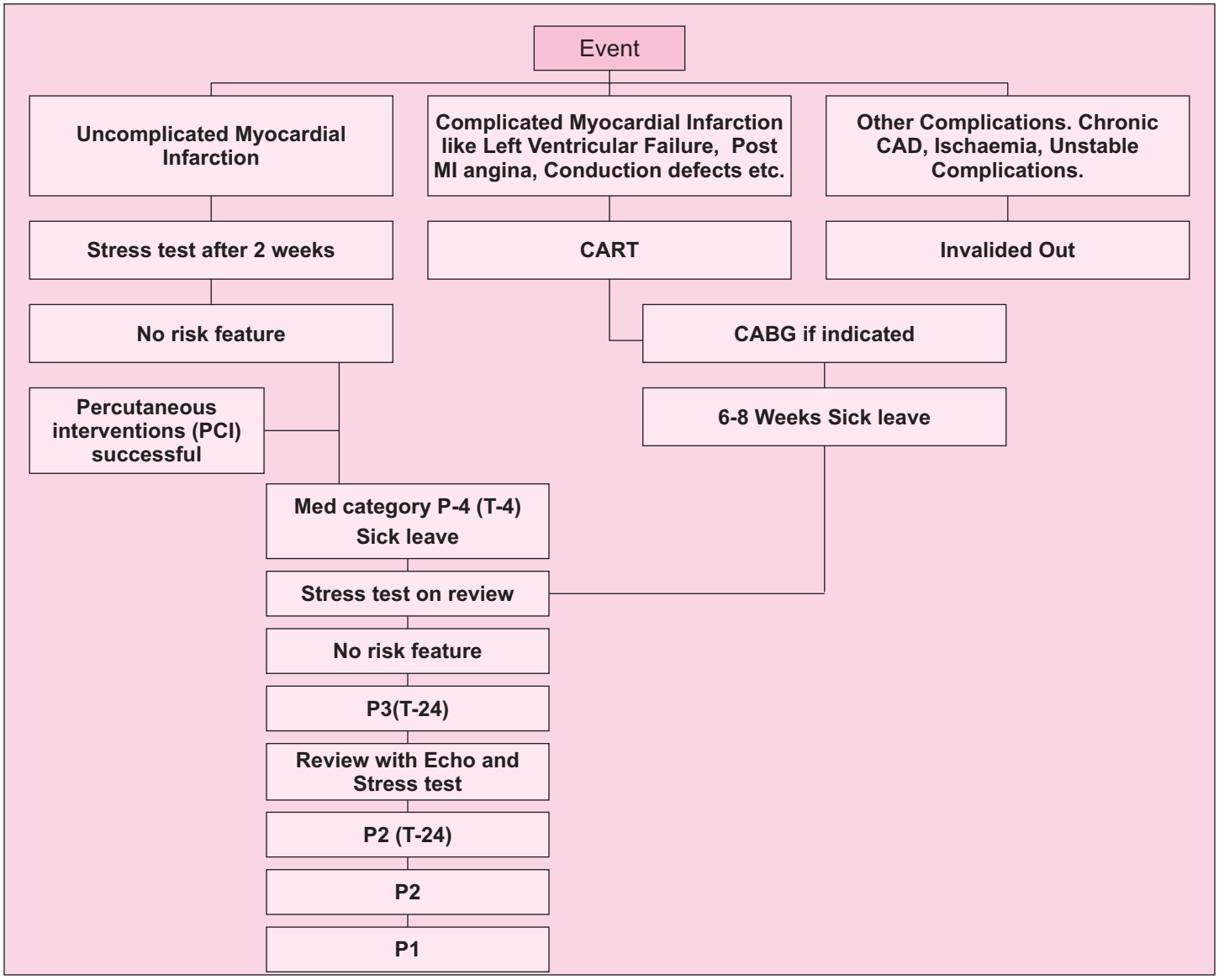
**Psychiatric disorders**

An entitled person would be referred for Psychiatric evaluation and care when he or she reports with symptoms which might be considered to be due to Psychiatric illnesses, by the authorised medical attendant, OC of unit, MCO, Military Police or Civil Police or even the relatives and friends of the individual. The examining Psychiatrist may ask for additional information, relevant backgrounds or circumstances suggesting the possibility of the illness in AFMSF – 10, from the OC of the unit.

All relevant history and clinical findings should be simply described by the AMA while referring the patient. AMA should also make possible efforts so that a person does not harm self or others. No patient will be held back from medical attention for want of AFMSF – 10.

All recovered cases of Psychotic disorders would be observed in temporary low medical category for 2 years/96 weeks with maintenance medication. Thereafter subject to satisfactory remission, they will be placed in medical category S2 permanent for 2 years without medication. At the end of this period, provided the clinical

Table - 2



condition is well stabilised and fresh AFMSF – 10 report is favourable, upgradation to S1 may be considered after review by Senior Adviser in Psychiatry.

Cases of bipolar/recurrent depressive disorders who require long term prophylactic therapy may be considered for retention in service in S2 permanent for longer periods on the recommendation of Senior Adviser (Psychiatry).

All cases recommended retention in service on account of their disease being unlikely to interfere in the performance of duty and in all instances of initial downgradation of medical category in S factor and upgradation to S1 for Officers would need to be concurred by Senior Adviser in Psychiatry. The medical board proceedings in such instances would be approved by DDMS Area/ Corps/Command for JCOs/OR and DGMS of respective service for Officers.

Individuals who are unlikely to be reasonably productive in the discharge of their duties on account of their illnesses would be invalided out of service. These would generally include cases of dementia, alcohol and drug dependence showing relapse, major Psychiatric disorders, neurotic and somatiform disorders, other mental disorders due to brain damage, dysfunction and physical disease which have taken a chronic course and are not responding well to treatment (6)

### Cancer

All medical officers must develop a strong sense of suspicion to the possibility of cancer and whenever suspected, must record a detailed history and conduct a thorough clinical examination of the patient. While transferring the patient, the medical officer should explain regarding the possibility of prolonged treatment in the oncology centre and arrange necessary administrative support.

The medical officers should constantly make efforts to educate the troops and families about cancer and try to dispel the widely prevalent myths regarding this disease. With the availability of highly advanced and modern methods of investigation and treatment in military hospitals, cancer could be detected at an early stage and treatment could help in remitting the disease and improving the quality of life of an individual.

All serving persons with cancer are placed in low medical category 2 or 3 in factor P with advice for follow up at regular intervals at the nearest service oncology centre. An individual who is incapable of discharging his/her duties effectively due to illness is recommended invalidment from service on medical grounds (7)

### Tuberculosis

All serving personnel suspected to be suffering from Pulmonary tuberculosis are hospitalised at authorised respiratory centres till the condition has stabilised and the patient is considered non-infectious. The patient is put in low medical category P3 temporary, till such time he/she is on medication, for a maximum duration of one year.

Once the patient is off-medication and minimum observation period of 24 weeks has been completed, he/she could be considered for upgradation to category P2 by medical specialist at the nearest service hospital.

All cases of pulmonary tuberculosis, where there are chances of drug resistance, are transferred to Military Hospital (Cardio thoracic Centre) Pune. Cases of multi drug resistant tuberculosis (combined resistance to rifampicin and isoniazid with or without resistance to any other drug) would be candidates for invalidment out of service. However patients showing clinical and radiological improvement and bacteriological quiescence within six months of start of anti TB treatment may be considered for retention in service at the advice of Senior Adviser in TB and Respiratory Disease or Consultant in Medicine.

Patients with single drug resistance or polyresistance (to more than one drug other than combined resistance to rifampicin and isoniazid) may be considered for retention in service (8)

### HIV/AIDS

A serving personnel found to be positive for HIV on ELISA/Rapid/Spot test at any testing centre is admitted and transferred to the nearest Immunodeficiency Centre with a diagnosis of Immunosurveillance (Inv). Their diagnosis is confirmed at this Centre based on three E/R/S tests using HIV kits with different antigens. In all indeterminate/discrepant HIV test results, the serum sample is tested by Western Blot/ Line Immunoassay.

The Immunodeficiency Centre confirming the diagnosis forwards a report regarding the positive test to AIDS Control Organisation in the Department of Community Medicine, AFMC, Office of DGAFMS/DG-3A and to the Commanding Officer of the individual by a confidential DO letter. The individual detected to be HIV positive is evaluated monthly by the Authorised Medical Attendant and advised yearly follow-up at the nearest Immunodeficiency Centre.

**Follow up** - In all newly diagnosed cases of HIV, the Immunodeficiency Centre prepares a HIV Surveillance Card (AFMSF 6B) in duplicate, of which one is kept with the individual and the copy is sent to ACO. The card records the follow up of the individual. When the individual is posted to a new unit, the records in the surveillance card is required to be monitored by the new AMA and the card would be presented by the individual at the time of follow up at MI Room or the nearest ID Centre.

Monthly and yearly follow up of HIV positive family members of a service personnel, whenever living with the family, is also carried out by the AMA and the local service hospital and all records maintained and notified to ACO. If the family member is not living with the service personnel, the latter will be counselled to get yearly follow up at the nearest civil HIV surveillance centre.

**Anti retroviral therapy** - The HIV persons on follow up, are put on Anti retroviral therapy on the basis of WHO criteria for initiating ART based on CD 4/8 counts, viral load and WHO stage of the disease. ART is provided to all service personnel, their families and to Ex-service pensioners under the ECHS.

**Medical Classification** – Asymptomatic HIV positive persons not on anti retroviral drugs are placed in low medical classification P2 (temp) for maximum 48 weeks with appropriate employability restrictions and regular monitoring of CD 4 counts or total lymphocyte counts. Those who are put on ART are placed in low medical classification P3 (temp) with employability restrictions for a period of one year, and thereafter they are placed in classification P3, if the CD4 count is above 200 or total lymphocyte count is above 1200 cells/cu mm and disease stage corresponds to WHO stage I, II or III. If the CD4 or lymphocyte counts are below this limit, and individual shows unsatisfactory response to therapy, he/she is considered for invalidment.

**Invalidment** – The guiding factor for invalidment is functional disability of the individual. However, disabling manifestations of the disease corresponding to WHO stage IV who have shown unsatisfactory response to therapy, such as HIV wasting syndrome, disabling neurological/psychiatric illness, disseminated tuberculosis, malignancies are considered for invalidment (9)

### Sexually transmitted diseases

All suspected cases of Sexually Transmitted Diseases (STDs) are to be referred for further management at the nearest STD Treatment Centre (STDTC). At the STD Centre, an etiological diagnosis is made after relevant investigations and AFMSF-18 (reporting of an STD case) is raised and dispatched to the Centre Disease Registry at AFMC, Pune for allotment of CDR Number. Simultaneously, AFMSF-6 (STD Treatment & Surveillance Card) is also raised in duplicate documenting the history, examination findings, investigations and treatment given. At discharge, the patient is placed on STD Surveillance and instructions for the given in AFMSF-6. The Original AFMSF-6 is dispatched to the patient's unit and duplicate retained at the original STDTC.

Surveillance protocol in various STDs :

(a) **Syphilis** : The patient is placed on 30 months STD surveillance with investigations as under :

(i) VDRL at 3, 6, 9, 12, 18, 24 & 30 months.

(ii) HIV antibodies at 3 & 6 months. 10

(iii) CSF studies (VDRL, Cytology and Biochemistry) at 6 & 30 months

FTC (Final Test of Cure) certificate is issued at 30 months, if all relevant investigations are normal.

(b) **Gonorrhoea** : The patient is placed on 06 months STD surveillance as under :

(i) VDRL at 3 & 6 months.

(ii) HIV antibodies at 3 & 6 months.

(iii) Urine 2 Glass test at 3 months.

(iv) Prostatic massage & smear at 3 months.

FTC certificate is issued at 6 months.

(c) **Chancroid and all other STDs** : The patient is placed on 6 months STD Surveillance as under :

(i) VDRL at 3 & 6 months.

(ii) HIV antibodies at 3 & 6 months.

FTC certificate is issued at 6 months.

The STD Surveillance Card (AFMSF-6) is held with the unit, preferably under the care of the RMO and it is the Unit's responsibility to direct the individual for periodical tests as advised and completion of STD surveillance.

On completion of FTC at the nearest STDTC, the AFMSF-6 (Original copy) is dispatched to the original STDTC, where the AFMSF-6 (both copies) is closed, dispatched to the individual's Record office and CDR informed.

If the original STDTC does not get intimation of an individual's completion of STD Surveillance as per the records held by them, they issue a Tracing Proforma (TP) to the individual's unit to direct the individual to report to the nearest STDTC for completion of STD Surveillance.

If the individual does not report for STD surveillance for 5 years from the date of FTC, his AFMSF-6 will be closed and dispatched to his Record office.

If the individual is proceeding on release during the period of surveillance, he has to be given pre-release treatment for syphilis and his AFMSF-6 closed and dispatched to his Record office (10)

It the individual is proceeding on release during the period of surveillance, he has to be given pre-released treatment for Syphillis and his AFMSF-6 closed and despatched to his record office.

## References


1. K Park. Park's Textbook of Preventive & Social Medicine, 18th edn, p 37 - 38. M/s Banarasi Das Bhanot, 1167, Prem Nagar, Jabalpur – 482001.
2. DGAFMS Medical Memorandum No 160, on Diabetes mellitus, issued in 2002 pages 11-13.
3. DGAFMS medical memorandum No 151, on Essential Hypertension, issued in 2002, page No 06.
4. DGAFMS Medical Memorandum No 140, on Problems of High Altitude, issued in July 1997, pages 14, 18, 27.
5. DGAFMS medical memorandum No 150, on Ischaemic Heart Disease (IHD) (Coronary Heart Disease), pages 11-14.
6. DGAFMS medical memorandum No 171, on Reference for Psychiatric Examination, Diagnosis, Treatment and Disposal of Service Personnel and their families suffering from Psychiatric Disorders, issued in 2002.
7. DGAFMS medical memorandum No 157, on Early Detection of Cancer, issued in 2002.
8. DGAFMS medical memorandum No 167, on Tuberculosis – Diagnosis and Treatment, issued in Sep 2002.
9. Office of DGAFMS letter No 5496/HIV Policy/DGAFMS/DG3A dated 23 May 2003 regarding Guidelines for Management and Prevention of HIV/AIDS in the Armed Forces.
10. DGAFMS medical memorandum No.114, on Sexually Transmitted Diseases, issued in 1998.

Col LS Vaz

# Medical Examinations, Medical Boards and Medical Documents : Policies and Procedures

The objective of Medical Examination is to detect disease at an early state when it may be latent (without producing any ill effect) and institute timely preventive and curative measures promoting positive health. It is, thus, the individual who is responsible to get his/her medical examination (ME) carried out. ME will only be carried out by the Authorised Medical Attendant (AMA) of the unit. A MO will be deputed by CO of the hospital for annual medical examinations of officers upto 55 years of age. After 55 years of age, AME will be carried out by a Medical Specialist deputed by the CO of the hospital. For routine investigations and treatment, the individual will be dependent on the nearest field ambulance/hospital.

### Initial Medical Examination

Initial medical examination on AFMSF – 2 will be conducted for the following :

(a) The medical examination of candidates for commission in the Armed Forces and for admission into the Rashtriya Indian Military College, Dehradun as cadets will be conducted by a medical board.

(b) Recruits for the Armed Forces will be examined by a Medical Officer of the Armed Forces in accordance with current standards of physical fitness and findings. Recruiting officers are responsible for the measurements, apparent age, intelligence and mental suitability of the candidates selected by them. Medical Officers are responsible for the health, physical fitness for service, likely extent of development and identification marks.

(c) Short service Officers applying for permanent commission

(d) Candidates for admission to NDA, IMA, AFMC, schools for probationer Nurses and Engineering cadets of various Armed Forces Institutes.

### Medical boards

Medical Boards will be held on candidates for commission in the Armed Forces, officers selected for Permanent Regular Commissions and on Armed Forces personnel in the following circumstances :

(a) Officers/Cadets of the Armed Forces recommended sick leave and on return there-from and officers recommended change of climate on medical grounds.

(b) Officers on the expiry of a period of six months spent continuously in hospital.

(c) All ranks of the Armed Forces considered unfit for further service or claiming a disability pension or gratuity.

(d) All ranks of the Armed Forces, who are to be placed in lower medical category.

(e) All ranks of the Armed Forces permanently placed in a low medical category who are proposed to be discharged, because no suitable employment compatible with their low medical category can be found for them.

(f) Officers/Cadets of the Armed Forces for upgrading their medical category.

(g) Individuals placed permanently in a low medical category applying for a fresh medical board.

(h) Persons (before the age of superannuation) serving under Civil Service Regulations, proposed for invaliding from service or claiming pension.

(j) Candidates for admission to the National Defence Academy, Indian Military Academy, Rashtriya Indian Military College, AFMC, and Schools for Probationer Nurses.

(k) All pensioners and ex - service personnel for assessment/reassessment of the percentage of their disability.

(l) In such other cases as may be ordered by service HQ.

Medical Boards will ordinarily be composed of a President and two members. If this number is not available, a board may consist of two medical officers only. The President of the Medical Board will ordinarily be of the rank of Major or above or equivalent rank of the Navy or Air Force. The medical officer in charge of a patient or who gives a specialist opinion on the case will not, as far as possible be a member of the Board which considers it, and in no instance may act as President of the board.

### Annual Medical Examination (AME)

A complete clinical examination and investigations as per AO 1/2004 and as considered necessary by the Authorised Medical Attendant (AMA) will be carried out for officers. The details and findings including medical advice, if any, will be entered in the officer's Health Record Card (HRC) for Officers below 35 years of age, while for those above 35 years, AFMSF - 3B will be filled up, in addition to HRC. In case during the AME, the AMA finds that the officer requires specialized investigations / treatment, reference will be made to the nearest hospital where such medical facilities are available. The AMA will suitably advise the officer, if a minor disability is noted during ME and record it on AFMSF - 3B/HRC para 4, 6 and 7.

The dates of AME and Annual Confidential Report (ACR) have been delinked in case of all officers. Medical classification recorded in AME immediately preceding the ACR will remain valid unless, due to disease or injury during the interim period, it has been changed by

appropriate Medical Categorisation Board.

AME for JCOs/OR will be carried out once a year, two months before the initiation of ACR and in the months of Mar to Jun for those individuals for whom there is no ACR. A complete medical examination and relevant investigations as considered necessary by the AMA will be carried out. Body weight will be checked as per age, height and weight chart. The details of findings including medical advice, if any, will be entered in the individual's health record card. Urine for sugar and proteins will be carried out for OR at the time of AME during 26th year of age, 36th year and thereafter every five years. For JCOs this should be carried out every year.

## Periodic Medical Examination (PME)/Periodic Medical Board (PMB)

The aim of carrying out PME is to ensure an individual is periodically examined in detail by all relevant specialists for early detection and cure of any disease. The PME will be recorded in AFMSF - 3A and the individual will be brought before a medical board. The composition of Medical Board will be as per para 419 of RMSAF – 1983.

AMA and OC/Comdt of nearest service hospital will provide necessary guidance to the officers for PME. The officers are required to be examined by all the specialists including Dental, Eye and ENT. The lady officers will be examined by Gynaecologist. USG of abdomen will be carried out for ladies. Findings of the PME are to be noted in AFMSF - 3A. It is the responsibility of the officer as well as the CO of the unit to which he/she is posted to ensure that the PMB is held on time when due. However, if for any reason the officer fails to undergo PME during scheduled time, he/she will take up a case for delayed PME. Dispensation shall be based on the merits of the case. Any deliberate omissions shall be administratively dealt with. All the periodic Medical Boards shall be approved and perused by the Medical Authorities.

An age - wise schedule and venue of PME is given at Appendix 'A' to AO 1/2004. It shall be mandatory for an officer to undergo Periodic Medical Board (PMB) at the prescribed age, ie, during 36th, 41st, 46th, 51st, 54th, and 58th year of age. Officers who are abroad during the schedule of PMB, will undergo the same within three months of arrival in India. No sanction will be required for the same.

The PMB as well as all Medical examination / boards will be held at the duty station of the officer, if a service hospital with requisite facilities is located at the station. Otherwise, it will be carried out at the nearest station where such facilities exist

Periodic medical board will be held for JCOs during 41st year of age i. e. on completion of 40 years of age or within 1 year of promotion to the Rank of Nb Sub, whichever is earlier at the nearest hospital. The board proceedings will be recorded on AFMSF - 3A and will be approved by ADMS Div/DDMS Area/Corps.

## Medical classification

The Army has a unique system of medical classification which is based on functional capacity of individual to perform military duties with a view to enable better cadre management especially of LMC individuals as regard their treatment, employment, promotion and financial emoluments. The SHAPE classification is based on fitness includes following five factors :

(a) **'S' Factors (Psychological)** : This factor denotes psychological aspect and covers personality, mental acuity, emotional stability and psychiatric disease.

(b) **'H' Factor (Hearing) :** This factor covers auditory ability to hear spoken voice or audible signals often against considerable back ground noise and its important in certain trades and Military situations.

(c) **'A' Factor (Appendages)** : This covers the functional efficiency of upper and lower limbs (including amputees, loss of fingers and toes), shoulder girdle, pelvic girdle and associated joints and muscles

(d) **'P' Factor (Physical Capacity)** : This covers general physical capacity or stamina as may be affected by medical/surgical conditions not covered by other factors.

(e) **'E' Factor (Eye sight) :** This covers visual acuity and good eye sight.

Classification is further divided into 5 Grades based on functional capability of the individual. The grades are as under

**IA** Fit for all duties anywhere

**IB** Fit for all duties anywhere, under medical observation and has no employability restrictions. Disabilities for which an officer needs to be placed in SHAPE 1B are asymptomatic dyslipidemia, asymptomatic hyperuricemia, impaired glucose tolerance, simple obesity, asymptomatic ECG abnormality, supraventricular or ventricular ectopics, cervical spondylosis, low backache, cholelithiasis, benign prostate hyperplasis, varicose veins, cataract (operated) with corrected vision upto 6/9 both eyes and fracture of non weight bearing bones / sprains / stress fractures

**2** Fit for all duties but may have limitations as to type of duties and areas of employability.

**3** Except 'S' factors, fit for routine or sedentary duties but may have limitations of employability as spelt out in the Employment Management Index

**4** Temporarily unfit for Military duties on account of hospitalization /sick leave

**5** Permanently unfit for Military duties.

To ensure that administrators are properly guided about utilization of officers who have been downgraded in medical category an employment management index has been formalized. Medical board may add medical advice in various cases as thought necessary by it. This also permits low med cat officers to be posted to locations where their disease will not be aggravated due to service conditions. Employment management index which are recommended

are as follows :

(a) **F 1A** : Fit for military duties anywhere.

(b) **F1B** : Fit for military duties anywhere, under medical observation and has no employability restrictions.

(c) **F2** : Fit for military duties anywhere. However at the discretion of Medical board may state :

(i) Unfit for posting to HAA (above 2700 meters) OR

(ii) Places that have sub - zero temperature for more than three months in a year.

(d) **F3** : Fit for normal military duties with restrictions as advised by medical authorities.

(e) **F4 :** Fit for normal military duties not involving strenuous exertions.

(f) **F5** : Unfit for military duties.

If AMA is of the view that the existing medical classification of an individual needs to be changed, he/she will refer the officer to appropriate specialist in that discipline. After clinical examination and investigations, the concerned specialist will write his/her opinion and recommendations about the medical classification of the officer on AFMSF - 15 and request CO of the hospital for holding Medical Board.

The individual will be communicated about the disability and medical classification awarded. It will be explained to him/her that it is subject to approval from higher medical authorities. The medical classification awarded to the officer will be communicated to the officers' unit by the approving/perusing authority at the earliest but not later than thirty days from the date of holding the board.

While placing an officer in a classification below SHAPE – I, Medical Board must clearly state in the Board proceedings whether or not the disease / disability of the officer is attributable to service and will also bring out aggravation, if any. In formulating opinion about attributability or non – attributability, all medical officers comprising the Medical Boards and the approving authorities must follow the guidelines given in the publication "Guide To Medical Officers (Military Pensions) 2002".

In case one or more factors of the medical classification is required to be lowered temporarily on account of disablement, the grade assessed should be that from which no further deterioration is expected.

Temporary classification in any grade factor will be permissible for a maximum period of 24 weeks. Then the officer will be upgraded/downgraded/placed in Permanent LMC in the same grade factor depending on the clinical response. Opinions given by Specialist officers for classification/ reclassification purposes will be valid for a period of three months. If an officer requires observation beyond the permissible period, he/she will be placed in permanent LMC, except in "S" factor where provisions of para 36 of AO 1/2004 will be applicable.

All personnel in 'S3' factor can be observed on a temporary basis for a maximum period of 48 weeks. He/She will not be placed in S3 permanent. In case, after 48 weeks, the officer cannot be upgraded to S2 temporary, he/she will be downgraded to S5.

There are certain diseases or group of diseases which are not amenable to short term therapy or quick cure. Some such diseases are, viz, Ischemic Heart Diseases, Hypertension, Diabetes Mellitus, Peptic Ulcer and Malignant diseases. Medical experience has shown that a large number of officers suffering from these diseases require prolonged medical treatment and surveillance. It is thus appropriate for officers placed in temporary LMC P3 for diseases such as above, to be placed in appropriate permanent LMC (P2 or P3) after the initial observation of 24 weeks depending on their clinical condition.

Classification med boards of PBOR does not require approval (RMSAF 425 (a) (v)). Classification boards of officers (other than S Category) are to be approved by CO Hospital. Medical boards of officers placed in 'S' category are to be approved in Office of DGMS (Army). Upgradation of IHD and Malignant cases are to be approved by DGMS (Army).

### Follow up LMC Personnel

All LMC individuals are required to be followed up and may require specialist care and change of treatment from time to time. Follow up system for LMC individuals will be as follows :

(a) The AMA will maintain a register for all LMC personnel on posted strength of the Unit. Necessary information will be obtained from the unit HQ. Units who have no RMO, will forward the names of the LMC individuals to the Staff Surgeon/MO i/c, Central MI Room to enable the AMA to maintain the requisite register.

(b) The AMA will call such individuals for examination and enter their personal particulars, nature of disability, medical category and date of the next review in a register and also any investigation, treatment or any follow up action required to be taken. All LMC individual are to be seen by the AMA at least once a month and cases may be referred to the concerned Specialist, if required.

(c) Necessary investigations will be carried out well in advance of the date of the next Medical Board and Specialist opinion obtained in time.

(d) When an individual in LMC is posted out from a unit, all medical documents will be forwarded by the Officer Commanding, Unit to the next unit with a request that these documents be handed over to the RMO/AMA of the new unit.

(e) A similar system as above will be followed for officers who are observed in SHAPE - 1B.

When an individual is placed in a classification lower then SHAPE - 1, whether temporary or permanent, it is obligatory for him/her to appear before a Reclassification Medical Board on due date. It will be ensured by the OC Unit of the indl that if Reclassification Medical Board of an individual is due, he/She will not be sent on annual leave/long casual leave and will be detailed on a course

only after taking prior permission for postponing the Medical Board from DDMS Corps/Area well in advance. OC unit will forward a Statement of the Case whenever delay in holding Reclassification Medical Board is anticipated by more than two weeks from the due date. Permission will be obtained for holding Reclassification Medical Board at the next station, if indl is to be attached on a long course.

Whenever an officer is in Permanent LMC for two or more disabilities and where the Reclassification Medical Boards are due for different disabilities within 12 weeks of each other, the officer will be assessed for both the disabilities simultaneously and awarded the necessary classification. This will be done with review of the classification for the disability which falls earlier. Where an officer, already in LMC, develops another disablement within 12 weeks of being reviewed for the former, he/she may be recommended observation for the second disability for a period proportionate to the unexpired period of the former disability, so that he/she can be reviewed simultaneously for both the disabilities during net review.

Posting/job assignment by Military Secretary's Branch of Low Medical Category officers will be guided by a matrix based on

(a) Medical Advice as given in Medical Board Proceedings.

(b) Job content

(c) Endorsement in the ACR as given by IO/RO/SRO regarding officer's demonstrated physical capacity.

Where sick leave has been recommended by the Medical Board to an officer, the approval will be accorded as under :

(a) Upto six weeks - No approval is required.

(b) More that six weeks - DDMS Command except where the Medical Board is held at AH, Delhi Cantt, when Approving Authority will be the Commandant, Army Hospital.

(c) 2nd spell of Sick Leave - Will be approved by DGMS (Army)

An officer who is not satisfied with the opinion of a Medical Board may submit a representation against the findings of the Board to the CO, medical unit, where the Board was held. This appeal will be submitted within one week of the Medical Board being held. A copy of the appeal will be sent directly to DGMS (Army) - 5A. Copies of the appeal will also be sent to the ADMS Div/DDsMS Area/Corps/Command simultaneously.

Early review of low medical classification

For individuals placed in temporary Low Medical Classification (LMC), it is obligatory to appear before the Re - classification Medical Board at the stipulated time and venue as given in the previous Medical board proceedings. In case of permanent low med classification, the individual will be reviewed after two years. However, for officers early review can be asked at any time if the Authorised Medical Attendant (AMA) certifies that the officer's condition has improved materially. The requisite application will be recommended by the OC unit certifying the performance of the officers and will be forwarded through the immediate superior formation Commander to DDsMS Corps/Area/Command for granting an early review. The competent authority to grant such a review will be MG (Med) Command. In case of PBOR review of permt category is permitted only after one year with requisite certificates from AMA. The competent authority for grant of such review is ADMS Div/DDMS Corps.

Condonation of Delay

Officers should undergo AME/PME as per schedule given in Appx 'A' to AO 1/2004/DGMS. If an officer fails to undergo AME during the schedule period of Apr to Sep and Oct to Mar he/she will take up case for delayed AME. In case he/she has not undergone AME for the year he/she will seek dispension of AME for the year and will undergo AME/PME for the next year. The authority for sanctioning delayed AME/PME is the respective formation commander and for the officers posted at Delhi the competent authority is MP Branch. Detailed guidelines are mentioned in letter No 76086/DGMS - 5A dt 16 Sep 2004.

If an officer fails to report for recategorisation when due, condonation of delay can be asked from MG (Med) Command. The offr concerned will fwd a Statement of case duly recommended by his CO and Fmn Cdr to medical authorities. In case of lapse by officer requisite counseling/administrative action will be taken.

Condonation of delay in undergoing AME/PME and Re - cat med board of PBOR will be carried out by Fmn Cdrs. Units will fwd statement of case through administrative channels for obtaining requisite sanctions. Guidelines for the same are contained in DGMS letter No 76086/DGMS - 5A dt 11 Feb 2005.

**Obesity**

During AME/PME the AMA will check height and weight of individual and also carry out requisite investigations. Guidelines for disposal of over - weight officers are as follows :

(a) If body weight is more than 10% but less than 20% over and above the Ideal Body Weight (IBW) and the individual has no symptoms/signs of any diseases and no abnormality is detected after investigation, the individual will be advised in writing to reduce body weight to within 10% over and above his IBW within 10 weeks for officers and 12 weeks for PBOR, with copies to his CO and SEMO. If the individual fails to reduce his/her weight to the acceptable level even after the specified period he/she will be down graded to Medical Classification P2(T - 24).

(b) If the body weight is in excess of the IBW by more than 20%, investigations will be carried out to exclude any metabolic abnormality. If no abnormality is detected the PBOR will be placed in category P2 (T - 24). In case of officer he/she will be disposed of as under :

(i) If the officer has no metabolic abnormality

and ECG is normal, The medical specialist should decide whether over weight is due to obesity or due to increased muscle, mass/bone thickness by measuring the following parameters :

- Body Mass Index (BMI) = Normal range : 20 - 25 A person is definitely obese if it is more that 27.
- Waist and Hip ratio :Normal range – 0. 6 to 0. 9. A person has definite central obesity if it is more than 0. 9.
- Skin fold thickness measurement with the help of caliper.
  - Normal range of Tricep skin fold – 12 - 15 mm.
  - Normal range of sub scapular skin fold - 18 - 20 mm.

(c) All the above measurements will decidedly determine whether over weight is due to obesity or due to increased muscle mass/bone thickness. If the over weight is due to obesity, the officer should be down graded to Medical Classification P2 (T - 24).

(d) Individual downgraded for obesity will have no restrictions of employment.

**Management of Individuals in LMC for Alcohol Dependence / drug abuse**

Alcohol Dependence and Drug Abuse are incompatible with Military Service/ethos and all such cases should be invalided out of service unless they show an unequivocal determination to give up the use of Alcohol/Drug for good in the shortest time span. There is a well laid down procedure for disposal of such cases, which has been mentioned in revised DGAFMS memorandum No 111.

**Army Aviators**

On completion of the medical examination, the medical classification in respect of Army Aviators will be indicated as follows :

(a) SHAPE – 1 FLYING FIT

(b) SHAPE – 1 AND FLYING UNFIT

(c) SHAPE – 1 AND FLYING RESTRICTED* "Flying restricted" status will not be acceptable for initial entry into Army Aviation.

AME in respect of Army Aviators will be carried out on the scheduled time as per AO 1/2004/DGMS by medical officers trained in Aviation Medicine. In case aviation trained medical officers is not present in the station the Army Aviator may be directed to the SMO of the nearest AF Wing (Flying station).

(a) If any Army Aviator is declared as 'Flying unfit' at the time of AME it will be recorded on AFMSF 15 and his category will be down graded to ensure that the officer is not allowed to resume flying duties.

(b) AME which is scheduled to be held at MH on the specified age will be carried out as in vogue, which is in addition, to that conducted by a specialist in aviation medicine.

(c) ECG during AME will be carried out on alternate years up to 30 years of age and there after it will be carried out each year. TMT (Max) will be carried out on all air crew provided no medical contraindication exists at the age of 40 and every five years thereafter.

Army Aviators will acclimatize for high altitude area for a minimum period of 36 hours before under taking flying in high altitude area. After 36 hours of acclimatization, Army Aviators will be cleared for flying by the MO of the Aviation unit. A record of such medical examination and clearance for flying will be maintained by the concerned medical authority as well as the Aviation unit. Similarly a post flight check will be conducted on return from the high altitude area and a record will be maintained.

**Special Medical Examinations**

All ranks of the Armed Forces including civilians employed therein will be medically examined by a medical officer on the following occasions :

(a) Prior to proceeding on active service.

(b) Prior to release, retirement, discharge or dismissal, re - employment, except in the case of civilians.

(c) To assess physical fitness for special duty.

(d) Prior to being tried by a Court Martial or when committed to prison.

(e) To take up a policy with LIC at stations where there are no civil doctors.

(f) Other occasions when medical examination is considered necessary.

JCOs and OR of the Army and their equivalents in the Navy and Air Force will also be examined on occasions mentioned below

(a) Prior to their re - mustering/change of branch/trade when a higher medical standard is required.

(b) Prior to regular engagement/reengagement or extension of the term of engagement.

(c) On transfer from one unit to another (Medical inspection only)

(d) When proceeding to or returning from leave (Medical inspection only)

Personnel before proceeding to HAA on permanent posting will be subjected to ME to detect any disease/disability which might be aggravated in HAA. Similarly, Personnel will be subjected to ME within two months of their return from HAA. Their medical examination will be carried out by AMA and record maintained in HRC.

**Unscheduled Medical Examination**

Any officer wishing to have a medical examination at anytime of the year may request for such an examination at his/her convenience not more than once in a year, provided he is not asking for review of his/her disease/disability for which he/she is downgraded to low medical category temporarily. Permanently placed low medical category officers can ask for a review at any time, if the AMA certifies that the officers' condition has improved materially.

#### Medical Examination – Individuals Proceeding Abroad

All ranks and families proceeding abroad at Government expense on duty/deputation/study leave or any other form of official duty will on all cases be examined by the authorized medical attendant and obtain a certificate of medical fitness. When a body of men are moving overseas, findings of the medical examination will be recorded on a nominal roll in the case of officers and in AB - 64 in the case of JCOs and OR. Within a week of return from overseas, similar medical examination will be carried out of all service personnel

### Release Medical Examination / Board

All ranks are required to be medically examined by a medical officer prior to release, retirement, discharge, completion of tenure or service limit or release/discharge at their own request vide paras 391 (a) and 418 (e) of RMSAF, 1983. Such medical examination will be conducted by the authorized medical attendant (RMO/Staff surgeon) and the report will be recorded on the form AFMSF - 18 in quadruplicate. The OC unit will ensure that the individual is medically examined by the medical officer or brought before a medical board prior to release. If an individual is proceeding on Leave Pending Release this may be conducted before he proceeds on such leave. The individuals who are in SHAPE - 1 will be required to undergo only a Release Medical Examination.

In the event of the individual being in low medical category or any disability being found, or claimed by the individual at the time of release, he will be brought before a medical board well in time so that the board proceedings are completed prior to his release from service. A Release Medical Board can be held, in advance by eight months to the date of release from service. The proceedings of the medical board will be recorded on form AFMSF - 16. The medical board will also render a certificate in the prescribed proforma to be attached with the AFMSF - 16 (for those released in low medical category), making an annotation about the individual's longevity, which will be accepted by competent authority for the purpose of commutation of pension.

The Release Medical Examination Report (AFMSF - 18) in respect of personnel released in medical category SHAPE - 1 do not require approval by ADMS concerned and will be disposed of directly by the OC unit of the individual. A Release Medical Examination can be held in advance by eight month from the date of release from service.

Release Medical Board Proceedings (AFMSF - 16) in respect of personnel released in low medical category will however, be approved by the ADMS/DDMS of the Area / Div / Corps / Command, who will in turn forward the medical board proceedings to MG (Med) Command for approval /confirmation and disposal. One copy of Release medical Examination (AFMSF - 18) will be given to individual by the authorized medical attendant to be attached with his application for commutation. In case of individuals released in low medical category, an extract of board proceedings and also of the annotation made by the Release Medical Board about the individual's longevity will also be given to him. He can attach this when he applies for commutation of pension to CDA (Pension).

### Attributability / Aggravation

Before an award can be made for a disability or death claimed to be related to service, a causal connection between disability or death and military service has to be established by evidence.

Disablement or death shall be accepted as due to military service provided it is certified by appropriate medical authority that :

(a) The disablement/death is due to a wound, injury or disease which :
  (i) Is attributable to military service, or
  (ii) Existed before or arose during military service and has been and remains aggravated thereby. This will also include the precipitating/hastening of the onset of a disability.

Attributability / aggravation shall be conceded if causal connection between death/disablement and military service is certified by appropriate medical authority. In respect of diseases, the following rules will be observed

(a) For acceptance of a disease as attributable to military service, the following two conditions must be satisfied simultaneously.
  (i) That the disease has arisen during the period of military service
  (ii) That the disease has been caused by the conditions of employment in military service.

(b) If medical authority holds, for reasons to be stated, that the diseases although present at the time of enrolment could not have been detected on medical examination prior to acceptance for service, the disease, will not be deemed to have arisen during service. In case where it is established that the conditions of military service did not contribute to the onset or adversely affect the course of disease, entitlement for causal pensionary award will not be conceded, even if the disease has arisen during service.

(c) Cases in which it is established that conditions of military service did not determine or contribute to the onset of the disease but influenced the subsequent course of the disease, will fall for acceptance on the basis of aggravation.

(d) In case of congenital, hereditary, degenerative and constitutional diseases which are detected after

the individual has joined service, entitlement to disability pension shall not be conceded unless it is clearly established that the course of such disease was adversely affected due to factors related to conditions of military service.

If it is established that the disability was not caused by service, attributability shall not be conceded. However if service conditions result in worsening of the disease aggravation by service is to be accepted unless any worsening in his condition was not due to his service or worsening did no persist on the date of discharge/claim.

The onset and progress of some diseases are affected by environment factors related to service conditions, dietic compulsions, exposure to noise, physical and mental stress and strain. Disease due to infection arising in service, will merit an entitlement of attributability. The diseases affected by environmental factors in service is as follows :

(a) Diseases known to be affected by exposure to weather like Bronchitis, Rheumatism and Nephritis

(b) Diseases know to be affected by stress and strain of service.

(c) Disease endemic to certain areas like Malaria, Kalazar, Filariasis, Dysentery, Cholera.

(d) Diseases due to infections in service.

(e) Disease known to be affected by dietary compulsions like Gastritis, Gastric and Duodenal Ulcers.

(f) Diseases know to be affected by service in the submarine arm of the Navy.

(g) Diseases which run their course independently of external circumstances like Malignant disease, cancer etc.

(h) Sexually transmitted diseases are not accepted as attributable to/aggravated by service.

**Injuries**

In respect of accidents or injuries the following rules shall be observed :

(a) Injuries sustained when the man in "on duty" as defined, shall be deemed to have resulted from military service, but in cases of injuries due to serious negligence/misconduct the question of reducing the disability pension will be considered.

(b) In cases of self inflicted injuries whilst on duty, attributability shall not be conceded unless it is established that service factors were responsible for such action; in cases where attributability is conceded, the question of grant of disability pension at full or at reduced rate will be considered.

(c) In all injury cases, Board should ask for injury report (IAFY - 2006) and Court of Inquiry proceedings. While deciding attributability, Board should rely on directions of Fmn Cdr given on Injury Report and findings of Court of Inquiry.

(d) In cases where there is no record in official documents or other verification, date, place, circumstances etc should be carefully recorded in the individual's statement and board should say whether the disability claimed resulted from the injury. They should leave the question of entitlement open for decision by Pension Sanctioning Authority.

Right to appeal

Where entitlement is denied by the Pension sanctioning authority on initial consideration of the claim, the claimant has a right of appeal against decision on entitlement and assessment. For decision on entitlement all concerned authorities have to give opinion. Assessment of degree of disablement is entirely a matter of medical judgement and is responsibility of medical authorities.

## Medical Case Documents

**Non fatal cases**

Presently all medical documents are being dealt with as per procedures laid down in paras 79 (b), 94, 95, 96, 422 and 760 of RMSAF 1983 and the relevant regulations laid down for Navy and Air Force.

The consumer protection act (CPA) 1986 provides for the legal right of the patient to be informed about the quality, quantity, potency, purity and standard of services provided to the consumer. Further the Right to Information Act also provides for right to medical information.

The policy to be followed by all medical establishments in the Armed Forces will be as under :

(a) Various provisions in the RMSAF - 83 relating to handing over of medical documents to patients/NOKs will continue to be enforced as hitherto. However medical documents can be produced in a court of law under the instructions of competent legal authorities.

(b) Patients/NOKs will be informed verbally about the medical status and management of a case on a daily basis, particularly when a request is made. A Medical summary of the case alongwith results of investigations undertaken and treatment provided will be handed over to the patients/NOKs in addition to the info being endorsed on the discharge slip, as and when requested by the patients/NOKs. This is aimed at satisfying the needs of the patients/NOKs as well as facilitate subsequent management at a different medical facility. The fact that a summary has been handed over to the patient/NOK will be prominently endorsed on the case sheet.

On transfer of a patient from one hospital to another, the medical case sheets and connected medical documents pertaining to the case will be handed over to the patient, or an attendant, if detailed, to accompany the patient, in a sealed envelope, for delivering them to the receiving hospital. Before sending the documents, OC of the forwarding hospital will satisfy himself that the documents are up - to - date and the word "TRANSFERRED"

is inserted in the columns provided for in the medical case sheets, admission card, Field Medical card and clinical chart.

Medical case sheets of all non - fatal cases of professional interest particularly those relating to disease which the OC hospital considers as uncommon, may be submitted to Office of DGMS in the first Instance before final disposal as instructed in 23 above. These cases should be sent through the same channel as laid down for submission of Original fatal case documents and must be perused by the Adviser concerned and the Adviser in Pathology for their comments, which should be recorded on separate sheets of paper

In all other cases medical case sheets and connected hosp documents will be disposed off to AG/Org9/MPRS(O) in case of officers and Records concerned in case of PBOR. Documents of families are to be retained by OC hosp and destroyed as per ruling laid down.

**Fatal case documents**

The responsibility of preparing and processing the fatal case documents is of the hospital where the death occurs irrespective of the fact whether the patient was originally admitted there or received as a sick transfer from another hospital. If, however, a patient died enroute during sick transfer, he will be taken to the nearest service hospital, who will accept him as a Found Dead case and, after carrying he Postmortem/histopathological examination, (if required), will complete fatal case documents and process them in accordance with the instructions contained in this lesson.

Fatal case documents will be prepared in duplicate as follows :

(a) Original set will comprise of hand written medical case sheets. Investigation forms and other relevant documents.

(b) Duplicate set will comprise of typed copies of all the documents of the original set.

Only original fatal case documents will be prepared in case of :

(a) NCC Officers and cadets

(b) Police Battalions, Assam Rifles, Indo - Tibetan Border Police and BSF

(c) Coast Guard Personnel

(d) Documents will be submitted to Office of DGMS direct by the OC hospital in respect of Foreign Nationals who die while undergoing treatment in a Military Hospital, for perusal and onward transmission to Govt of the Country concerned, through the Min of Def/D (Med) and Min of External Affairs.

(e) Medical case sheets and connected medical documents of pensioners, will be perused and disposed of by the DDMS Command concerned to the respective Records holding Offices.

In case of unnatural deaths, i. e. deaths due to suicide, violence, accident, under suspicious circumstances and so on, OC hospital will ensure that civil police is informed in writing about the incident and their clearance obtained, in writing, before handing over the dead body to the relatives of the deceased. Confirmation that this requirement has been complied with will be incorporated in clear terms in the remarks endorsed by the OC hospital on the fatal case documents.

In cases of unnatural and unattended deaths, the main interest of the civil authorities in performing the postmortem examination is to find out whether death was due to foul play or not and, as such, they carry out few, if any, histopathological examinations on the tissues. In case a pathological death is suspected liaison will be maintained with civil authorities so that pathologist/MO of hospital attends the postmortem.

Fatal case documents in respect of service personnel who are transferred to civil hospitals and die there while under treatment. The following action will be taken :

(a) The OC hospital who transfers the case to civil should liaise with the civil medical authorities regarding progress of the case and treatment given to the individual.

(b) On the basis of the above information, he will complete the case sheets and other hospitalization documents and initiate fatal documents.

In cases classified as BCs/BCs for which no Injury reports are required to be prepared (except in cases of gross negligence or misconduct as specified in orders) and which end fatally after admission to hospital, duplicate copy of the case sheets and attributability certificate need NOT be prepared. In such cases, death certificate and case sheets in original, alongwith injury Report, if prepared, should be forwarded to Record Office concerned. These documents should clearly indicate that the death was on account of Battle Casualty/Accident.

Fatal case documents will be initially sent to Adviser in Pathology who in turn will forward them to the other Advisers concerned. In “Brought - in - dead” cases, documents need to be routed only through Adviser in Pathology.

DDsMS Command/Corps and ADsMS Area/Division will ensure that comments endorsed by various Advisers are communicated to the concerned unit/hospital and specialists concerned. DDsMS Commands, in their forwarding letters will indicate that :

(a) The comments of the Advisers have been communicated to the treating clinician, and

(b) A warning (where considered necessary) has been issued to the concerned officer for his lapse. A

Lt Col A Hazra

# Health Guidelines for UN Missions and International Travel

## Introduction

A large and increasing number of Armed Forces Personnel are being deployed as a part of United Nations peacekeeping forces in various countries across the world. In most of these countries of deployment, the governments or armed groups have been engaged in armed conflict for several years, a collateral impact of which is the forced migration or displacement of large numbers of people from their war-ravaged homes and the destruction or weakening of health systems with a diminished capacity to detect, prevent and respond to infectious disease outbreaks. The refugees or internally displaced persons (IDPs) are often compelled to live in cramped, congested living conditions, without access to safe water, sanitation, safe food or decent shelter which, in turn, heighten the risk of infectious disease epidemics. This was the cause of the cholera epidemic in the Democratic Republic of the Congo, in the aftermath of the crisis in Rwanda in 1994. In July of that year, between 500,000 and 800,000 people crossed the border to seek refuge in the outskirts of the Congolese city of Goma. During the first month after their arrival, close to 50,000 refugees died (1).

The contingent of troops assigned to a UN Peacekeeping Operation are deployed in unfamiliar environments and, apart from the vulnerability to the epidemic-prone diseases, are also exposed to a variety of emerging or locally endemic infectious diseases (against which they have no previous immunity); adverse environmental conditions, physical threats to health, as well as a variety of specific, operation-related health hazards. However, most such health risks can be minimized by taking suitable precautions before, during and after deployment, and it is the purpose of this chapter to provide guidelines on measures to prevent or reduce any adverse consequences to the health of our Armed Forces personnel proceeding abroad.

The current country/ continent-specific epidemiological intelligence and counter measures are available through the Armed Forces Central Epidemiological Surveillance Centre (AFCESC), Department of Community Medicine (PSM), Armed Forces Medical College, Pune, and through the latest publications of UN/ WHO. Medical Officers are also advised to acquaint themselves with the recent instructions and guidelines issued by Army Headquarters, regarding medical examinations for troops and families proceeding abroad (2), as well as the epidemiological descriptions, based on first-hand mission experiences, forwarded to the o/o DGAFMS/ DG-3A, o/o DGMS (Army)/ DGMS-5B and DGMS-3E, respectively by Senior Medical Officer (SMO) of the contingent of a particular UN mission.

## General considerations

The conceptual framework for assessing the potential health risks to troop contingents assigned to a UN peacekeeping mission, and integration of preventive medicine recommendations into the deployment planning process is outlined in the succeeding paragraphs. Taking into account that all situations are different, the primary objective of these guidelines is to supplement the country-specific summaries, describe several aspects where advanced planning is recommended/ needed and enable medical officers to provide valuable inputs and recommendations to Commanders in order to safeguard the health of troops before, within and after the mission. The following aspects must be taken into consideration :

(a) Medical screening.
(b) Vaccine-preventable diseases and immunization policy.
(c) HIV/ AIDS and sexually transmitted infections.
(d) Malaria prévention and chemoprophylaxis.
(e) Environmental health risks
  (i) Adverse climatic conditions (e.g., excessive heat and humidity, cold, high terrestrial altitude and UV radiation from the sun).
  (ii) Infectious diseases (e.g. insect/ arthropod borne diseases, food and water-borne health risks, water-contact diseases, soil-transmitted diseases, acute respiratory diseases etc.).
  (iii) Physical threats (including those associated with animals and bites/ stings).
(f) Waste disposal in mission area.
(g) Personal hygiene.
(h) Oral health.
(j) Jet lag.
(k) Stress management .
(l) Road safety measures.
(m) Epidemiological surveillance.
(n) Notification and reporting.

A brief review of the medical support structure in UN peacekeeping missions has been included at the end of these guidelines.

## Medical screening

### Medical category

All personnel are required to undergo a pre-deployment medical examination and should be in SHAPE-1 or equivalent medical category. Women candidates should not be pregnant at the time of departure. This examination must have taken place within the preceding three months and shall be completed and recorded on UN form MS-2 (Entry Medical Examination: United Nations and specialized agencies) for a mission assignment with the United Nations.

### HIV screening

HIV screening will be done before departure as well as three months after return from foreign assignments as per guidelines mentioned in DGAFMS letter No 5496/DGAFMS/DG 3A dated 13 Nov 92, and even number

dated 10 Nov 95, and letter No 5496/Policy/DGAFMS dated 27 Sep 96. Details are also available in the handbook on HIV / AIDS for Medical Officers, developed by Armed Forces AIDS Control organization (3) as well as instructions issued by Army headquarters (2). As per existing policy, persons who are detected to have HIV infection during the initial screening are excluded from proceeding on the assignment abroad.

## Vaccine preventable diseases & immunization policy

### Vaccination requirements

There is no single schedule for the administration of immunizing agents. The schedule depends on the past immunization history of the individual, the amount of time available before departure and the intended area of deployment of troops in a particular UN Mission. These requirements are divided into those that are mandatory (e.g. Diphtheria, Pertussis, Tetanus, Typhoid, Yellow fever if indicated, Hepatitis B for medical staff, Poliomyelitis etc.) and those that are recommended (e.g. Meningococcus, Rabies, Hepatitis A, MMR etc.) (4). The United Nations Department of Peacekeeping Operations immunization requirements by Mission are given in **Appendix 'A'**. In case of a first-time deployment of troops to any UN Mission, Medical Officers are also advised to acquaint themselves with the recent WHO guidelines on International Travel and Health (an Internet version is available on the web-site http://www.who.int/ith) as well as the mission-specific immunization requirements from the Force Medical Officer (FMedO)/ Chief Medical Officer of the particular UN Mission. In case of a turnover deployment of troops in an ongoing UN Mission, the epidemiological situation reviews and recommendations for individual vaccines submitted by SMO of the contingent to the o/o DGAFMS/ DG-3A, o/o DGMS (Army)/ DGMS-5B and DGMS-3E, respectively as well as the Armed Forces Central Epidemiological Surveillance Centre (AFCESC), Dept of Community Medicine (PSM), AFMC, Pune should be consulted for determining the additional vaccination requirements for troops prior to deployment in Mission area.

### Immunisation policy

As per current UN policy, it is the responsibility of the Troop Contributing Country (TCC) to ensure that all personnel have received at least the initial dose of mandatory vaccinations before deployment into the Mission area, at national expense. The vaccines should be procured through the Office of DGAFMS/ DG-2 along with the requirements of various other prophylactics and drugs. The immunization status of each individual is to be properly documented in the WHO International Certificate of Vaccination. Should a multiple dose immunization regimen not be completed prior to deployment, the same may be completed in the Mission area and the TCC Hospitals should make provisions for administration of subsequent vaccinations including booster doses to members of the contingent. If the troops are deployed into a Mission area without the required vaccinations, these are provided by the UN, but all costs incurred are deducted from the reimbursement due to the troop contributing country. Failure to follow UN-recommended immunization policies may result in the denial of entry into the host country, as well as rejection of any resulting medical claims and compensation (4).

### Vaccine-preventable diseases and vaccines

The recommendations for vaccination against certain infectious diseases of potential risk for troops proceeding on mission abroad are summarised below :

(a) Yellow Fever Vaccine

Yellow fever occurs in Africa and South America. The World Health Organization (WHO) estimates that a total of 200,000 cases of yellow fever occur each year (5). A valid international certificate of immunization against yellow fever is required by many countries for entry of persons coming from or going to recognized yellow fever zones of Africa and South America; otherwise quarantine measures are applicable for up to 6 days. Persons aged >9 months who are travelling to or living in areas of South America and Africa where yellow fever infection is officially reported should be vaccinated. Information concerning known or probable infected areas is also available from WHO (http://www.who.int). For persons of all ages for whom vaccination is indicated, a single subcutaneous injection of 0.5 ml of reconstituted vaccine is used (6). The International Health Regulations require revaccination at intervals of 10 years. The International Certificate of Vaccination against Yellow Fever is valid from 10 days after date of immunization for 10 years; if re-immunized within that period, it is valid from the date of re-immunization. Yellow Fever Vaccination centres in India are as follows :

(i) National Institute of Communicable Diseases, New Delhi.

(ii) All India Institute of Hygiene and Public Health, Kolkata.

(iii) All major Airport Health Organizations.

(iv) All Port Health Organizations.

(v) Armed Forces Clinic, New Delhi (this is the designated centre for Armed Forces) (2).

(b) Hepatitis B vaccine

There is a heightened risk of acquiring Hepatitis B infection in unvaccinated persons deployed in UN Mission areas as they are frequently engaged in humanitarian relief activities and may be exposed to infected blood or other body fluids in health-care settings or due to sexual contact with potentially infected persons. All non-immune persons proceeding on a mission abroad should receive a 3-dose series of either plasma-derived or recombinant-DNA (yeast-derived) vaccine; 1 ml IM (deltoid) at months 0, 1 and 6. The complete series should be given prior to deployment if possible; otherwise remaining doses can be given in the country of deployment. A booster dose may be given for those who have taken the complete immunisation regime earlier.

(c) Meningococcal Vaccine

Sporadic cases are found worldwide. In temperate zones, most cases occur in the winter months. Localized

outbreaks occur in enclosed crowded spaces (e.g. dormitories, military barracks). In sub-Saharan Africa, in a zone stretching across the continent from Senegal to Ethiopia (the African "meningitis belt"), large outbreaks and epidemics take place during the dry season (November-June) (7). The current recommendation is to vaccinate all Hajj pilgrims, travellers to areas with current outbreaks and travellers to the sub-Saharan meningitis belt (8). The persons being deployed to countries where outbreaks of meningococcal disease are known to occur should be vaccinated with a single dose, 0.5 ml, SC, quadrivalent (A,C,Y,W-135) vaccine, at least 10 days prior to deployment.

(d) Typhoid Vaccine

Typhoid fever occurs in all parts of the world where water supplies and sanitation are sub-standard. Risk is greatest for travelers to developing countries (e.g., countries in Latin America, Asia, and Africa) who have prolonged exposure to potentially contaminated food and drink. It is recommended that all personnel proceeding on UN Missions abroad are vaccinated with either the Vi capsular polysaccharide (ViCPS) vaccine in a single dose of 0.5 ml, IM with a booster dose every 2 years, or in case the individual has been previously immunized with the TA (Heat-phenol inactivated) parenteral vaccine, then a sub-cutaneous, booster dose of the same (due once every 3 years). Medical Officers are advised to caution all personnel that typhoid vaccination is not a substitute for careful selection of safe food and drink. Typhoid vaccines are not 100% effective, and the vaccine's protection can be overwhelmed by large inocula of S. typhi. (9, 10).

(e) Japanese Encephalitis Vaccine

Approximately 50,000 sporadic and epidemic cases of JE are reported annually from the People's Republic of China (PRC), Korea, Japan, South-east Asia, the Indian subcontinent, and parts of Oceania. Viral transmission occurs across a much broader area of the region than is recognized by epidemiologic surveillance. In temperate regions, JE virus is transmitted during the summer and early fall, approximately from May to September. In subtropical and tropical areas, seasonal patterns of viral transmission are correlated with the abundance of vector mosquitoes and of vertebrate-amplifying hosts. These, in turn, fluctuate with rainfall, with the rainy season, and with migratory patterns of avian-amplifying hosts. In some tropical locations, however, irrigation associated with agricultural practices is a more important factor affecting vector abundance, and transmission may occur year-round. Patterns of JE viral transmission vary regionally, within individual countries, and from year to year (11).

Immunisation should be considered for persons deployed for extended periods of time in rural areas where JE is endemic or epidemic. Primary series of three 1.0 ml doses SC at days 0, 7, and 30. Alternate schedule on days 0, 7, 14, is slightly less immunogenic. Single dose booster indicated 3 years after basic series. Last dose should be given 10 days before departure. Use with caution in persons with multiple allergies, especially history of urticaria or angioedema (11).

(f) Tetanus Toxoid (TT)

This should be given to all persons as and when due/ required as booster.

(g) Other Vaccines

As dictated by mission and the individual situation, consideration for the usage of other vaccines may be appropriate.

Lapsed vaccination schedule

Vaccines should be administered as close to the recommended intervals as possible. However, longer-than-recommended intervals between doses do not reduce final antibody concentrations, although protection might not be attained until the recommended number of doses has been administered. With the exception of oral typhoid vaccine, an interruption in the vaccination schedule does not require restarting the entire series of a vaccine or toxoid or addition of extra doses (12).

Unknown or uncertain vaccination status

Medical Officers frequently encounter persons who do not have adequate documentation of previous vaccinations. Only written, dated records should be accepted as evidence of vaccination. Although vaccinations should not be postponed if records cannot be found, an attempt to locate missing records should be made by contacting previous unit of the individual and searching for a personally held record. If records cannot be located, these persons should be considered susceptible and should be started on the appropriate vaccination schedule (12).

## HIV/ AIDS and sexually transmitted infections

### Risk factors in UN peacekeeping operations

Throughout the world, military personnel, including United Nations Peacekeepers, are uniquely at risk for infection with HIV and other STIs. Military duty often puts soldiers in stressful situations and can also take them away from home for extended periods of time. The need to relieve stress, loneliness, and boredom can lead to risky behavior. The factors which further increase the likelihood of high-risk behaviour amongst UN peacekeepers are the use of alcohol and drugs to cope with stress, less inhibitions and restrictions in a new country and the ready access to sex workers near campsites and frequented off-duty areas (13). It must also be borne in mind that UN peacekeepers are deployed in active conflict zones or in the immediate post-conflict scenario. There is a likelihood of significantly elevated prevalence rates of HIV/ AIDS and Sexually Transmitted Infections (STIs) amongst certain vulnerable population groups in these regions (such as Internally Displaced Persons (IDPs), Refugees, Commercial Sex Workers etc.). The main factors contributing to the vulnerability and favouring the spread of HIV/AIDS and STIs amongst these population groups are mobility across borders, armed conflict, poverty and economic disparities, drought, high-female illiteracy, local cultural and ethnic practices, low access to Voluntary Confidential Counseling and Testing (VCCT) services, taboos around sexuality, denial, silence, stigma,

discrimination and fear.

### Pre-induction training

Medical Officers accompanying troop contingents on United Nations peacekeeping operations must impart "Pre-Induction Training" to all ranks such that they are fully aware of the risks of contracting HIV/ STIs and learn effective prevention strategies, so they can protect their health and the health of civilian populations in the locales they work, and maintain the integrity of their missions. The key approach to prevention of HIV/ AIDS and sexually transmitted diseases is abstinence or responsible sexual behaviour. Details are also available in the handbook on HIV / AIDS for Medical Officers, developed by Armed Forces AIDS Control organization (3).

### The UN policy of "Zero Tolerance"

It must also be emphasized that the United Nations has a policy of "Zero Tolerance" in fraternization with local population in the country of deployment and any allegation of sexual exploitation and abuse (SEA) on the part of UN peace-keepers may constitute a criminal offence regardless of whether there is involvement of money or material in exchange of sex.

### Hospital-based control measures

All Troop Contributing Country (TCC) hospitals in the Mission area must exercise universal precautions, adequate sterilization practices, blood and injection safety procedures and pay special attention to proper handling/ disposal of biomedical wastes including use of incinerators.

### Post Exposure Prophylaxis kits

Post Exposure Prophylaxis (PEP) kits must be available in the TCC Level 2 and Level 3 hospitals, respectively to ensure administration within 2-72 hours to all personnel who have been exposed to the HIV virus due to either accidental needle stick injuries or as a result of sexual violence.

### Blood safety

In all UN Missions, blood and blood products are provided from sources that meet WHO standards and are monitored by the Chief Medical Officer of the mission. Blood for transfusion is provided only from a known source (abroad procurement).

## Malaria prevention and chemoprophylaxis regimens

### Magnitude of the problem

Malaria is endemic in most tropical countries, particularly in Africa, South America and South Asia, with 400 million individuals infected and 1.5 million dying from the disease each year. It is one of the major diseases affecting peacekeepers and an important cause of morbidity and mortality. In 1995, health statistics from UNAVEM (Angola) showed that 970 out of 7,005 UN peacekeepers had malaria. This indicates a general lack of awareness of the disease among peacekeepers, as well as inadequate or incorrect use of environmental and personal protection measures. Prevention of malaria is further hampered by delays in diagnosis, development of Anopheles mosquitoes resistant to standard insecticides and resistant-strains of Plasmodia (**4).** Chemoprophylaxis and treatment of falciparum malaria are becoming more complex because *P. falciparum* is increasingly resistant to various antimalarial drugs. Chloroquine resistance of *P. vivax* is rare and was first reported in the late 1980s in Indonesia and Papua New Guinea. Focal "true" chloroquine resistance (i.e. in patients with adequate blood levels at day of failure) or prophylactic and/or treatment failure have since also been observed in Brazil, Colombia, Ethiopia, Guyana, India, Myanmar, Peru, the Republic of Korea, Solomon Islands, Thailand and Turkey. Chloroquine-resistant *P. malariae* has been reported from Indonesia (14).

### Malaria prevention

Physical protection, including environmental prevention, impregnated bed nets, the possibility to treat uniforms and use of repellants must be provided to all troops. Due to the operational needs of a peacekeeping mission, troops must use chemoprophylaxis against malaria. Thick and thin smears are the gold standards for diagnosing malaria. All Troop Contributing Country (TCC) medical facilities in endemic areas must have the capability of diagnosing malaria, including microscopy, appropriate staining supplies and adequately trained laboratory personnel. Rapid diagnostic tests should only be used in conjunction with microscopy, and only tests to identify *P. falciparum* should be used.

### ABCD of malaria protection

Medical Officers should note the following four basic principles of protection against malaria and advise troops accordingly (14) :

(a) Be Aware of the risk, the incubation period, and the main symptoms.

(b) Avoid being Bitten by mosquitoes, especially between dusk and dawn.

(c) Take antimalarial drugs (Chemoprophylaxis) when appropriate, to prevent infection from developing into clinical disease.

(d) Immediately seek Diagnosis and treatment if a fever develops one week or more after entering an area where there is a malaria risk and up to 3 months (or, rarely, later) after departure from a risk area.

### Malaria risk-stratification

Depending on the malaria risk in the country of deployment (see "Country list" for details concerning the malaria risk situation and recommended prevention available on the web-site http://www.who.int/ith), the recommended prevention method may be mosquito bite prevention only, or mosquito bite prevention in combination with chemoprophylaxis, as given in Table - 1.

### Use of antimalarial drugs for chemoprophylaxis

The choice of antimalarial drug for chemoprophylaxis will depend upon the malaria risk situation and the reported resistance pattern of the malarial parasite to these drugs in the country of deployment of troops. Alternate chemoprophylaxis may have to be considered for those

Table - 1 : Malaria risk and recommendations for prevention

| | Malaria risk | Type of prevention |
|---|---|---|
| **Type I** | Very limited risk of malaria transmission | Mosquito bite prevention only |
| **Type II** | Risk of *P. vivax* malaria only; or fully chloroquine-sensitive *P. falciparum* | Mosquito bite prevention plus chloroquine chemoprophylaxis |
| **Type III** chloroquine+proguanil | Risk of *P. vivax* and *P. falciparum* malaria transmission, combined with emerging chloroquine resistance | Mosquito bite prevention plus chemoprophylaxis |
| **Type IV** | (1) High risk of *P. falciparum* malaria, in combination with reported antimalarial drug resistance; or (2) Moderate/low risk of *P. falciparum* malaria, in | Mosquito bite prevention plus mefloquine, doxycycline or atovaquone-proguanil chemophylaxis (select according to reported |

Source: WHO (Ref 14)

individuals with history of known hypersensitivity to the recommended drug and/or other specific contraindications. The antimalarial drugs commonly used for chemoprophylaxis, dosage regimens, contraindications and special precautions for use are listed in Table - 2.

**Implementation of malaria prevention and control measures**

A SOP should be formulated which should include all aspects of prevention of malaria, including the drugs to be used for chemoprophylaxis, environmental management measures, personal protective measures to be used, insecticides and spraying equipment, manpower training, supervision and command support. This should be incorporated in the administrative instructions issued by the National Senior of the Contingent in the mission area. Adequate stocks of second and third line antimalarial drugs should be ensured. Also provision for synthetic pyrethroids such as deltamethrin/ permethrin for impregnating mosquito nets/ uniforms should be catered for and impregnation of mosquito nets/ uniforms implemented preferably before deployment and monitored.

## Environmental health risks

The deployed military contingent in any UN Mission is subject to a variety of environmental health risks other than those resulting from combatant operations.

Types of environmental health risks

The various environmental health hazards in the area of deployment may include :

(a) Adverse climatic conditions (e.g., excessive heat and humidity, cold, high terrestrial altitude and UV radiation from the sun).

(b) Infectious diseases (e.g. insect/ arthropod borne diseases, food and water-borne health risks, water-contact diseases, soil-transmitted diseases, acute respiratory diseases etc.).

(c) Physical threats (including those associated with accidents, explosions, animals and bites/ stings, and certain forms of ionizing radiation).

(d) Ambient chemical and radiological contaminants in air, water, food, and soil.

Troops will inevitably be exposed to these hazards, and exposures may or may not occur intermittently, continuously, or simultaneously, but they will occur. In some situations, environmental health risks may be present for only a short time, but at high exposure levels. These may have detrimental effects on individual health and well-being or even degrade the mission. In other situations; continuous, but less extreme levels in the environment, may put military personnel at increased risk of delayed, permanent health problems (15, 16).

**Environmental health and safety planning considerations**

The following aspects must also be taken in consideration by medical officers/ specialists in PSM, when evaluating environmental health and safety considerations during the planning process to ensure valuable and effective input to commanders (15) :

**(a) Accommodation**

Type, adequate ratio to be determined and all other related general health aspects to be addressed.

**(b) Ablution**

Type, adequate ratio, hot & cold water supply, drainage, etc to be determined and addressed in appropriate SOPs.

**(c) Mess facilities**

Ensure adequate, placement, equipment, personnel, etc.

**(d) Immunizations**

Ensure that all personnel are administered all necessary and required inoculations as per international requirements, as well as requirements imposed by legislation and endemic diseases in the country of deployment.

**(e) Prophylactic medicines**

Ensure that all personnel are supplied with necessary chemo-prophylactic drugs as required and properly educated on use. Registers to be instituted and maintained throughout the period of deployment.

**(f) Quarantine/ isolation**

Table - 2 - Antimalarial drugs for use as prophylaxis

| Recommended Drug | Adult Dose & Duration of Prophylaxis | Main Contraindications | Special Precautions |
|---|---|---|---|
| Chloroquine | (1 tablet = 150 mg chloroquine base) 300mg base (2 tablets) once every 7 days, starting 1 week before entering the area, once weekly while in the area, and once weekly for 4 weeks | Hypersensitivity to chloroquine; history of epilepsy; psoriasis. | (i) Concurrent use of chloroquine can reduce the antibody response to intradermally administered HDCC rabies vaccine.<br>(ii) Extended use of chloroquine can cause retinal damage, 6 monthly eye checkups are recommended |
| Chloroquine + Proguanil | Chloroquine as above, plus Proguanil (1 tablet = 100 mg) 200mg (2 tablets) daily starting one day before entering the area, continuing daily while in the area and daily for 4 weeks after | Hypersensitivity to chloroquine and/or proguanil; liver or renal insufficiency; history of epilepsy; psoriasis. | (i) Concurrent use of chloroquine can reduce the antibody response to intradermally administered HDCC rabies vaccine.<br>(ii) Proguanil can interfere with live, oral typhoid vaccine |
| Mefloquine | (1 tablet = 250 mg mefloquine) 250mg (1 tablet) every 7 days, starting at least 1 week (preferably 2-3 weeks) before entering the area, once weekly while in the area, and once weekly for 4 weeks after leaving the area. | Hypersensitivity to Mefloquine; psychiatric or convulsive disorders; not recommended for persons performing activities requiring fine coordination and spatial discrimination e.g. pilots, machine operators. | (i) Restrict use to 1 year.<br>(ii) Do not give Mefloquine within 12 hours of quinine treatment. |
| Atovaquone-Proguanil combination | (1 adult tablet =250 mg Atovaquone plus 100 mg Proguanil)<br>1 tablet daily, starting 1 day before entering the area, continuing daily while in the area, and daily for 7 days after return | Hypersensitivity to atovaquone and/or proguanil; severe renal insufficiency. | Proguanil can interfere with live, oral typhoid vaccine |
| Doxycycline | (1tablet = 100 mg doxycycline)<br>(1 capsule = 50mg , 100 mg or 200 mg doxycycline)<br>100mg once daily starting 1 - 2 days before entering the area, continuing daily while in the area, and daily for 4 weeks after leaving the area. | Hypersensitivity to tetracyclines; liver dysfunction. | (i) Doxycycline should only be used if other drugs are unsuitable. It is an option to consider for epileptic patients who have to enter a high-risk chloroquine-resistant malaria area.<br>(ii) Restrict use to 3 months (due to lack of safety data for long-term use of daily 100 mg administration).<br>(iii) Doxycycline makes the skin more susceptible to sunburn. People with sensitive skin should use a highly protective (UVA) sunscreen and avoid prolonged direct sunlight, or switch to another drug.<br>(iv) Doxycycline should be taken on a full stomach with plenty of water to prevent oesophageal irritation.<br>(v) Doxycycline may increase the risk of |

Ensure capability at the TCC medical facility in case of emergency requirements.

**(g) Camp-site layout/ planning/ construction**

Close inter-sectoral collaboration with engineers in the context of water supply, drainage, structural requirements, refuse disposal, etc.

**(h) Occupational health monitoring**

Ensure monitoring of possible chemical, biological and physical influences on personnel.

**(j) Health education/ briefing.**

Proper briefing of all personnel during the pre-deployment phase (mobilization) about environmental health risks and their prevention; health education throughout the deployment as well as follow-up medication/ investigations to be done during the post-deployment phase (de-mobilization).

**(k) Disease outbreak investigations**

All cases to be investigated recorded and followed up. Detailed reports to be archived for future reference. Necessary notifications as per International legislation to be adhered to.

**(l) Personal protective gear**

All personnel utilised in activities where protective gear is essential such as vector control, de-contamination, barrier nursing, etc.

**(m) Disease vector and pest control**

Ensure adequate routine disease vector/ pest control activities including residual spraying, fumigation, ULV fogging, rodent control and proper storage/ handling of hygiene chemicals.

**(n) Office accommodation**

Inputs with respect to floor space, ventilation, lighting (natural as well as artificial), etc.

**Prevention of effects of heat**

It is the "greatest overall threat" to military personnel deployed in areas with a hot and humid climate. The important components of a heat-injury prevention programme include "heat acclimatization", which may take 10-14 days; proper work-rest cycles, scheduling work during the coolest times of the day, adequate hydration, consumption of salt-containing foods/ drinks and command emphasis on the strict implementation of preventive measures.

**Prevention of adverse effects of cold**

Loss of body heat to the environment causes cold injury. Cold injuries can occur in any environment. Air temperatures between 32-55$^0$ F can lead to a general lowering of body temperature (hypothermia, a life-threatening condition) and local non-freezing injuries (chilblains and trench foot). Air temperatures below freezing can result in hypothermia and local freezing of body tissues (frostbite). Risk of cold injuries is increased for persons who are in poor physical condition, dehydrated, or wet.

**Counter-measures include :**

**(a) Clothing and cover**

Exposed skin is more likely to develop frostbite. Ensure full provision of ECC clothing. Clothing should be clean, loose, multi-layered and dry. Remove layers of clothing, as needed to avoid sweating. Change socks 2-3 times per day, if wet. Cover the head to conserve heat.

**(b) Hydration and nutrition**

Provide warm food and beverages, especially at night. Increase water intake and avoid alcohol.

**(c) Physical activity**

Plan for shortened periods of sentry/guard duty. Shivering is a warning sign of impending cold injury; increase activity, add clothing, or seek warm shelter. Use the buddy system; observe all personnel for early warning signs/ symptoms.

**Ultraviolet radiation from the sun**

The ultraviolet (UV) radiation from the sun includes UVA (wavelength 315-400 nm) and UVB (280-315 nm) radiation, both of which are damaging to human skin and eyes. The intensity of UV radiation is indicated by the Global Solar UV Index, which is a measure of skin-damaging radiation. The Index describes the level of solar UV radiation at the Earth's surface and is often reported as the maximum 10-30 minute average for the day. The values of the Index range from zero upwards the higher the Index value, the greater the potential for damage to the skin and eyes, and the less time it takes for harm to occur. The Index values are grouped into exposure categories, with values greater than 10 being "extreme". In general, the closer to the equator the higher the Index. UVB radiation is particularly intense in summer and in the 4-hour period around solar noon (16).

Adverse effects of UV radiation

**(a) Short-term effects**

(i) Exposure to UV radiation, particularly UVB, can produce severe debilitating sunburn and sunstroke, particularly in light-skinned people.

(ii) Exposure of the eyes may result in acute keratitis ("snow blindness"), and long-term damage leads to the development of cataracts.

(iii) Persons on prophylactic/ therapeutic drugs (e.g. oral contraceptives, doxycycline, etc.) develop adverse dermatological reactions on exposure to sunlight.

(iv) Phototoxic contact reactions are caused by topical application of products, including perfumes, containing oil of bergamot or other citrus oils.

(v) Exposure may suppress the immune system, increase the risk of infectious disease, and limit the efficacy of vaccinations.

**(b) Long-term adverse effects on the skin include :**

(i) Development of skin cancers (carcinomas and malignant melanoma), mainly due to UVB radiation.

(ii) Accelerated ageing of the skin, mainly due to UVA radiation, which penetrates more deeply into the skin.

Precautions to reduce exposure to UV rays

(a) Avoid exposure to the sun in the middle of the day, when the UV intensity is greatest.

(b) Wear clothing that covers arms and legs (summer clothing is UV-protective and generally more effective than even good-quality sunscreen).

(c) Wear UV-protective sunglasses of wrap-around design and a wide-brimmed sun hat.

(d) Apply a broad-spectrum sunscreen of sun protection factor (SPF) 15+ liberally on areas of the body not protected by clothing and reapply frequently.

(e) Take precautions against excessive exposure on or in water.

(f) Check that medication being taken will not affect sensitivity to UV radiation.

(g) If adverse skin reactions have occurred previously, avoid any exposure to the sun and avoid any products that have previously caused the adverse reactions.

**High terrestrial altitude**

Adverse health effects will most likely occur at elevations of about 2,500 meters and higher. Acute mountain sickness, high altitude pulmonary edema, and high altitude cerebral edema are the most serious types of altitude illness. Symptoms may be delayed for several days after ascent. Pulmonary edema and cerebral edema are life-threatening emergencies that require immediate descent to lower elevation. Risk of cold injury, heat injury, and solar UV radiation are all increased at higher terrestrial altitudes.

Counter-measures include :

(a) Acclimatization schedule as per Advance Army Order on prevention of adverse effects of high altitude and cold, issued in 2002.

(b) Avoid alcohol and barbiturates.

(c) Remain well hydrated; individual water requirements are greater at high altitude.

(d) Protect skin (sunscreen), lips (lip balm), and eyes (sunglasses) from UV radiation.

**Protection against insect / arthropod-borne diseases**

The key to preventing vector-borne diseases is to avoid being bitten by disease-carrying insects and other arthropods. For some diseases, it is the only means of protection. Arthropod vectors of disease can pose a threat at any time, day or night. A comprehensive vector-borne disease prevention program will include (17) :

(a) Emphasizing prevention of disease by ensuring appropriate supplies, educating personnel about diseases and preventive measures, and soliciting command support at all levels.

(b) Proper camp site selection.

(c) Ensuring command emphasis on compliance with malaria chemoprophylaxis.

(d) Issuing adequate tubes of 33% DEET or other suitable insect/arthropod repellent lotion per person. Personnel should be instructed in its proper use. While at risk (during periods of vector biting activity), all personnel should apply the repellant to all exposed skin surfaces.

(e) Requiring all personnel to sleep under mosquito nets both during day and night. The mosquito nets should be treated with synthetic pyrethroids to increase their efficacy.

(f) Wire-mesh screening of all doors/ windows.

(g) Applying insecticides (camp area treatments) by properly trained personnel.

(h) Applying rodent control measures if needed (fleas must be eradicated before rodents are killed to prevent transmission of flea-borne diseases, such as plague).

(j) Chemoprophylaxis against Onchocerciasis (River Blindness) : The African Programme for Onchocerciasis Control (APOC), which includes Sudan and other 18 African countries recommends once-a-year administration of oral Ivermectin in the dosage of 150 µg/kg of body weight.

**Food and water-borne health risks**

Food-borne diseases

Food safety is a subject of great concern today, generated and fuelled by the ever increasing cases of food-borne diseases and the appearance of major food safety hazards involving beef, poultry, eggs, fish and sea products etc. Whilst bacteria cause the majority of cases, the most numerous being Campylobacter and Salmonella species, others like Clostridium, Staphylococcus, Botulism as well as chemical contaminants also play a major role in outbreaks. Investigations have identified the commonest factors, exclusive of above-mentioned bacteria, associated with outbreaks of food-borne diseases are (18) :

(a) Preparation of food too far in advance from the likely time of consumption.

(b) Inadequate storage temperatures/facilities.

(c) Inadequate cooking or re-heating.

(d) Inadequate cooling and holding.

(e) Contamination of cooked food (due to handling with "dirty" hands or exposure to dust/ flies).

(f) Consumption of raw food (not properly washed or peeled)

Food safety standards

Catering operations are an integral part of United Nations peacekeeping operations, consequently high and uniform standards of food safety are essential and must be maintained at all UN-provided or military contingent

provided catering facilities. Military contingent members may be required to dine in UN-provided catering establishments during travel in the mission area and on the other hand, apart from own troops, military members from other contingents as well as visiting UN international staff may require partaking food from TCC 'team-sites' or hospitals, on several occasions. It is the responsibility of medical officers to carry out routine inspections of all catering operations to monitor food safety management systems for compliance with these generic standards (18).

Precautions for avoiding unsafe food and drink during travel

Medical officers must educate all personnel on the following (16, 19) :

(a) Consume food from mission approved sources only and completely avoid food bought from street vendors.

(b) Wash hands with soap and water before eating, handling food or kitchen utensils, and after using latrines.

(c) Avoid cooked food that has been kept at room temperature for several hours.

(d) Eat only food that has been cooked thoroughly and is still hot.

(e) Avoid uncooked food, apart from fruit and vegetables that can be peeled or shelled, and avoid fruits with damaged skins.

(f) Avoid dishes containing raw or undercooked eggs.

(g) Avoid ice cream from unreliable sources, including street vendors.

(h) In countries where poisonous biotoxins may be present in fish and shellfish, obtain advice locally.

(j) Boil unpasteurized (raw) milk before consumption.

(k) Boil drinking-water if its safety is doubtful; if boiling is not possible, a disinfectant agent can be used.

(l) Avoid ice unless it has been made from safe water.

(m) Avoid brushing the teeth with unsafe water.

(n) Bottled or packaged cold drinks are usually safe provided that they are sealed; hot beverages are usually safe.

Safe drinking water

UN Missions are usually deployed in areas where locally available water sources are unsafe for human consumption and diseases like cholera, enteric fever, viral hepatitis, etc. are endemic amongst the local population. In most UN Missions, the Memorandum of Understanding (MoU) between the Troop Contributing Country (TCC) and the United Nations (as per the wet-lease agreement) lays down that providing the source of water is the responsibility of the UN whereas, the purification and further distribution of drinking water to troops is the responsibility of the TCC. Hence, the water purification plants, reverse osmosis plants and chemicals for treatment of water have to be provisioned by the troop contributing country and carried to the mission area by all units of the contingent.

**Role of medical authorities**

Medical Officers need to pay special attention to the following aspects during the various phases of deployment :

(a) Pre-deployment phase

(i) Make recommendations to commanders while planning for procurement of equipment/ stores and chemicals for setting up water treatment, distribution and storage systems in the mission area.

(ii) Provision for laboratory reagents and test kits for free chlorine estimation as well as bacteriological examination of drinking water in the mission area. A rapid and sensitive test kit to detect microbial contamination of water such as "$H_2S$ method" is recommended under field conditions in the mission area.

(b) During deployment and immediate post-deployment phase

This is a crucial phase during which the troops are vulnerable to traveller's diarrhoea. Safe drinking water supplies in the form of bottled/ packaged water supply which is either UN-provided or from the Contingent's own resources, as the case maybe, must be ensured for all personnel. In case the same is not available, then individual water sterilising outfits or Aquatabs must be used to make water potable.

(c) Post-deployment phase

(i) Medical Officers must advise the Unit Commander and Engineers in selecting an appropriate source of water and monitor the establishment of drinking water supply systems.

(ii) Establish a drinking water quality surveillance system (including regular free chlorine estimation as well as bacteriological examination of samples).

(iii) Offer timely and appropriate advice to commanders in the event of reported contamination of drinking water supplies to troops. Measures like supply of bottled / packaged water or boiling of water must invariably be resorted to under such circumstances.

**Drinking water safety precautions in mission area**

(a) Ensure bulk water containers remain properly sanitized. Maintain adequate chlorine residual level (minimum of 2.0 ppm) in all bulk water.

(b) If local water must be used, proper chlorination or even superchlorination, depending on the risk, should be carried out after calculating the chlorine demand by Horrock's test. If reagents for Horrock's test are not readily available, 'fixed dose' chlorination may be resorted to by adding 4 scoopfuls of WSP to 500 litres of water and confirming adequate chlorination after 60 minutes contact period by OT reagent, before

(c) When detachments are separated from the main bodies, all personnel on such detachments should carry either bottled/ packaged water supply or possess individual water sterilising outfits or Aquatabs.

**Acute respiratory diseases**

Acute respiratory diseases such as influenza, cold, sore throat, and meningococcal disease and more recently SARS and avian influenza, can be highly contagious particularly in crowded conditions. Additionally, tuberculosis infections are increasing rapidly in many areas of the world and can be a significant threat to personnel in close contact with indigenous populations. Preventive measures include providing living areas with adequate space/ ventilation and head-to-foot sleeping arrangements to reduce droplet and aerosol spread of these diseases. Encourage all personnel to practice cough etiquettes and hygienic hand washing.

**Diseases spread by contact with soil**

Hookworm, strongyloides, and various diseases can be contracted by contact of skin with contaminated soil. Minimize direct skin contact with soil (such as walking barefoot and sleeping on bare ground). Wash hands frequently.

**Diseases spread by contact with water**

Diseases like schistosomiasis, leptospirosis, etc, are spread by direct contact with fresh water lakes, ponds, and streams (see Fig. 1). Counter-measures include :

(a) Avoid/ minimize swimming, wading, or bathing in fresh water that may be contaminated. All recreational swimming areas must be inspected and cleared by the medical authority.

(b) Wear shoes when walking on shores, riverbanks and muddy terrain.

(c) Leptospirosis prophylaxis: Prophylaxis should be considered when personnel are in a high-risk area and they have prolonged contact with mud or standing water. Doxycycline, 200 mg once a week,

Fig. 1 : Children bathing in the highly contaminated waters of a stream in South Sudan(UNMIS)

Fig. 2 : Intense water logging following rains in a settlement in South Sudan(UNMIS)

can provide protection.

**Animals**

Animals can spread disease through close contact (e.g. anthrax, Q fever) or bites and scratches (e.g. rabies). Animals with these diseases, including rabies, may not exhibit any obvious signs of illness. Educate all personnel to :

(a) Avoid all unnecessary contact with local animals. Commanders must insist that stray or wild local animals will not be fed or kept as pets or mascots.

(b) Conduct proper food storage and waste disposal inspections to prevent attracting stray animals. Water containers should be protected or raised high enough from the ground to prevent animals from contaminating the water.

(c) If bitten or scratched, immediately wash the wound with soap and water and seek medical evaluation.

**Protection against bites and stings**

Educate all personnel to take adequate precautions to adopt measures to protect themselves from being bitten by snakes, centipedes, scorpions and spiders. Personnel should not go bare foot, sleep directly on the ground and put their hands or feet in crevices or holes. Boots, clothing and bedding should be checked and shaken out before use. In the event of stings or bites, should report immediately to the nearest medical facility. First-aid measures may be taken as appropriate while evacuating/moving to the medical facility.

**Specific anti-venom requirements in mission area**

Medical Officers must gather information on the varieties of poisonous/ non-poisonous snakes and scorpions found in the mission area, prior to deployment and make provisions for specific anti-venom requirements (e.g. anti-venom to African varieties of poisonous snakes).

Scorpion control

Scorpion control is difficult and requires patience but is

not impossible.

**(a) Outdoor control measures**

(i) The first and most important step in control is to eliminate the scorpions' habitat. Wood, large stones, vegetation, garbage and other debris should be removed from the vicinity of tents/ living areas. Gloves and protective clothing should be worn when cleaning up areas where scorpions may hide.

(ii) Outdoor applications of hygiene chemicals (insecticides) are aimed at eliminating scorpions from the immediate area (before they gain entry into the living area). Most hygiene chemical sprays will also reduce insect populations that serve as food and will have some effect on reducing the number of scorpions. The following hygiene chemicals should be sprayed :

- Hit (Propoxur)-once a week
- Deltamethrin 2.5% WP-once a month

(iii) Use a compression sprayer to spray the hygiene chemicals at the following places :

- On the ground upto a distance of 6 feet around the tents/ pre-fabricated shelters. This "treated turf" will not only deter scorpions from re-entering but also keep ants, spiders and crawling insects from entering the living areas.
- Also spray upto a height of 3 feet, on the outside surfaces of tents / pre-fabricated shelters.
- Then spray around all entry points such as windows, doors, openings in tents.
- Hiding places should be located and treated, and any scorpions that are observed can be treated directly. Repeated applications may be necessary for effective control since scorpions may hide for two to three months after feeding.

(b) Indoor control measures

(i) Keep the insides of tents/ shelters clutter-free. Good housekeeping is a key measure to deny indoor hiding places for scorpions.

(ii) Place steel boxes, cupboards and other equipment on bricks to provide adequate ground clearance for cleaning and brooming on a daily basis.

(iii) Use the hygiene chemical, Cresol Black liquid for wet mopping of flooring, wherever feasible.

(iv) Indoor sprays upto a height of 3 feet on tents and walls with Hit/ Propoxur.

(v) Impregnation of lower portion of tent inner-fly with Deltamethrin 2.5% SC.

(c) Personal protective measures

(i) Always wear adequate footwear when walking around at night to minimize the possibility of being stung by a scorpion.

(ii) Always use a torch when you walk around at night.

(iii) Vigorously shake your clothes, bed sheets, blankets, sleeping bags, socks and footwear (by turning upside down) before using them.

(iv) Sleep inside Deltamethrin impregnated bednets.

(v) Apply the repellent 33% DEET over hands and feet at night.

(vi) Impregnation of cuffs, collars and lower portion of trousers with the hygiene chemicals Permethrin or Deltamethrin 2.5% SC.

## Waste disposal in mission area (15)

### Sewage Disposal

A waste management system that deals with the collection, storage, treatment and disposal must be developed early in the planning process. The selection of the method used is dependent on local facilities and services available as well as the local geology. Placement of the facilities requires special consideration to minimize potential impacts to the environment and prevent contamination of the water supply for deployed forces and local inhabitants.

Solid waste management

The method of choice for the disposal of solid waste must take into account the sensitivities of the local population. If existing landfills are not available, burial of waste should employ the characteristics typical of landfill operations. Landfill operations will not be conducted in the vicinity of watercourses or in areas of high water tables. Burning of solid waste may be an acceptable alternative.

Fig. 3 : UN-provided ablution units deployed under field conditions in the UN Mission in Sudan

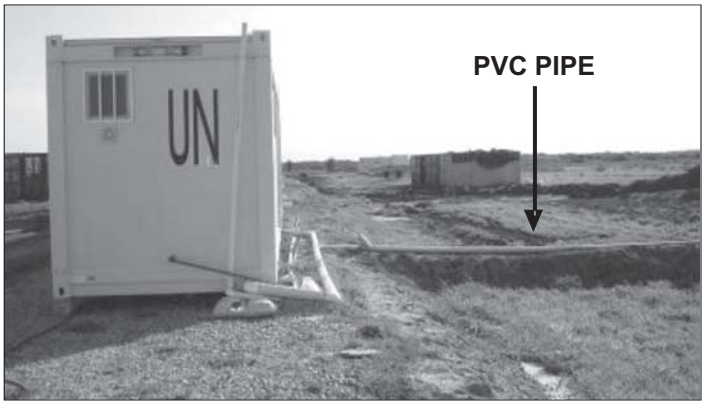
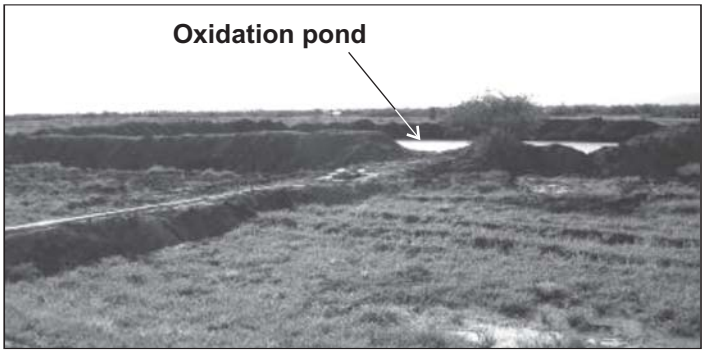



Fig. 4 : Sewage is carried through PVC pipes from ablution unit to an oxidation pond (UNMIS)



Bio-medical waste management

Bio-medical waste generated by medical facilities in the mission area should be disposed off either by incineration or other suitable methods. Medical authorities should ensure the disposal method does not present any immediate or future danger to personnel or the local population. Ashes should be disposed of by burial in an appropriate landfill site.

Sullage disposal

Effluent from showers/ bathing facilities must be located downstream of any military or civilian water sources. Construction should ensure proper drainage of sullage water runoff to preclude pooling. All measures will be taken to prevent creation of pest (e.g. mosquito, etc) breeding sites. Planning must be done in collaboration with Engineers.

Storm water management

Storm water management will reduce pooling within the camp area. Storm water is best managed during the base camp design process, where proper site preparation and maintenance will minimize these risks.

Personal hygiene

Maintenance of good personal hygiene includes frequent hand-washing, proper dental care, maintenance of clean, dry clothing (especially socks, underwear, and boots), and bathing with water from an approved source. If bathing facilities are not readily available at any given point in time, sites of perspiration must invariably be wiped clean with a washcloth daily. Change socks as frequently as practical. Foot powder will help prevent fungal infections.

## Oral health

Neglecting essential oral hygiene practices during deployment can result in periodontal disease and increase the risk of tooth decay. All personnel should undergo periodic dental inspection and take prompt treatment for problems, if any.

## Jet lag

Rapidly crossing several time zones may result in fatigue, irritability, reduced efficiency, and early morning wakefulness within the first 24 hours, lasting up to five days after landing. Preventive measures to reduce jet-lag include re-scheduling sleep hours to coincide with the destination time-zone before embarking upon the journey, and in-flight measures like avoidance of alcohol/caffeinated beverages, maintaining adequate hydration and refraining from overeating.

## Stress management

During the tenure of deployment to any UN Mission, the members of the peacekeeping contingent are frequently confronted with various situations which result in significant and often prolonged levels of stress on them. It is important for the Medical Officers to be able to recognize different types of stress reactions in individuals and be familiar with measures that can be taken to deal with them.

### Factors contributing to stress among peacekeepers (4)

(a) Not professionally trained for the task at hand as well as lack of influence (e.g. Military Observers, who can only monitor and report, and cannot directly intervene in the situations they are observing).

(b) Need to show impartiality to different parties in a conflict, despite personal beliefs and convictions.

(c) Lack of security and concerns about personal safety.

(d) Need to suppress emotions.

(e) Uncomfortable living conditions and lack of privacy.

(f) Separation from home, family and friends.

(g) Cultural differences, language difficulties and dietary changes.

(h) Lack of recreation facilities.

(j) Traumatic stress (e.g. witnessing violence or death, experiencing intimidation or threat, serious accident or life-threatening illness).

### Recognising mission-related stress in individuals

The following behavioral changes are likely to occur in individuals in response to undue stress :

(a) Changes in behaviour.

(b) Changes in eating habits.

(c) Sleep disturbances.

(d) Psycho-somatic complaints.

(e) Decrease in personal hygiene.

(f) Withdrawal from others.

(g) Prolonged periods of silence.

Medical officers should be able to identify persons having serious problems adjusting to deployment as they may be at risk for suicide. Recognition and early referral of personnel at risk is an important aspect of preventing suicides.

### Managing mission - related Stress

It is important to recognize the emotional, functional and physical changes in individuals accompanying stress-related reactions. While these cannot be totally prevented, awareness of such problems by an individual or his colleagues, openness in discussing such problems and the availability of professional help should this be required, are key factors to successfully managing stress.

Some of the measures to combat mission-related stress are as follows :

(a) Before deployment, commanders should ensure that all personnel have secured a current will, made arrangements for childcare, arranged for bills to be paid in absentia, and provided in advance for possible family separation.

(b) Pre-deployment training on stress-management techniques and giving adequate information on what to expect and what not to expect in the mission area.

(c) Making provisions for organized sports, recreational activities and social gatherings (such as Barakhana, screening of movies etc.) at the HQ or unit or sub-unit level.

(d) Keep personnel regularly informed about the mission situation and likely tasks in the days to come.

(e) Debriefing of personnel following exposure to traumatic events, to be conducted in group sessions, and preferably with participation of trained counsellors.

(f) Training of medical personnel to recognize signs and symptoms of stress and to manage such conditions.

(g) Access to professional counselling should this be required. This is generally available at TCC Level 2 or Level 3 hospitals.

## Road safety

### Introduction

It is important to note that road traffic accidents are the main cause of serious injury and fatalities in peacekeeping missions. In a study conducted in 1997, it was shown that out of a total of 876 accidents reviewed, 64% comprised road traffic accidents. Most resulted from human error on the part of the peacekeeper, or of another party. Although not directly responsible for accident prevention, the Medical Officer in the field has a duty to advice the contingent commander if road safety measures are not being adopted. Strict enforcement of such measures will lead to reduction in loss of human life and limb (4).

### Road safety programme

Basic components of a road safety programme in the mission area include (4, 20) :

(a) Commander's emphasis on road and vehicular safety.

(b) Clearly documented safety regulations and Standard Operating Procedures (SOPs) which are understood by all drivers and vehicle occupants. These measures have to be strictly enforced (e.g. speed limits, use of seat-belts, alcohol control, vehicle breakdown drill, restrictions on night driving and under no circumstances should any individual drive alone).

(c) Certified driving standards for military and heavy vehicles, and orientation drives for new drivers.

### Re-orientation and training of drivers

It is advised to gather prior information on the driving norms in the country to which troops are proposed to be deployed. If the situation so warrants, then special training must be conducted for all drivers on left-hand drive vehicle as well as driving on the right side of the road before leaving for the mission area. All drivers must know the informal rules of the road; in some countries, for example, it is customary to sound the horn or flash the headlights before overtaking (20). Drivers must be advised to give right of way to pedestrians, cyclists and maintain a safe driving distance from local vehicles. Medical Officers must also conduct basic first-aid training courses for all contingent members.

UN driver's permit

It is also important to note that a national driving license issued by the Troop Contributing Country to its contingent members does not suffice to drive vehicles in the mission area. In addition, a UN driving license is an essential pre-requisite for driving either the contingent-owned or UN-owned vehicles. It is the responsibility of the Transport Section of the UN Mission to conduct driving tests, assess the suitability of individuals and issue driver's permits.

### Special precautions

While travelling in conflict-prone areas of the mission, it is advisable to wear bullet proof jackets and UN helmets; keep car doors locked and windows shut and not to pick up strangers.

### First-aid kits and blood safety

All vehicles must carry adequate first-aid kits including splints, IV fluids and plasma expanders, as safety of local blood supplies cannot be guaranteed.

### Land-mines

In many UN peacekeeping missions there is a significant threat from large-scale and indiscriminate deployment of land mines. All contingent members are advised to use only those roads or tracks that have been de-mined and clearance to this effect issued by the Mine Action Service of the UN mission.

## Health education

During the pre-deployment phase, Medical Officers should endeavour to collect the relevant health intelligence on the country/ region of intended deployment and based on this impart relevant health education and training to the troops which should continue during the period of deployment at regular intervals. It is important for troops to have a high level of awareness about the anticipated health risks in the mission area and learn how to minimize the risks of acquiring these diseases in order to maintain optimal levels of health, reduce the likelihood of repatriation due to prolonged periods of illness/ convalescence and carry out the mission-mandated tasks effectively.

## Epidemiological surveillance

Senior Medical Officer/ Medical Officers in the Contingent should develop and employ a plan for epidemiological surveillance for the entire period of deployment, including during the moves, for early diagnosis and treatment of diseases/ health-related conditions which may adversely affect the troops and take appropriate containment measures, both medical and administrative, to control any outbreak. SMO of the Contingent should formulate SOPs on medical care and health of troops, in consultation with the specialist in Preventive and Social Medicine (if accompanying the Contingent), as per existing policies.

The SOPs should be issued as administrative instructions through the National Senior of the contingent.

## Notification and reporting

The SMO of the contingent is required to compile information from all contingent medical facilities and submit reports on the out-patient attendance, in-patient treatment details, disease outbreak investigation reports (on occurrence), medical aid to civilians, etc. to the following :

(a) Force HQ : Daily/ weekly/ monthly reports (as per mission policy)

(b) DGMS (Army)/ DGMS-3E (UN Cell): Weekly reports (or, as per instructions)

(c) o/o DGAFMS / DG-3A; DGMS (Army)/ DGMS-5B and AFCESC, Dept of Community Medicine (PSM), AFMC, Pune: Six-monthly reports as per format (including the conditions prevalent in the area of deployment, morbidity/ mortality reports, epidemiological investigation reports of disease outbreaks and specific recommendations (if any) on chemoprophylaxis, additional immunisation requirements, etc.).

(d) Notification about diseases governed by the International Health Regulations to the medical authorities at the Force HQ of the Mission.

All contingents that are deployed/ return from UN/ foreign assignments should send a health intelligence feedback to the Armed Forces Central Epidemiological Surveillance Centre (AFCESC), so that the information can be used to update these guidelines.

## Medical support structure in UN missions

There is a clear command structure within a peacekeeping force. The Force Medical Officer (FMedO), subordinated directly to the Force Commander (FC) (or the designated Head of Mission), plans, directs, advises and supervises all activities related to the Mission's medical support plan. He/ she is the senior medical adviser to the Force Commander (FC), and supervises all contingent medical officers in the Mission and exercises functional control of all medical assets provided for the Mission (4).

The Senior Medical Officer (SMedO) of the national contingent is the medical adviser to the National Senior in mission area as well as the FMedO's point of contact on medical matters. He/ she implements the Medical Support Plan for the Mission in accordance with UN medical policies and the FMedO's directions and oversees health-care, hygiene and implementation of preventive measures in contingent's area of operations.

### Levels of medical support

The levels of Troop Contributing County (TCC) medical support for UN peacekeeping missions are as follows :

(a) Basic Level

This effectively refers to basic first-aid and preventive medicine practised at the smallest sub-unit level. As there is no medical officer present, care is provided by the peacekeeper, or by a trained paramedic or nurse, using basic medical equipment and supplies.

(b) Level one medical support

This is the first level where a medical officer is available. The Level 1 Hospitals are usually attached to Infantry Battalions, Engineer Company, De-mining Company and other sub-units at various team-sites in the area of operations of a contingent. It provides first-line primary health care, emergency resuscitation, stabilization and evacuation of casualties to the next level of medical care within a peacekeeping mission.

(c) Level two medical support

This is the next level of medical care and the first level where surgical expertise and specialist medical facilities are available. The task of a Level Two medical facility is to provide second-line health care, in-patient treatment emergency resuscitation and stabilization, limb and life-saving surgical interventions, hygiene control and preventive medicine, basic dental care, basic laboratory support and diagnostic radiography, and casualty evacuation to the next echelon.

(d) Level three medical support

This is the highest level of medical care provided by a deployed UN medical unit. It combines the capabilities of Level One and Two units, with the additional capability of providing specialized in-patient treatment and surgery, as well as extensive diagnostic services. It is important to note that a Level Three unit is only deployed in missions with a large number of personnel, and in smaller UN missions, this level of support is generally obtained from existing civilian hospitals within the Mission area or in a neighbouring country.

(e) level four medical support

A Level Four medical facility provides definitive medical care and specialist medical treatment unavailable or impractical to provide for within a Mission area. This includes specialist surgical and medical procedures, reconstruction, rehabilitation and convalescence. Such treatment is highly specialized and costly, and may be required for a long duration. It is neither practical nor cost-effective for the UN to deploy such a unit within the Mission area. Such services are generally sought in the host country, a neighbouring country, or in the troop contributing country itself. The UN arranges for transfer of a patient or casualty to such a facility and continues to monitor the patient's progress.

### Primary role of TCC medical facilities

Military contingents are normally self-sufficient with respect to medical care, and often bring with them what appear to local populations to be large medical structures and resources. They are generally not deployed for humanitarian purposes, but rather for the care of their own and associated personnel. Where populations are medically at risk, lack of access to these facilities may generate local resentment. However, TCC medical units often receive requests from the Sector / Force Headquarters of the UN mission to provide emergency medical support to the local population on humanitarian grounds. In such instances, after providing emergency medical care at the TCC medical facility, the patient(s)

should be transferred to civilian or NGO-aided medical facilities in the mission area.

While the mandate of medical components of military forces may not allow direct assistance to local populations in a humanitarian basis, contingent medical officers can make meaningful contributions by assisting other UN agencies and International NGOs in programme development and technical assistance with the concurrence of the contingent commander. The role of

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## Appendix A

**DPKO immunization requirements by mission (updated oct 2004)**

| Region | Mission | Mandatory | Recommended | Optional |
|---|---|---|---|---|
| West Africa | UNAMSIL | Yellow Fever | Typhoid | Cholera |
| | UNMIL | | Poliomyelitis | Rabies |
| | ONUCI | | Diphtheria/ Tetanus | |
| | | | Meningococcus | |
| | | | Hepatitis A | |
| | | | Hepatitis B | |
| East Africa | UNMEE | Yellow Fever | Typhoid | Cholera |
| | MONUC | | Poliomyelitis | |
| | ONUB | | Diphtheria/ Tetanus | |
| | UNMIS | | Meningococcus | |
| | | | Hepatitis A | |
| | | | Hepatitis B | |
| North Africa | MINURSO | Yellow Fever | Typhoid | Rabies |
| | | (if coming from endemic area) | Poliomyelitis | Meningococcus |
| | | | Diphtheria/ Tetanus | |
| | | | Hepatitis A | |
| | | | Hepatitis B | |
| Middle East | UNDOF | Nil | Typhoid | Cholera |
| | UNTSO | | Poliomyelitis | Rabies |
| | UNIFIL | | Diphtheria/ Tetanus | |
| | UNAMI | | Hepatitis A | |
| | UNAMA | | Hepatitis B | |
| | UNFICYP | | Meningococcus | |
| Eastern Europe | UNMIK | Nil | Typhoid | |
| | UNOMIG | | Poliomyelitis | Rabies |
| encephalitis | | | Diphtheria/ Tetanus | Tickborne |
| | | | Hepatitis A | |
| | | | Hepatitis B | |
| | | | Influenza (winter months) | |
| South Asia | UNMOGIP | Nil | Typhoid | Cholera |
| | | | Poliomyelitis | Rabies |
| | | | Diphtheria/ Tetanus | Japanese encephalitis |
| | | | | |

## Appendix A

**DPKO immunization requirements by mission (updated oct 2004) Contd.**

| Region | Mission | Mandatory | Recommended | Optional |
|---|---|---|---|---|
| | | | Hepatitis A | |
| | | | Hepatitis B | |
| South East Asia | MINUSTAH | Yellow Fever (if coming from endemic area) | Typhoid | Rabies |
| | | | Poliomyelitis | |
| | | | Diphtheria/ Tetanus | |
| | | | Hepatitis A | |
| | | | Hepatitis B | |
| | | | Japanese encephalitis | |
| Central America | MINUSTAH | Yellow Fever (if coming from endemic area) | Typhoid | Rabies |
| | | | Poliomyelitis | |
| | | | Diphtheria/ Tetanus | |
| | | | Hepatitis A | |
| | | | Hepatitis B | |

[Source : UN Department of Peacekeeping Operations, New York, 2004]

Lt Col Rahul Ray

## Additional Information

### Units and Measures

#### Systeme International d'Unites

The use in medicine of the Systeme International d'Unites (SI) was endorsed by the 30th World Health Assembly in May 1977. The SI is universally acceptable system of units of measurement. It is essentially an expanded version of the 'metric system' and comprises units like base units and derived units.

(a) Base Units

Seven units have been selected to serve as the basis of the system. These SI base units are mentioned below together with their symbols and the quantities they measure (Table - 1) :

Table - 1 : Base Unit

| Quantity | Name of the unit | Symbol for unit |
|---|---|---|
| Length | Meter | m |
| Mass | Kilogram | kg |
| Time | Second | s |
| Electric current | Ampere | A |
| Thermodynamic | Kelvin | K |
| Luminous intensity | Candela | cd |
| Amount of substance | Mole | mol |

(b) Derived Units

By multiplying a base unit by itself or by combining two or more base units by simple multiplication or division, it is possible to form a large group of units known as 'SI derived units'. Examples of a few simple derived units are given below (Table - 2) :

Table - 2 : Desired Units

| Quantity | Name of derived units | Symbol for unit |
|---|---|---|
| Area | Square metre | $m^2$ |
| Volume | Cubic metre | $m^3$ |
| Speed | Metre per second | m/s (or $m.s.^{-1}$) |
| Acceleration | Metre per second square | $m/s^2$ (or $m.s.^{-2}$) |
| Substance concentration | Mole per cubic metre | $Mol/m^3$ (or $mol.\ m^{-3}$) |

(c) A number of SI derived units have been given special names, most of which are the names of scientists who made an outstanding contribution to the field of study concerned. Out of 18 SI derived units given special names, some are mentioned below (Table - 3) :

Table - 3 : Desired units with special names

| Quantity | Name of unit | Symbol for unit | Derivation of unit |
|---|---|---|---|
| Frequency | Hertz | Hz | $s^{-1}$ |
| Force | Newton | H | $m.\ kg.\ s^{-2}$ |
| Pressure | Pascal | pa | $n/m^2$ |
| Work; energy; quantity of heat | Joule | j | N. m |
| Power; radiant flux | Watt | w | j/s |

#### Useful Factors for Conversion

| To convert | Multiply by |
|---|---|
| Inches to metres | 0.0254 |
| Metres to inches | 39.37 |
| Inches to centimetres | 2.539 |
| Centimeters to inches | 0.3937 |
| Metres to feet | 3.28 |
| Feet to metres | 0.3047 |
| Kilometers to mile | 0.6214 |
| Grams to pounds (a voirdupois) | 0.0022 |
| Pounds to grams | 453.592 |
| Kilograms to pounds | 2.204 |
| Pounds to kilogram | 0.4537 |
| Grams to grains | 15.432 |
| Grains to grams | 0.0648 |
| Ounces to grams | 28.35 |
| Grams to ounces | 0.0353 |
| Litres to gallons | 0.22 |
| Gallons to litre | 4.546 |
| Litres to pints | 1.76 |
| Pints to litres (British) | 0.5681 |
| Litres to fluid ounces | 35.2 |
| Cubic centimeters to fluid ounces | 0.0352 |
| Fluid ounces to cubic centimeters | 28.57 |
| Gallons to cubic feet | 0.1605 |
| Cubic inches to gallons | 0.003607 |
| Cubic inches to cubic metres | 16.386 |
| Cubic feet to cubic metres | 0.0283 |
| Cubic centimeters to cubic inches | 0.061 |
| Cubic metres to cubic feet | 35.316 |
| Pints to cubic centimeters | 568.182 |
| Square feet to square yards | 0.111 |

| | |
|---|---|
| Parts per 100,000 into grains per gallon | 0.7 |
| Grains per gallon to parts per 100,000 | 1.43 |
| 1 Joule(J) to K cal | 0.0239 |
| 1 K cal to Joule | 4184 |
| 1 roentgen to Coulomb | $2.58 \times 10^{-4}$ |
| 1 rad to Grey | 0.01 |
| 1 rem to Sievert | 0.01 |
| 1 mEq/l of hardness producing ion to mg of $CaCO_3$ | 50 |
| lb per cubic feet to KG per cubic metre | 16.023 |

**Physical Data**

(a) Air

(i) **Weight :** 1 Cu ft of air at 62˚F and pressure of 14 lb weighs 0.076097 lb.

(ii) **Volume** : 1 lb of air at 62˚F and pressure of 14.7 lb, is 13.141 cft in volume.

(iii) **Mean atmospheric pressure** : 14.7 lb per square inch at sea level.

(b) Heat

(i) **Thermometer Scales**

Fahrenheit and centigrade conversion formula

(F-32) x 5/9 = C

(C x 9/5) +32 = F

(ii) **The Calorie**

It is the amount of heat required to raise 1 gram of water through 1˚C (i.e. to change the temperature of 1 g of water from 3.5˚C to 4.5˚C). The large or major calorie (sometimes spelt with a 'K' or a capital 'C' or Kilogram calorie is the amount of heat required to raise 1 Kilogram of water through 1˚C.

(C) Water

(i) **Specific gravity** : 1.0

(ii) **Standard temperature** : 62˚F or 16.6˚C

(iii) **Boiling point** : 212˚F or 100˚C

(iv) **Freezing point** : 32˚F or 0˚C

(v) 1 gallon of water weighs 10 lb at 62˚F

(vi) 1 gallon salt water weighs 10.272 lb.

(vii) 1 cu ft contains 6 ¼ gallons of water & weighs 62.5 lbs.

(viii) 1 cu ft salt water weighs 63.5 lbs.

**Measurement of light**

(a) Candela of candle power

It is the intensity of light at a point placed at a distance of one foot from a light source of a standard candle.

(b) Lumen

It is the total quantity of light, which falls on one square foot of surface, all points of which are one foot from a light source of one standard candle.

(c) Lux

It is the amount of light reaching a surface measured per unit area.

(d) Lambert

It is the amount of light reflected from a surface area.

Measurement of Daylight

Daylight factor is the ratio of illumination at a given point to illumination at a point exposed simultaneously to the whole hemisphere of the sky (taken as 500 foot candles) excluding direct sunlight. The day light factor may be summarised as follows :

**Measurement of Noise**

(a) Loudness is measured by decibel, which is a ratio of the sound in question to the smallest distinguishable sound, which is 0.0002 dynes/$cm^2$.

(b) Frequency is determined by number of cycles per second (CPS of C/S) or in Hertz (Hz). One HZ is equal to one wave per second.

$$\text{Daylight factor} = \frac{\text{Instantaneous illumination indoors}}{\text{Simultaneous occurring illumination outdoors}} \times 100$$

**Hygiene Chemicals Provisioning Scale**

The provisioning scales of certain hygiene chemicals are given in Table - 6. These scales are for the guidance of the provisioning organization only and not the scales for demand, which should be based on the local requirement under medical advice.

Contd. . . . .

## Prevention and control of diseases and important orders on health matters

### Army Orders

Some of the important Army Orders on various health matters are :

| | |
|---|---|
| Cerebrospinal fever | AO 426/64 |
| Dispensation, commutation med bd | AO 153/79 |
| Med bd: Grant of PC to SSC Offr | AO 121/79 as amended |
| Re-survey med bd(RSMB) | AO 121/79 as amended |
| Avoidance of delay in finalisation of C of I proceedings in death cases | AO 123/81 |
| Disposal of low medical category personnel other than officers | AO 46/80 as amended |
| Introduction of medical treatment entitlement certificate for ex-service personnel & widows | AO 10/97 |
| Issue of indl water sterilising outfit to Army pers travelling by train on leave/duty | AO 393/68 |
| Med exam of Armed Forces pers and families proceeding abroad at Govt expense on duty/deputation/study leave | AO 299/77 & AO 5/79 |
| Entitlement of medical treatment in civ/pvt hosps and procedures for re-imbursement of med exp | AO 32/81 |
| Precautionary measures to be undertaken while travelling by rail | AO 117/76, 56/77 |
| Malaria and other mosquito borne diseases 27/2004, | SAO 25/5/71, AO AO 6/79 & 16/86 |
| Immunization | AO 337/71 |
| Effects of cold and prevention | SAO 23/S/72 |
| Sanitary rules for cook houses | AO 515/72 |
| Scrub typhus | AO 550/72 |
| Food poisoning | AO 35/73 |
| Food handler's examination | AO 36/73 |
| Prevention of heat stroke and heat exhaustion | AO 57/73 And AO 7/80 |
| Medical care and reclassification of diseases | AO 11/2001 |
| Infectious intestinal disorders | AO 209/73 |
| Barber's shop cleanliness | AO 247/73 |
| Disposal of personnel (other than officers) on discharge from hospitals (IMB) | AO 482/73 |
| Medical treatment and disposal of Armed Forces personnel and their families suffering from pulmonary tuberculosis and leprosy | AO 150/75 |
| Accn for relatives and patients who are on DI/SI list in MHs | AO 84/77 |
| Medical treatment in civil / pvt hospitals | AO 163/77 AO 32/81 & AO 38/84 |
| Control of sexually transmitted diseases (STD) | AO 164/77 |
| Supply of spectacles to Armed Forces personnel | AO 69/79 |
| Prevention of carbon mono-oxide poisoning | AO 101/79 |
| Swimming pool sanitation | AO 149/79 |
| Control of housefly | AO 163/79 |
| Infectious hepatitis | AO 164/79 |
| Prevention of food and water borne diseases | AO 25/2004 |
| Duties and responsibilities in relation to health of service personnel and families | AO 165/79 |

| | |
|---|---|
| Prevention of rabies | AO 182/79 AO 111/80 |
| Relapsing fever | AO 202/79 |
| BPET | AO 7/80 |
| Appeal medical board | AO 14/80 |
| Dental inspection | AO 36/80, AO 71/81 & AO 39/83 |
| Effects of high altitude and prevention | AO 110/80 & AO 55/85 |
| Introduction of entitlement certificate for non service beneficiaries entitled to medical/dental treatment from service institutions | AO 120/80 And AO 16/91 |
| Medical documentation | SAO 8/S/83 |
| Medical and psychiatric examination of personnel recommended trials by court martials | AO 37/83 |
| Sick leave (officers) | AI 10/83 and para 426 of RMSAF 1983 |
| Sick leave (JCOs / OR) | Para 427 of RMSAF 1983 |
| Medical treatment and disposal of leprosy | AO 36/87 |
| Medical cat for courses of instruction | SAO 6/S/89 |
| Release medical board | AO 3/89 |
| First Aid snake bite | AO 4/89 |
| Disability Compensation Medical Board | AO 17/89 |
| Health care system in the Army- Instructions for Medical Examination and classification of serving officers | AO 11 /2001 |
| Biological hazards of micro wave radiation and Preservation | AO 269/69 |
| Boiling of milk before consumption | AO 19/65 |
| Disposal of dead body died of infectious disease | AO 428/69 |
| DDT sprays | AO 341/65 & 203/67 |
| First Aid Snake bite | AO 4/89 |
| Food inspection zones | AO 814/64 |
| Infection/intestinal diseases | AO 209/73 |
| Infectious/Serum hepatitis-prevention and control of | AO 164/79 |
| Supply of spectacles to Armed Forces Personnel | AO 69/79 |
| Prevention of Carbon Monoxide poisoning | AO 181/79 |
| Relapsing fever | AO 202/79 |
| Heath care system in the Army Instr for medical examination and classification of serving officers | AO 01/2004/DGMS |
| Health care system in the Army : Instrs for medical examination and Categorisation of serving JCOs/OR. | AO 3/2001 |

**Note** : Army Orders related to food hygiene and sanitation eg., AO 185/53, 19/65, 313/65, 515/72, 35/73, & 36/73 are under revision.

DGAFMS Office Guidelines

**Sub: Preparedness for Biological and Chemical Warfare.**

Guidelines issued by office of DGAFMS vide letter no. 3048/DGAFMS/DG 3A dt. 24 Dec 2001.

## Navy Orders

Some of the important Navy Orders on various health matters are

| | |
|---|---|
| Medical Check-up of Ex-servicemen boarded out due to T.B. | NO 31/79 |
| Medical attendance in Ships and Establishment | NO 40/79 |
| Medical Standard (Officers/Sailors) | NO 3(S)/85 |
| Mosquito Borne Diseases | NO 36/86 |
| Control of Rabies | NO 26/99 |
| Sick List Concession Officers | NO 5/87 |
| Morbidity and mortality return | NO 6/99 |
| Annual Health Return | NO 16/87 |
| Alcohol and Drug Abuse | NO 4/90 |
| Control of Meningococcal Meningitis | NO 1/91 |
| Hosp Stoppage Sick Attendant | NO 4/94 |
| Medical Treatment in quarters : Service Officers | NO 12/94 |
| Medical Treatment of dependent parents | NO 27/94 |
| Posting of personnel in low med cat to remote areas | NO 31/94 |
| Immunization | NO 34/94 |
| Naval Medical Research Advisory Panel | NO 38/94 |
| Procedure for disposal of naval personnel on discharge from hospitals | NO 45/94 |
| Refusal to undergo medical examination, treatment, operation, immunization and to appear before medical board | NO 51/94 |
| Protection of ears from high intensity noise | NO 54/94 |
| Mouth to Mouth breathing | NO 59/94 |
| Entitlement of medical treatment in civil/private hospital and procedure for re-imbursement | NO 6/95 |
| Medical Board-Assessment of Dental disability of Officers and Sailors | NO 11/95 |
| Medical examination of Naval personnel before release, retirement and discharge | NO 15/95 |
| Naval Health Committee in Shore Command/Establishments | NO 21/95 |
| Dental Returns | NO 22 & 23/95 |
| Medical and Dental Treatment of Ex-Service personnel and families | NO 24/95 |
| Notification of Communicable Diseases | NO 25/95 |
| Pest Control on Ships and Aircrafts | NO 31/95 |
| Dental Inspections | NO 32/95 |
| Sanitary Rules of Food handlers | NO 34/95 |
| Hospital and Blood Bank | NO 35/95 |
| Provision of beds for crisis expansion - Naval Hospitals | NO 36/95 |
| Food Poisoning | NO 38/95 |
| Annual Medical Examination Officers | NO 2/96 |
| Psychiatric examination, treatment and disposal of naval personnel and families | NO 3/96 |
| OPD treatment to naval personnel and families from Govt Civil hospitals where service facilities are not available | NO 21/96 |
| Reporting of casualties | NO (Spl) 3/99 |
| Maintenance of STD Register | CNO 1/2000 |
| Preventive measures against effects of Heat | NO 3/99 |

### Air Force Orders

Some of the important Air Force Orders on various health matters are given below: -

| | |
|---|---|
| Arsene poisoning | AFO 147/70 |
| Air craft noise and preservation of hearing | AFO 239/70 |
| CO Poisoning | AFO 460/70 |
| Relapsing fever | AFO 473/70 |
| Responsibilities of AF Health | AFO 162/75 |
| Prevention of scrub typhus | AFO 277/76 |
| Aircraft noise and preservation of hearing | AFO 326/76 |
| Effects of cold and high altitude and their prevention | AFO 462/76 |
| International certificate of vaccination and inoculation | AFO 461/76 |
| Malaria eradication | AFO 1091/76 |
| Prevention of epidemic typhus (louse borne) | AFO 163/76 |
| Prevention of diseases conveyed by infected food and drinks | AFO 414/76 |
| Prevention of viral hepatitis | AFO 113/80 |

**Themes for World Health Day :** Themes for the World Health Day since 1950 are given below:

1950 Know your own health services
1951 Health of your child and world's children
1952 Healthy surroundings make healthy people
1953 Health is wealth
1954 Nurse, pioneer of health
1955 Clean water means better health
1957 Food and health
1958 Ten years of health progress
1959 Mental illness & mental health in the world of today
1960 Malaria eradication a world challenge
1961 Accidents and their prevention
1962 Preserve sight Prevent blindness
1963 Hunger Disease for millions
1964 No truce for tuberculosis
1965 Eradication of small pox
1966 Man and his cities
1967 Partners in health
1968 Health in the world of tomorrow
1969 Health, labour and productivity
1970 Early detection of cancer saves life
1971 A full life despite diabetes
1972 Your heart is your health
1973 Health begins at home
1974 Better food for a healthier world
1975 Small pox; point of no return
1976 Foresight prevents blindness
1977 Immunize and protect your child
1978 Down with high blood pressure
1979 A healthy child a sure future
1980 Smoking or health; choice is yours
1981 Health for all by the year 2000
1982 Add life to years
1983 Health for all the countdown has begun
1984 Children's health tomorrow's wealth
1985 Healthy youth our best resource
1986 Healthy living every one a winner
1987 Immunization a chance for every child
1988 Health for all all for health
1989 Let's talk health
1990 Our planet, our health think globally, act locally
1991 Should disaster strike, be prepared
1992 Heart beat the rhythm of health
1993 Handle life with care prevent violence and negligence
1994 Oral health for a healthy life
1995 Target 2000 A world without polio
1996 Healthy cities for a better life
1997 Emerging infectious diseases. Global response. Global alert
1998 Pregnancy is special, let us make it safe
1999 Active aging makes the difference
2000 Safe blood starts with me
2001 Mental Health Stop exclusion Dare to care
2002 Move for Health
2003 Shape the Future of LifeHealthy Environment for Children
2004 Road Safety is No Accident
2005 Make Every Mother and Child Count
2006 Working Together for Health
2007 Invest in Health , Build a Safer Future
2008 Protecting Health from Climate Change

## Important Health Related Days

| | |
|---|---|
| **January** | |
| 01 Jan | Anti smoking Day |
| 12 Jan | National youth Day |
| 30 Jan | Leprosy Eradication Day |
| 30 Jan | Martyr's Day |
| **February** | |
| 05 Feb | Oral Health Day |
| **March** | |
| 06 March | National Science Day |
| 08 March | International Women' Day |
| 15 March | National Environmental Day |
| 22 March | World Water Day |
| 24 March | World Tuberculosis Control Day |
| **April** | |
| 06 April | Pulse Polio Immunisation Day |
| 07 April | World Health Day |
| 18 April | World Heritage Day |
| 22 April | World Earth Day |
| **May** | |
| 01 May | Labour Day |
| 03 May | International Energy Day |
| 11 May | National Technology Day |
| 12 May | World Nursing Day |
| 14 May | Mother's Day |
| 17 May | World Telecommunication Day |
| 21 May | Anti- Terrorism Day |
| 29 May | Commonwealth Day |
| 31 May | No Tobacco Day |
| **June** | |
| 05 June | World Environmental Day |
| 26 June | International Anti-Drug Day |
| **July** | |
| 01 July | Doctor's Day |
| 10 July | Safe Motherhood Day |
| 11 July | World population Day |
| 27 July | WHO ORS Day |
| **August** | |
| 01 August | World Breast feeding Day |
| 01-07 August | World Breast Feeding week |
| 05 August | Filaria Control Day |
| **September** | |
| 01-07 September | National nutrition Week |
| 08 September | International Literacy Day |
| 25 September | World Heart Day |
| 27 September | World Tourism Day |
| **October** | |
| 01 October | Voluntary Blood Donation Day |
| 01 October | World Habitat Day |
| 06 October | World Wildlife Day |
| 07 October | World Housing Day |
| 11 October | World Sight Day |
| 12 October | Mental Health Day |
| 14 October | World Disaster Control Day |
| 16 October | World Food Day |
| 21 October | Iodine Deficiency Disease Control day |
| 31 October | National Integration Day |
| **November** | |
| 01 November | World Ecology Day |
| 11 November | Anti- Poverty Day |
| 15-21 November | National Newborn Week |
| **December** | |
| 01 December | World AIDS Day |
| 02 December | National Population Prevention Day |
| 03 December | World Disability Day |
| 10 December | World Human Right Day |
| 11 December | UNICEF Day |
| 23 December | Farmer's Day |

## Indicators for Obesity

**(a) Body Mass Index (BMI)**

= Weight in Kg/Height in (metre)$^2$

Normal range = 20-25

A person is definitely obese if it is more than 27

**(b) Waist Hip ratio**

Waist is measured with a tape at a point mid way between 12$^{th}$ rib and upper border of iliac crest on both sides.

Hip is measured with a tape at upper point of greater trochanter of femur on both the sides.

Normal range 0.6 0.9

A person has definite central obesity if it is more than 0.9.

**(c) Skin fold thickness measured with the help of a caliper**

Normal ranges

(i) Triceps skin fold = 12-15 mm

(ii) subscapular skin fold = 18-20 mm

**(d) Broca index**

=Height (cm) minus 100

## Ideal Weight as per age and Height (AO -01 /2004)

Table - 4 : Male average nude weights in kilograms for different age groups and heights
(10% variations on either side of average acceptable)

| Height in Cms | AGE IN YEARS | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 15-17 | 18-22 | 23-27 | 28-32 | 33-37 | 38-42 | 43-47 | 48+ |
| 156 | 48 | 49 | 51 | 52.5 | 53.5 | 54 | 54.5 | 55 |
| 158 | 49 | 50 | 52 | 54 | 55 | 55.5 | 56 | 56.5 |
| 160 | 50 | 51 | 53 | 55 | 56 | 56.5 | 57 | 57.5 |
| 162 | 51 | 52.5 | 54.5 | 56 | 57.5 | 58 | 58.5 | 59 |
| 164 | 52.5 | 53.5 | 55.5 | 57.5 | 59 | 59.5 | 60 | 60.5 |
| 166 | 53.5 | 55 | 57 | 59 | 60.5 | 61 | 61.5 | 62 |
| 168 | 55 | 56.5 | 58.5 | 60.5 | 62 | 63 | 63.5 | 64 |
| 170 | 56.5 | 58 | 60 | 62 | 64 | 64.5 | 65 | 65.5 |
| 172 | 58 | 60 | 61.5 | 63.5 | 65.5 | 66 | 66.5 | 67.5 |
| 174 | 59.5 | 61 | 63.5 | 65.5 | 67.5 | 68 | 68.5 | 69 |
| 176 | 61 | 62.5 | 65 | 67 | 69 | 69.5 | 70 | 71 |
| 178 | 62.5 | 64 | 66.5 | 68.5 | 70.5 | 71.5 | 72 | 72.5 |
| 180 | 64 | 65.5 | 68 | 70.5 | 72.5 | 73 | 74 | 74.5 |
| 182 | 66 | 67.5 | 69.5 | 72 | 74 | 75 | 75.5 | 76.5 |
| 184 | 67 | 70 | 71.5 | 74 | 76 | 76.5 | 77.5 | 78 |
| 186 | 69 | 70.5 | 73 | 75.5 | 78 | 78.5 | 79 | 80 |
| 188 | 70.5 | 72 | 75 | 77.5 | 79.5 | 80 | 81 | 82 |
| 190 | 72 | 73.5 | 76 | 78.5 | 80.5 | 81 | 82 | 83 |
| | | | | | | | | |

The body weights are given in this chart corresponding to heights (in cms) on even numbers only. In respect of the heights (in cms), in between, the principle of "average" will be utilized for calculating body weights.

Table - 5 : Female average weight in kilograms for different age groups and heights
(10% variations on either side of average acceptable)

| Height in Cms | AGE IN YEARS | | | | | | |
|---|---|---|---|---|---|---|---|
| Cm | 20 | 25 | 30 | 35 | 40 | 45 | 50 |
| 148 | 38.5 | 41.0 | 42.5 | 44.0 | 45.0 | 46.5 | 47.0 |
| 150 | 40.5 | 41.5 | 43.5 | 45.0 | 46.0 | 47.0 | 48.0 |
| 153 | 42.0 | 43.5 | 45.5 | 46.5 | 48.0 | 48.5 | 49.5 |
| 155 | 43.0 | 44.5 | 46.0 | 47.5 | 49.0 | 49.5 | 50.0 |
| 158 | 45.0 | 46.5 | 48.0 | 49.5 | 50.5 | 51.5 | 52.0 |
| 160 | 46.0 | 47.5 | 49.0 | 50.5 | 51.5 | 52.5 | 53.0 |
| 163 | 47.5 | 49.0 | 51.0 | 52.0 | 52.0 | 54.0 | 55.0 |
| 165 | 49.0 | 50.5 | 52.5 | 54.0 | 55.5 | 56.0 | 57.5 |
| 168 | 50.0 | 52.0 | 54.0 | 55.5 | 57.0 | 58.0 | 59 |
| | | | | | | | |

TABLE - 6(A) : Provisioning scales for hygiene chemical items

| S. No. | Item | A/U | Percentage of str for provisioning | | Scale per 1000 men per month | | Remarks |
|---|---|---|---|---|---|---|---|
| | | | Field | Peace | Field | Peace | |
| 1. or 4) be | *Deltamethrin 2.5% WP or | Kgs | 50 | 80 | 0.25 | 0.25 | 1. Either of the Synthetic pyrethroids (Sr 1, 2, 3 will be procured. However, the insecticides will suitably rotated to avoid devp of resistance. 2. The requirement of residual insecticide will be worked out in the ratio. Malathion : Synthetic pyretheroids :: 30 : 70 |
| | | | | | | | |
| 2. | *Cyfluthrin 10% WP or | Kgs | 50 | 80 | 0.25 | 0.25 | |
| 3. | *Lambdacyhalothrin | Kgs | 50 | 80 | 0.25 | 0.25 | |
| | 10% WP or | | | | | | |
| 4. | *Bifenthrin | Kgs | 50 | 80 | 0.25 | 0.25 | |
| 5. | *Malathion 50% | Ltrs | 50 | 80 | 10 | 10 | The requirement of larvicides will be worked out in the ratio Baytex : Abate : BTI : Baytex Gran :; 30 : 30 : 20 : 20 |
| 6. in | Baytex 1000 | Ltrs | 50 | 100 | 02 | 05 | |
| | | | | | | | |
| 7. | Abate 50% EC | Ltrs | 50 | 100 | 02 | 05 | |
| 8. | Baytex Granules | Kgs | 50 | 100 | 02 | 07 | |
| 9. | Bacillus Thuringiensis var israelensis (Bti) | Ltrs | 50 | 100 | 25 | 50 | |
| | 12 AS | | | | | | |
| 10. | Pyrethrum 2% | Ltrs | 100 | 100 | 3.02 | 3.02 | The requirement of fogging agents will be worked out in the ratio Malathion 95% : Deltametthrin 1.5% 30 : 70 |
| 11. worked | Malathion 95% Technical | Ltrs | 80 | 80 | 05 | 05 | |
| | | | | | | | |
| 12. | Deltamethrin 1.25% ULV | Ltrs | 80 | 80 | .05 | .05 | The requirement of synthetic pyrethroids for impregnation will be worked out in the ratio. Deltamethrin 2.5% SC : Cyfluthrin 5% EW |
| 13. bednets | Deltamethrin 2.5% SC | Ltrs | 100 | 100 | 22 | 22 | |
| | | | | | | | |

| S. No. | Item | A/U | Percentage of str for provisioning | | Scale per 1000 men per month | | Remarks |
|---|---|---|---|---|---|---|---|
| | | | Field | Peace | Field | Peace | |
| 15. | Mosfree | Kgs | 80 | 100 | 1600 | 2000 | The requirement of Repellants will be worked out in the ratio<br>Mosfree : Odomos : DEPA 20%<br>60 : 30 : 10 |
| 16. | Odomos | Kgs | 80 | 100 | 800 | 1000 | |
| 17. | DEPA 20% (Spray) | Kgs | 80 | 100 | 800 | 1000 | |
| 18. | Diflubenzuron 25% WP | Kgs | 100 | 100 | 0.5 | 0.5 | The requirement of antifly agents will be worked out in the ratio.<br>Nuvan : Diflubenzuron 25% WP :: 80 : 20 |
| 19. | Nuvan | Ltrs | 100 | 100 | 01 | 01 | |
| 20. | Coumatetralyl 0.0375% Bait | Kgs | 100 | 100 | 2.5 | 2.5 | The requirement of rodenticide will be worked out in the ratio Coumatetralyl : Bromadialone<br>50 : 50 |
| 21. | Bromadialone 0.005% Bait | Kgs | 100 | 100 | 2.5 | 2.5 | |
| 22. | Baygon | Ltrs | 100 | 100 | 03 | 05 | The requirement of anti-cockroaches agents will be worked out in the ratio<br>Baygon : Fipronil<br>80 : 20 |
| 23. | Fipronil 0.05% Gel | No. (Cartridge) | 100 | 100 | 01 | 01 | |
| 24. | DEPA 50% | No. | 100 | 30 | 1000 | 300 | To be procured and issued in scrub typhus infested areas. |
| 25. | Cresoli Liquid Black | Ltrs | 40 | 60 | 160 | 240 | |
| 26. | Lime slacked | Kgs | 100 | 100 | 05 | 05 | |
| 27. | Water Sterilising Powder | Kgs | 100 | 50 | 15 | 15 | |
| 28. | PAC (Polyvinyl Aluminum Chloride) | Ltrs | 100 | 20 | 25 | 25 | |
| 29. | Aquatabs | No. | 100 | 30 | 500 | 300 | |

Table - 6 (B) : Scales for residual insecticides in north-east sector

| S. No. | Item | A/U | Percentage of str for provisioning | | Scale per 1000 men per month | | Remarks |
|---|---|---|---|---|---|---|---|
| | | | Field | Peace | Field | Peace | |
| 1. | DDT 50% | Kgs | 50 | 50 | 01 | 04 | 1. Either of the Synthetic pyretherolds (Sr 3, |
| 2. | Malathion 50% | Ltrs | 20 | 10 | 10 | 10 | 4, 5 or 6) will be procured. |
| 3. | Deltamethrin or | Kgs | 50 | 80 | 0.25 | 0.25 | 2. The requirement of residual insecticide will |
| be | | | | | | | |
| 4. | Cyfluthrin or | Kgs | 50 | 80 | 0.25 | 0.25 | worked out in the ratio |
| 5. | Lambdacyhalothrin or | Kgs | 50 | 80 | 0.25 | 0.25 | DDT : Malathion : Synthetic pyretheroids :: |
| 6. | Bifenthrin | Kgs | 50 | 80 | 0.25 | 0.25 | 70 : 20 : 10 |
| | | | | | | | 3. After the phasing out of DDT the ratio would |
| be | | | | | | | |

Authy : DGAFMS letter No.25114/DGAFMS/DG-3A dated 14 May 2004



Table - 6 (C) : List of hygiene chemicals

| S. No. | Item | Use | Method of preparation | Remarks |
|---|---|---|---|---|
| **ADULTICIDES : As residual insecticides (for spray on walls as per stn pgme)** | | | | |
| 1. and | Deltamethrin 2.5% WP Synthetic pyrethroid with rapid knock down effect and long residual life. | Used as a residual spray against mosquitoes. Effect lasts up to 3 months. No. of spray rounds required 2/annum. | Mix 400 gm in 10 litres of water and spray over 500 Sq. m area @ 20 mg a.i. per Sq.m. | A broad spectrum insecticide can be used against other vectors pests also. |
| 2. m area | Cyfluthrin 10% WP Synthetic pryethroid with rapid knock down effect and long residual life. | Used as a residual spray Effect lasts up to 3 months. No. of spray rounds required 2/annum. | Mix 125gm in 10 liters of water against mosquitoes. @ 25 mg a. i. per Sq. m. | -do- and spray over 500 Sq. |
| 3. | Lambdacyhaloithrin 10% WP Synthetic pyrethroid with rapid knock down effect and long residual life. | Used as a residual spray Effect lasts up to 3 months. No. of spray rounds required 2/annum. | -do- against mosquitoes. | -do- |
| 4. | Bifenthrin | -do- | -do- | -do- |

| S. No. | Item | Use | Method of preparation | Remarks |
|---|---|---|---|---|
| 5. | Malathion 50% EC | Used as a residual insecticide. | | Mix 1 Litre in 10 Litres |
| of water | To be used in Malathion Organophosphorus Insecticide. | Effect lasts up to 2 months. | (5%) spray over 250 Sq m. @ | susceptible areas. 02 |
| coats | Available as amber coloured liquid. | No. of spray rounds required | 2gm a.i. per Sq m. | of spray are required to |
| be | | 3/annum. | | done to get the right dose. |
| 6. | DDT (50%) WP | Insecticide used for killing | Mix 1 Kg in 10 Litres of water | |
| and | To be used in DDT Organochlorine Insecticide supplied in powder form | adult mosquitoes. Residual effect up to one month. No. of spray round 2/annum | spray over 500 Sq. m area @ 1 gm a.i. per Sq.m. | susceptible areas. To be gradually phased out by 2007. |
| **FOR IMPREGNATION OF BEDNETS/MOSQUITO NETS** | | | | |
| 1. | Deltamethrin 2.5% SC Synthetic pyrethroid to be used specifically for | To be used as personal | Steps of impregnation of nets | Re-treatment required |
| absorption | treatment of bed nets. | every six months. It is | protective measure against | (a) Estimate water |
| | treated bed nets | mosquitoes. | capacity of net mosquito. | advisable not to wash |
| | | | (b) Add 11 ml of insecticide in the above qty of water. | frequently. |
| | | | (c) Dip net mosquito in solution till completely soaked and entire solution absorbed. | |
| | | | (d) Rub and squeeze net to ensure equal distribution in the net. | |
| | | | (e) Dry nets by laying them on ground. Once semi-dry hang on a wire in shaded area for complete drying. | |
| 2. | Cyfluthrin 5% EW Synthetic pyrethroid to be used for treatment of bed nets. | To be used as personnel protective measure against mosquitoes. | 1 ml per 1 sq.m. area in the required quantity of water @ 50 mg a.i. per Sq.m. Method of trearment as followed for deltamethrin. | Re-treatment required every six months. It is advisable not to wash treated bed nets frequently. |
| **SPACE SPRAY (To be sprayed after closing all doors and windows and open after ½ hr)** | | | | |
| 1. | Pyrethrum 2% | Used for indoor space spray. | Mix 1 litre with 19 litres of K-Oil | |
| or | To be used for quick knock | | | |
| | Natural insecticide used for space | | Diesel and spray 400 | |

| S. No. | Item | Use | Method of preparation | Remarks |
|---|---|---|---|---|
| gm hectare. | pyrethroid used during outbreaks or impending epidemics of vector borne diseases on advice of health auth. | be used during dawn or dusk. Windows and doors should be kept down of vectors. | | or K-Oil and spray @ 0.5 a.i. per open during the fogging operation. The speed of the vehicle should be about 06 Km/hr. |
| 2. | Malathion 95% Technical used for outdoor thermal fogging. | Fogging to be done during dawn or dusk when the wind velocity is low. | Mix 5 litres in 95 litres of diesel or K-Oil. | -do- |
| **LARVICIDE (For killing mosquito larvae-in water collections where breeding occurs)** | | | | |
| 1. water and when water | Fenthion 1000 EC Organophosphorus insecticide available as a brown liquid with a garlic smell. | 1. Not to be used in drinking/potable water Reapply every week. | Used as a mosquito larvicide in polluted water collections. depth is upto 10 cm. Mix 25 ml in 10 litres of water and spray over 500 Sq.m. when water depth is upto 50 cm. | Mix 5 ml in 10 litres of spray over 500 Sq.m. collections. 2. For adult mosquitoes and flies in outdoor locations mix 15 ml in litres of water and spray over 1000 sq.m. area. |
| 20 2. with stagnant/polluted | Fenthion Granules 2% | Used for mosquito larval control in water with organic pollution and weed growth. | Use 5 Kg per hectare in water upto 10 cm depth. Use 25 Kg per hectare in water upto 50 cm depth. | Is thrown (broadcast) hand in water. |
| 3. and meters. Do when used | Temephos 50% EC it is an organophosphorus insecticide available as a brown coloured viscous liquid. | Used for mosquito larval control in potable water. It has other aquatic vectors like black fly. Reapply every week. | Mix 25 ml in 10 litres of water a high mammalian safety. in potable water. | spray over 500 linear not increase the dose |
| 4. of water | Bacillus Thuringiensis var israelensis It can also be used against (Bti) 12 AS it is a Biocide that kills mosquito larval stages on ingestion | Should not be used in potable water. Available in 1200 ITU/mg potency. Repeat | (2.5%) and spray @ 1 litre per 50 linear metre. | Mix 250 gm in 10 litres larval stages of black flies. |

| S. No. | Item | Use | Method of preparation | Remarks |
|---|---|---|---|---|
| | as a ready to use bait. | required. | It is placed in the evenings and multiple dose consumption results in death of rodents. | |
| 2. with | Bromadialone 0.005% bait. It is a single dose anticoagulant. | Available as a ready to use bait. | A single dose consumption by rodents results in death. Single dose of 50 mg/Kg bait kills rats and mice. | To be used in rotation Coumatetralyl. |
| **COCKROACHES** | | | | |
| 1. | Propoxur 20% EC. It is a carbamate insecticide. Available as white to brown colour liquid | To be used for cockroaches It has rapid knock down. | Mix 100 ml in 1 litre of water and spray over 100 sq.m. area. | It is also used for debugging |
| 2. crevices of | Fipronil 0.05% Gel. It is an insecticide and of the Phenyl Pyrazole group. where cockroach infestation is present. | It can be used anywhere treatment against cockroaches. It is a safe, non-staining, odourless and extremely effective product. | To be used in crack and crevice cockroaches in kitchen and dining areas. To be reapplied when the gel is consumed by the cockroaches. | Apply in cracks and common harbourages |
| **ANTI FLY** | | | | |
| 1. is a against | Dichlorvos (DDVP) 76% EC It is an organophosphorous insecticide available as a light blue coloured liquid with high vapour pressure. | It is used as a house fly larvicide. It has a rapid knock down effect and a long residual life. | Mix 10 ml in 1 litre of water and spray over 50 sq.m. area (0.5%) | Spraying should be done under supervision as it highly toxic insecticide. It can also be used bedbugs, cockroaches, mosquitoes, fleas etc. |
| 2. water and | Diflubenzuron 25% WP. It is an insect growth regulator. | Can be used as a larvicide. It inhibits the synthesis of chitin. | It is used as a house fly spray over 10 sq.m. area @ 1 gm a.i. per sq.m. | Mix 10 gm in 5 litres of mosquito larvicide also. |
| **PURIFICATION OF WATER** | | | | |
| 1. requirement | Water Sterilising Powder White powder with strong smell of chlorine. Potency maintained only by | Used by Engrs for disinfecting For disinfecting water. It is water before issue to tps. | est by Horrock's test. Make paste Used for disinfecting vegetable | For disinfecting water- issued only to Engr Regt. and add in water |

| S. No. | Item | Use | Method of preparation | Remarks |
|---|---|---|---|---|
| 2. Engr of water | PAC (Polyvinyl Aluminium Chloride) Supplied in liquid form. potable water in | It is used to quicken the settling down of suspended impurities in water, before it is chlorinated. | It is added to water in canvas tank and stored water. if slightly turbid. ~~Add 18 ml per 1000 litres of~~ water if highly turbid. | Only to be issued to Regt/MES for supply of Add 9 ml per 1000 litres field/peace. |
| 3. till tablet | Aquatabs Available as tablets in blister packs. | For sterlising water in individual water bottle, drivers on convoy duties, patrol parties, etc. Also be issued to tps on leave/TD passing through areas of impending epidemics on advise of ~~med auth.~~ | Add one tablet in 1 litre water dissolves. | bottle. Shake the bottle |
| **OTHER ITEMS** | | | | |
| 1. face, lips. | Lip Salve ~~Issued to tps at high~~ Supplied in tubes. altitude. | A cream for prevention of cracking of lips/cheeks in cold weather. | Apply by finger or cotton on | |
| 2. | Foot Powder ~~Supplied in plastic containers.~~ Contains boric acid 6%, Starch 10%, Salicylic Acid 2%, Zinc stearate 3%, Talc 78% and Excucated Alum 1%. | It is a fungicide. Also used to ~~prevent fungal infection.~~ | Wash and dry toes, groin and ~~axilla to remove sweat and~~ moisture. Sprinkle between toes/other parts of body. | |
| 3. black water and drains/floors/ latrines. | Cresoli Liquid Black. A dark brown, oily, emulsifiable liquid. Turns white on dilution with water. | Used as disinfectant for to enter into septic tanks latrines/bath rooms/ hospitals as it damages the night etc. | For Drains- sputum mug/linen/drains in For Hospitals- Add 50 ml in 1ltr of water and steep linen/for 4 hrs before washing. Also used to disinfect | Do not allow Cresoli Add 25 ml in 1 ltr of spray along soil digesting bacteria. |

Col RajVir Bhalwar & Wg Cdr Rajesh Vaidya

# Military Preventive Medicine

## Introduction

Mathematician philosopher Bertrand Russell had stated that man is continuously engaged in three kinds of conflicts - **Man and Nature; Man and Man; and Man and Himself** - in that order. A study of history of mankind confirms this view. Men come closer to each other when pitted against nature, be it natural calamities like earthquakes, floods, etc or day to day individual struggles against nature in finding food, clothing and shelter. Once he has conquered nature, he turns his aggression against fellow human beings the extreme spectrum of which is war. Once he has vanquished his mortal enemy he turns to self-indulgence in an attempt to avoid boredom giving rise to the modern life style diseases of overindulgence.

What took mankind centuries to experience is experienced by a soldier in a single lifetime, either in combat or preparing for combat. Deployments in alien and hostile environments, be it the Siachen glacier, the deserts of Rajasthan, or the jungles of North-East, take their toll in form of injuries and diseases due to hostile environment manifesting in cold injuries and effects of high altitude in the glacier, effects of heat in the desert and arthropod- borne diseases like malaria in the forests of North-East outnumber battle casualties. Once he survives these vagaries of nature and the uncertainties of battle, he faces periods of inactivity and perhaps loneliness, leading to ennui under stress of which some men loose their morale leading to psychiatric morbidity and incidence of sexually transmitted infections including HIV (1).

Among all the three adversaries, nature still reigns supreme. Deserts, jungles, severe cold, severe heat, and other unhealthy environments still account for most of the morbidity and mortality among the Armed Forces personnel. Any terrain is strategically and tactically disadvantageous if disease conditions are harmful to the troops operating in it.

Unit effectiveness is greatly dependent upon the health of its soldiers. Military units are unable to carry out their missions when the soldiers are weakened by disease. The success or failure of an Army, the outcome of a war, and the fate of a Nation may, therefore, rest upon how well diseases are prevented through effective preventive medicine practices in the units. For example, historical records of Armies in the field are replete with accounts of failures for which disease was a major contributing factor. This was true of Napoleon in his retreat from Moscow in 1812. Confronted with cold weather and louse borne typhus, his elite Army was almost completely decimated (2).

Napoleon's loss is understandable in view of his lack of knowledge concerning the medical threat. But, modern armies have also experienced great losses from preventable diseases. Arthropod- borne diseases alone were responsible for the loss of 16,576,100 man- days among United States Armed Forces during World War II. The entire Asia - Pacific campaign in World War II was seriously threatened by the debilitating effects of malaria (3).

During the talk of strategy of the South East Asian Campaign, Admiral Mountbatten stated, "More serious than the monsoon, however, was the incidence of tropical diseases. The jungles of Burma are infested with malaria mosquitoes, the scrub typhus mites, and the bacteria and amoebae of dysentery. Between them they presented a more redoubtable enemy than the Japanese themselves. I, therefore, set up at once an inter-service, inter-Allied medical advisory division to help the research and to organize an offensive drive against disease to be waged by the medical services. In 1943, for every man who was admitted to hospital with wounds, there had been 120 who were casualties from the tropical diseases. By 1944, these 120 men had been reduced to 20, although hospital admission still reached between 14 to 15 per thousand per week in peak periods. By 1945, the rate had dropped to ten men sick for one battle casualty and during the last six weeks of the war, these ten had been reduced to six. The enemy had no medical advisory division and appears to have made no advance in medical research. As our troops became more immune from circumstances against which the Japanese had no remedy, I was determined to enlist disease as an additional weapon on our side and deliberately chose unhealthy areas in which to fight" (4).

## Factors affecting health of troops

The impact of casualties caused by preventable diseases upon military campaigns has been a prominent and a continuous feature of military operations. From the beginning of recorded history up to the present time, Armies have had immense problems with heat, cold, and communicable diseases. It was realized in the past, as it is universally agreed today that losses of men in war from sickness far exceed the losses due to battle wounds. Frederick of Prussia said, "Fever cost me as many men as seven battles" and that saying was as true in the SE Asia Campaign during the Second World War as when uttered almost 150 years ago. The ultimate objective of a military force, success in battle, demands that troops be maintained in a constant state of good health. Among the many health hazards, there are four major components of the health threat to field forces:

(a) Heat

During the 1967 Arab- Israeli conflict, the Israelis enveloped the Egyptians, severing their lines of support. The Egyptians suffered a total of 20,000 deaths, mostly due to heat while the Israelis had no deaths due to heat and only 128 cases of heat injury. The Israelis demonstrated that health hazards, such as heat, could be as effective as tactical weapons in securing success on the battlefield. Our troops operating in the deserts of Rajasthan, also need to be protected from the ill effects of extreme heat.

(b) Cold

In World War II, during the winter of 1944- 45 in the European theatre, over 54,000 US soldiers were admitted to hospitals with cold injuries. Over 90, 000 US soldiers were admitted with cold injuries throughout the war (5). In the twenty four days the British were in combat on the Falkland Islands, they sustained 777 total casualties, 109 (or 14%) were cold injuries. When the British had the Argentinians surrounded at Port Stanley, they could have waited until the Argentinians exhausted their food and water. But they were forced by the adverse environment to attack, thus sustaining additional combat casualties. Our troops deployed in the Siachen glacier, are engaged more in the day to day battle against a bitterly cold, high altitude environment rather than frequent engagements with the enemy. The respiratory group of ailments has also increased due to these adverse environmental conditions.

(c) Arthropods

There are many species of arthropods that transmit diseases, which seriously affect military operations. Napoleon's Le Grand Armee numbered over 600,000 when it crossed the Russian border in June of 1812. Although he succeeded in taking Moscow, guerrillas, disease, and cold injury decimated his troops, forcing his retreat. Only 100,000 men returned to France. There were 70, 000 combat losses versus 430,000 losses due to disease. Of these, over 100,000 of Napoleon's soldiers were lost to louse borne typhus (6). In our conflicts with China and Pakistan, the same experience was repeated. The areas were infested with malaria mosquitoes and scrub typhus mites, and the latter disease caused at least 500 casualties in a vital combat sector . It is extremely unfortunate that valuable lessons learnt during wars are so quickly forgotten after the combat is over.

(d) Diarrhoeal diseases

These can be contracted from contaminated water or food, but in either case it can have a catastrophic impact on a fighting force as illustrated by Rommel's predicament in North Africa. Not one of Rommel's original highly successful generals was available to help him when he needed them most- at El Alamein. They had all, over time, been medically evacuated for illness. Rommel himself was not present when the battle began, he was in Germany recovering from hepatitis. His Chief of Staff and his Intelligence Officer were evacuated just prior to the battle and his Operations Officer was evacuated during the battle, all three for amoebic dysentery. In 1980, during Operation Bright Star, the US commander rewarded his troops for a job well done by allowing them to go into town the evening prior to redeployment. Thirty percent of his command contracted shigellosis and were sick with gastroenteritis on the flight back to the States.

In the field our soldiers have increased vulnerability to preventable diseases because of :

(a) The harshness of the environment, and the tactical situation, often requiring them to go into places good sense tells one to avoid. The environment may be mosquito- infested jungles; sandfly infested villages; hot, dusty deserts; or cold windy plains and high altitudes. Our soldiers and their leaders must be prepared to live and fight in such places.

(b) The disruption of the body's natural defenses. The human body has an excellent capacity to protect itself against disease and climatic injury. But the efficiency of these mechanisms is dependent upon one's overall well being. If soldiers are deployed around the world (as in UN Peace Keeping Missions), there may be disruption in their circadian rhythms. Added to this, exposure to extremes of heat or cold, meals at irregular hours, and deprivation of sleep, will result in troops who are more susceptible to illness and combat stress.

(c) Breakdowns in basic sanitation. Potable water and proper waste disposal are examples of things taken for granted in a garrison. But even using the latrine or changing socks becomes a challenge for the soldier when living in a muddy foxhole.

The Individual in a Field Environment Ordinarily, a soldier maintains a high standard of personal hygiene in a peacetime environment with convenient facilities. In the field, however, where proper sanitation requires coping with the elements of nature, problems arise; the soldier is suddenly faced with inconveniences. In a peacetime garrison, an individual follows a set course after rising in the morning. Routine acts of personal hygiene are performed in a conveniently located toilet and bathroom that is warm and has hot and cold water. However, upon arising in the field, one may feel too cold to change into clean underwear. There may be insufficient water to enable every soldier to have a daily bath and wash his undergarments. The toilet in the field is not as convenient and hygienic as the one in the garrison. An ordinarily well groomed individual may become dirty and unkempt in such an environment. Filth and disease go hand in hand. Dirty, sweaty socks may cause the feet to be more susceptible to disease. Dirty clothing worn for a prolonged period of time and unwashed hair are open invitations to lice. The problems entailed in reducing preventable diseases, therefore, pertain not only to the existing elements of nature but also to the reactions of soldiers brought into that environment. Inadequate individual personal hygiene in the field is one of the most difficult problems to overcome, because it requires a sense of responsibility on the part of each individual to try to maintain his health regardless of the difficulties encountered. This also includes the difficulty of ensuring personal prophylactic measures such as use of mosquito repellants for prevention of malaria so vital during night operations / exercises particularly when most vectors may be resting outdoors as is common in forested areas.

Reference in respect of camp sanitation are found in Susruta's works, where it was enjoined on medical men that they should be aware of the possible harmful effects to the health of troops and animals through shelter, water, food, fuel and fodder and to constantly protect the commander and his forces by taking all possible preventive measures against any harm to their health. In Chapter 7 of Mahabharata (600 BC) Karna, the

Commander-in-Chief of Kauravas warned that prevalence of fly nuisance, appearance of swarms of crows and vultures, and epidemics of intestinal diseases were sure precursors of defeat. In respect of establishment of camps for troops, it is stated in Kautilya's "Artha Shastra' (350 BC) Chapter 129, section 10, that camps should be sited by a survey party comprising of a surveyor, a combatant officer, an engineer and a meteorologist. The duties of the survey party consisted in the selection of a site with due consideration to the nature of the terrain, character of the soil, meteorological conditions such as the temperature and humidity variations, shelter from strong wind and sun to ensure its suitability appropriate to the arm or service whether at rest or in action. In the Mahabharata, in Chapter 7, instructions were issued on mobilization of Army, in respect of selection, establishment and siting of water points at such places not liable to contamination. Kautilya warned that in the field, where water is likely to be scarce, importance of pure water carried in a water cart or by each soldier on his person was not to be forgotten (7, 8, 9).

Caesar paid the utmost attention to physical fitness of his men, particularly to their bathing and to camp sanitation. Marlborough concentrated on clothing and feeding, and his Army was the best fed and clothed of its day in Europe. In Mahabharata, reference exists in respect of large stocks of provisions made available for sale to troops at controlled rates e.g., honey and ghee, in order to maintain the nutrition of the soldier. Parkes, Professor of Hygiene at the British Army Medical School, later R.A.M. College, was the first scientific military hygienist. He lived from 1819 to 1876, and his efforts to improve the living conditions of the soldier had such a remarkable and world-wide effect that, when he died, Von Moltke said; 'Every Regiment in Europe ought to parade on the day of Dr. Parkes' funeral and present arms in honour of one of the greatest friends a soldier ever had'.

Reference in respect of naval hygiene also exists. Capt Cooke, the Commander of Ships scanning the South Pacific, found the good effects of citrus fruits especially lemon in the health of the sailors. In fact, the first vitamin to be described i.e. vit C has been named after the first alphabet of his name. Nelson interested himself in the prevention of scurvy and introduced the issue of lemon in the Royal Navy, which caused the Royal Mariner (and later all British sailors) to be nicknamed "LIMEY". James Lind, a naval surgeon, who lived from 1716 to 1765, had ideas a century and half ahead of his time. He recommended the delousing of sailors and baking of their infested clothing as a means of preventing typhus; he knew as much about scurvy as we do today and his recommendation for the introduction of lemon juice in the Navy as a daily issue contributed materially to naval victories during the time of Nelson. He introduced the sand filtration of water and the production of drinking water by distillation from seawater.

### Changing pattern of morbidity in the Armed Forces

Admissions to hospitals per 1000 of strength at present in Indian Armed Forces are approximately one eighth of what they were 100 years ago. In 1870, when there was no military operational activity in India, the admission rate per 1000 of strength was 1650; in 1976 the rate dropped down to 200.77; and in 2005 it was 105.87 per 1000 (10). Besides the rate, changes in morbidity pattern in the Armed Forces over the last 100 years or so is interesting to study as it reflects changes occurring throughout the world, both in developed and developing nations, during the last century.

For the developed nations, the evolution of patterns of disease spanned more than a century and fell into three fairly distinct stages. The first, marked by infectious diseases associated with poverty, malnutrition, and poor environmental sanitation and personal hygiene, gradually gave way thanks to better housing and sanitation, greater availability to safe drinking water, and vaccination services. In the second stage, degenerative diseases such as heart disease, cerebrovascular accidents, and cancer gradually began to replace infectious diseases as the leading causes of morbidity and mortality. Finally, the third stage reflects a growing concern with health problems caused by rapid urbanization and to changing social conditions in families, communities, and the workplace which foster stress manifested by increasing violence, alcohol abuse, and drug addiction.

One of the distinguishing features of the health situation in developing countries is that, whereas developed nations went through all three stages in more than a century, developing nations must face all three at once-consequently health conditions in these countries have become a veritable "epidemiological mosaic." The man in uniform is not insulated from these developments. Changes have been observed in the Armed Forces as well, where on one hand communicable diseases are still a priority (particularly in the field and operational areas) and on the other hand there is increasing trend in non-communicable diseases and injuries.

Overall morbidity rate per 1000 of strength decreased from 1322 to 123 during the last 130 years. Incidence of communicable diseases came down from 989 to 26 per 1000 of strength and made a major contribution towards the improvement of overall morbidity incidence; non-communicable diseases also decreased but as compared with the spectacular fall in the incidence of communicable diseases, the incidence of non-communicable diseases showed a more modest fall during the same period. Similarly, the proportionate morbidity due to communicable disease decreased from 75 to 19 percent of the overall morbidity but that due to non-communicable disease increased from 25 to 81 per cent during the past 130 years. Non-communicable diseases have been less sensitive than the communicable diseases to the socio-environmental improvements or perhaps these very socio-environmental changes have promoted them by encouraging life styles involving lesser physical activities coupled with the stress of modern living and increasing aspirations. Increased motorized transport also contributes to increasing incidence of Injuries NEA which heads the list for causes of morbidity and mortality in the Armed Forces today.

Reduction in incidence of communicable disease through general improvement in the environment by exogenous methods may reach its limit in near future. Further improvement in morbidity due to both communicable and non-communicable diseases will need conscious efforts on the part of the people themselves. Health education of service personnel and their families is, therefore, of utmost importance in addition to continuance of assiduous efforts to further improve their environmental condition.

Of the non-communicable diseases, 'Injuries' (non-enemy action) is one single cause of high morbidity (23.55 per 1000 in 2005). The other group, which has been causing concern, is the group called 'stress diseases'. Effects of hot climate have been with us for a considerable long time but effects of cold climate and high attitude are the new invaders consequent to the necessity of deployment of troops in the Himalayan ranges. Among the communicable diseases, sexually transmitted diseases including HIV/AIDS have assumed major significance in view of the global pandemic of HIV/AIDS, and increasing commitment of our troops both in stressful internal security duties and overseas deployments for UN Peace Keeping Missions. Moreover, routine health education may not adequately control these diseases. They require application of behavioural sciences and enlightened military leadership.

**Important causes of morbidity and their countermeasures**

(a) Dysentery and Diarrhoea

These are essentially the diseases of active service and have been present in every campaign, often with devastating results. Experience obtained during the two World Wars indicates that the only way to reduce the incidence is by the application of the principles of general sanitation. Over the years, because of better awareness among the rank and file, the incidence of diarrhoea and dysentery has declined in the Armed Forces. The incidence of admission due to intestinal infectious diseases (excluding cholera and food poisoning) in the year 2005 was 3.44 per 1000 in the Army, 1.18 per 1000 in the Navy and 0.36 per 1000 in the Air Force. (10). However, sporadic outbreaks of food poisoning among troops are reported from time to time. This calls for continuous efforts to maintain high degree of food and water hygiene.

(b) Malaria

In addition to its specific role as a major global public health problem, malaria as a military medical problem goes back into antiquity. Malaria has the potential of incapacitating such a large number of troops that military operations may be jeopardized. In India, the Vedic medical literature recognized it as the “King of Diseases”. The incidence of malaria in Army was 4.62 per 1000, in the Navy 7.16 per 1000 and in the Air Force 1.99 per 1000 in 2005.(10)

With increasing deployment of our troops overseas in UN Peace Keeping Missions, particularly in some of the worst malaria affected regions of the world such as the African Continent, it is important that global intelligence not only of the prevalence of various parasites and vectors of malaria be known to our medical officers but also the different drug resistance patterns including recommendations for treatment and prophylaxis in different parts of the world. These should be ascertained before deployment and adequate provisions of hygiene chemicals (including repellants and synthetic pyrethroids for impregnation of mosquito nets) and appropriate antimalarial drugs should be catered for. Then only such mishaps such as an Indian officer with the UN Peace Keeping Forces at Sierra Leone succumbing to cerebral malaria in the year 1999 could be avoided.

Enforcement of the use of countermeasures is a command function. The appearance in a unit of cases of a specific disease that should have been prevented by the application of the command directed countermeasures (e.g. cases of malaria that should have been prevented with the prescribed chemoprophylaxis) should bring about an epidemiological investigation to determine if the outbreak is due to failure of the prescribed countermeasures to prevent the cases (e.g. the malaria parasites are resistant to the prescribed chemoprophylaxis) or the result of command failure to enforce the countermeasures (e.g., the soldiers are not taking the drug). If the investigation shows that the cases are due to failure of the prescribed countermeasures, then better methods must be decided upon and put in place quickly. If due to the latter, disciplinary action may be warranted. In this connection, Field Marshall Sir William Slim, commander of the British Army in Burma in World War II, in his personal diary of the period, stated: “Good doctors are no use without discipline. More than half the battle against disease is fought, not by doctors, but by the regimental officers....When mepacrine was first introduced....often the little tablet was not swallowed. An individual medical test in almost all cases will show whether it has been taken or not....I, therefore, had surprise checks of whole units, every man being examined. If the overall result was less then ninety-five percent positive I sacked the commanding officer. I only had to sack three; by then the rest got my meaning.”(11)

(c) The Rickettsial Group of Fevers

Two common forms of typhus fever have been associated with the morbidity amongst troops and these are epidemic and the scrub typhus.

(i) **Epidemic Typhus Fever :** It was a scourge of armies and the navies upto and including World War 1. Known as 'Jail Fever', 'Ship Fever', “Camp Fever' and Barrack Fever'. This was associated with louse infestation and overcrowding concomitant with wars and famines. During the World War II, outbreaks were recorded at Naples among captured German and Italian troops in 1943 and in Middle East amongst Polish refugees. The epidemiology and aetiology was studied. It made their control easier and added a great deal of knowledge for the classification of fevers in this group. With improved knowledge in the dynamics of disease process, better experience of

organization of refugee and POW camps, and better methods of disinfestation, this disease should not become a major problem again.

(ii) **Scrub Typhus :** During the Second World War there were large outbreaks of this disease with a high mortality rate in the Eastern theatre. The problems became so serious that special research teams were established to elucidate the epidemiology. With the institution of rational preventive measures e.g. use of mite repellents and avoidance of mite infested areas along with large scale use of modern insecticides, the hazard of this disease was reduced to a great extent. However, the lessons learnt were soon forgotten and during and after the operations in J&K from 1947 to 1953 there were serious outbreaks. In 1965, Indian troops occupying the Pakistan territory adjacent to Jammu and Amritsar suffered heavy casualties due to scrub typhus which could have been averted. It is observed that the incidence shoots up whenever troops are deployed for operational purposes and they fail to observe preventive measures. The incidence in 1971 and 1972 during and after Indo-Pak War was 0.12 and 0.04 per 1000 respectively. However, scrub typhus need not always be associated with operations. Time and again there have been focal outbreaks during peacetime including in a training academy where after outdoor training few officer cadets contracted scrub typhus.

(d) Plague

Homer, 3000 years ago, described the first outbreak among the Greeks at the siege of Troy. The relationship between what is now known as epizootic plague and the human plague had been appreciated in Bhagavata Purana written sometime between 700 to 500 BC. The people were warned to 'desert their homes when rats fall from the roof above, jump about and die'. The earliest official record of plague was made by Emperor Jehangir in 1612. The first serious outbreak was in Bombay in 1896 having probably been imported from Hongkong, and thence it spread to Kolkata and subsequently throughout India. A plague commission appointed to investigate into the various factors involved in the epidemiology of plague completed the report in 1904 and rationally established the role played by the rat and the rat flea in its transmission. Plague accompanied armies all over Europe from Norman days to the end of the 17th century. It was essentially a disease of the base and Comm Z area, of besieged cities and towns but not of troops on the move. With the present knowledge of its epidemiology and control measures based on rodent and flea control, judicious use of residual insecticides and efficient vaccine in prevention, drugs and antibiotics for its treatment, it is extremely unlikely that our troops will ever be seriously menaced by plague. In any case, plague has never been a disease of military camps, even when the Cantonments were too close to the infested towns. The disease made a comeback in India in September1994 after a gap of almost 30-years (after 1966), when 4 persons tested positive for bubonic plague in Beed (Maharashtra) followed by an outbreak of pneumonic plague in Surat (Gujarat). Cases were also reported from Delhi, Mumbai, Kolkata and some other places. 4780 suspected cases were reported, out of which 167 tested positive for plague and 53 deaths were reported.

(e) The Enteric Group of Fevers

These played havoc amongst the armies in the past. It is difficult to know its true incidence in the earlier wars of history but its incidence was 100 per 1000 in the S. African war of 1899-1902. In India, between the years 1890-1898, the incidence rose from 18.5 per 1000 per annum in 1890 to 36.9 per 1000 per annum in 1898. Due to its rising incidence a medical organization was set up with two objectives in view, firstly to institute bacteriological inquiries in connection with enteric fevers and secondly to undertake detailed inspection of sanitary conditions existing in unit lines. In July 1899 the importance of examining water supplies and ensuring their purity and protection was realized.

Prophylactic inoculation first invented by Prof. Arlmoth Wright of St. Mary's Hospital London was introduced for mass immunization of troops. Later, bleaching powder was introduced for purification of water by Horrocks. These preventive measures resulted in an appreciable decline. In 1907 the incidence came down to 13 per 1000 per annum and during the World War I, the incidence did not go higher than 5 per 1000 in the various theatres of operations.

The incidence of enteric fever in the Indian Army during the post-war period of 1919-33 remained between 3 and 4 per 1000. At about that period, the quality of TAB vaccine which hitherto had been prepared from the old classical strains of bacilli, was further improved by ensuring that only virulent organisms which had fulfilled certain tests, were employed in its preparation. Since the introduction of this more potent vaccine, the incidence of enteric fever in the Army 1941 came down to approximately 1 per 1000, 0.13 per 1000 in 1950 and less than 0.10 per 1000 thereafter.

The superiority of this improved vaccine was clearly demonstrated during the N.African campaign of the last world war. The incidence of enteric fever among Axis troops who were still being protected with the old type of vaccine prepared from classical strains of doubtful virulence, was much higher than that among allied troops, and assumed almost epidemic proportions among the large number of prisoners of war taken at El Alamein. Re-inoculation with stocks of captured vaccine, failed to check the spread of the diseases, but as soon as stocks of the potent vaccine became available the epidemic was quickly brought under control. On the other hand, although ideal conditions existed for the spread of enteric fever among the British and Indian prisoners of war in enemy hands, to the great surprise of the Axis medical

authorities, very few cases of enteric fever were encountered, inspite of the fact that the sanitary conditions of these prison camps were primitive. Improved sanitation, control of water supplies and care of food, both in Cantonments and in the field, had also contributed to the lowering of incidence of enteric fever. But from the mentioned facts it seems obvious that this remarkable reduction in its incidence had been mainly achieved by enforcement of the routine practice of prophylactic inoculation with the potent TAB vaccine. This fact is also corroborated with the study of the morbidity tables of Burma campaign during the last war when malaria, dysentery, viral hepatitis and typhus were responsible for high sick rate but enteric groups of fevers was at no time a serious problem.

In recent years there has been a slow but steadily increasing trend in the incidence of enteric fever in the Armed Forces. In the Army it has risen from a rate of 0.40 per 1000 in 1991 to 1.58 per thousand in 2005; in the Navy from 0.50 per 1000 in 1991 to 1.04 per 1000 in 2005; and in the Air Force form 0.30 per 1000 in 1991 to 0.67 in 2005.(10) This indicates some deficiency in the food and water sanitation as well as probable effect of advent of drug resistant strains of S typhi. Another reason may be that our troops are now less insulated from the civil environment and eateries. It also raises doubts about the complete efficacy/coverage by vaccination. The problem is compounded by the fact that the production of the vaccine (TA), by the laboratories of Government of India has stopped, but some laboratories of the State Governments are producing the same. Hence its administration and availability must be closely monitored. The feasibility of introducing the newer oral vaccines against enteric fever and monitoring their efficacy in military setting also needs to be explored.

(f) Cholera

In the past cholera has always been present among the troops both in the field and in the barracks. Cholera had been endemic in certain parts of India for a long time and had assumed epidemic proportions from time to time due to well-known causes. Troops were thus liable to contract infection in the field and in garrison towns. High mortality and ignorance of its causation created scare. Considerable research on cholera has been carried out in India and its epidemiology has been understood to a great extent. It used to be said 'you can eat cholera, you can drink cholera but you cannot catch cholera'. Outbreaks of cholera occurred in the war 1914-18 in Austria, Germany, Russia, Turkey, Palestine and Mesopotamia. Localized outbreaks have occurred in the Army from time to time.

Cholera is now commonly due to El Tor biotype. The majority of the cases nowadays are mild or asymptomatic. Epidemiological studies have shown that cholera is responsible for about 5-10% of all acute diarrhoea cases in a non-epidemic situation. Global experience of the current pandemic has shown that cholera can get introduced into any country, but can create problem only in areas where other acute enteric diseases are endemic signifying defective sanitation and unsafe water supply (12).

A new strain of cholera, code named O139, emerged in India in 1992. It spread westwardly to Pakistan and in the East to Bangladesh. In the early months of 1993, cholera caused estimated one-lakh cases and 10,000 deaths in southern Bangladesh. Although it has not spread that rapidly since then, it still remains a threat.

(g) Small pox (Obituary)

There was a time when the prevalence of the disease was very high. As a result of successful vaccination drive, surveillance and containment, it has been possible to achieve global eradication of the disease on 29 Oct 1979 with the active support of WHO. India reached the goal of smallpox eradication in April 1977.

(h) Brucellosis

Undulant fever was responsible for causing a high sick rate amongst the naval and military garrisons in Malta. David Bruce discovered the causal organism in 1884 but it was not until 1905 that a committee under the chairmanship of Bruce found goat as the reservoir of infection. The knowledge of aetiology of this disease helped in its elimination from the Army and Navy. Sporadic cases of brucellosis, both Malta fever and abortus fever, have been reported amongst the troops in India. Improved management of dairy farms under veterinary and medical supervision, pasteurization and the popular custom of boiling milk are responsible for the low incidence of brucellosis amongst our troops.

(j) Malnutrition

The task of feeding sailors and soldiers in war has always been a difficult one. Scurvy was for centuries the dread of mariners. In planning military nutrition in India one must bear in mind two facts viz., the supply of food to large bodies of troops in the field may pose a logistic problem and secondly the nutritional state of recruits on enrolment. It should be our endeavour that the troops are supplied with rations not only to subsist but also for promotion of positive health. Sometimes, however, it is not possible to deliver these rations and as a result, the nutrition of the troops may suffer. Ration scales now cater for different requirements e.g. at high attitude and for the edentulous. Vitamin C and compound vitamin tablets can be issued to the troops in emergency to prevent deficiency diseases whenever they have to subsist on freeze dried rations. Morbidity due to malnutrition has been negligible in recent years.

(k) Sexually Transmitted diseases (STD)

In 1898, incidence of sexually transmitted diseases was 30.5 per thousand per annum in the Army, which rose to 60.5 per 1000 per annum in 1920. However, it dropped to 7.5 per 1000 in 1938. During World War II there was a steep rise in the incidence of STD and reached its peak in 1943 with a rate of 49.3 per thousand. As mentioned earlier stress of war affects people in different ways; for some there is breakdown in morale leading to war psychosis, while in others it is the loosening of morals - leading to increased incidence of STDs. Both call for effective military leadership.

The post war decline in STDs began in 1946, when the admission rate was 46.6 per thousand, further coming down to 10.5 per thousand in 1951. Since 1956, the incidence has been below 4, and this downward trend continues to date as shown in Figure 6. Comparative data of the three services, in recent times show that this fall is most marked in the Navy as shown in the graph. In the year 2005, the incidence of hospital admission for STD's in the Army was 0.13 per 1000, in the Navy 0.39 per 1000 and in the Air Force 0.04 per 1000.(10)

(l) HIV infection and AIDS

There has been a gradual increase in the incidence of HIV infection in the Armed Forces since the first case of HIV was detected in the services in the year 1986. In the year 2005, the rate per 1000 for the Army was 0.13, for the Navy 0.09, and 0.03 in the Air Force. (10). Most of those infected (45%) have acquired infection from exposure to commercial sex workers (CSW) (13).

Besides, the problem in the Armed Forces has to be seen in the context of the Global and National Scenario since with increasing commitments of our forces both within the country and internationally (UN Peace Keeping Missions), there is increasing interface between the civil and military populations. Globally there are over 30 million HIV positive persons in the world, and some of the worst affected continents are Africa and Asia (these are the very places our troops are deployed during peace keeping missions). In India there are over 5 million infected with HIV. Most of the big cities such as Mumbai, Chennai, Pune, Delhi, Kolkata, Goa , and the North East are pockets of intense HIV transmission (14, 15).

Military service provides a disciplined highly organised environment in which HIV/AIDS prevention and education can be provided to a large “captive audience”. In some ways, such efforts fit perfectly well with the ethos of a profession that places a high value on loyalty to comrades and the tradition of officers looking after the welfare of troops under their command. From this perspective, HIV prevention and education is every bit as important to life and health as rescuing a wounded colleague on the battlefield or securing a position once taken.

(m) Stress Diseases

The group of illnesses called 'stress diseases' is gradually emerging in the list of important diseases. Modern civilization with its accelerated tempo of life has brought in its wake stimuli which hitherto were absent or were of such low impact that they did not stimulate the chain of psycho-physical reactions enough to cause manifest effects. Age of 'infections' is gradually passing to an age of 'stress'. Stress constitutes a chain of psycho-physical reactions which, when generated in excess of or for longer periods than necessary for physiological functions, creates manifestations of 'stress diseases'. This group broadly includes psychiatric diseases, hypertension and ischemic heart disease. Stress diseases has shown a steady incidence in the past three decades and unlike communicable diseases seems refractory to preventive measures.

About 20% of the total manpower wastage caused by invalidments and deaths can be attributed to this group of diseases. All these diseases are multifactorial in origin and have complex aetiology; but the fact that the incidence of these diseases in the western countries has been steadily increasing, indicates that the impact of modern living has definitely a bearing in the genesis of these diseases.

Even in peacetime, the occupation of the soldier exposes him to certain stressful conditions peculiar to military service. Increasing demands made on the military for internal security duties, Low-Intensity-Conflicts (LIC), aid to civil authorities, etc together with the nomadic existence of the soldier unsettling family life may increase stress among servicemen.

(n) Injuries (non-enemy action)

Like the stress diseases, the incidence of injuries (non-enemy action) also has maintained a steady trend in the past three decades and appears refractory to control measures. Injuries cause great wastage of man-days and manpower. Moreover, the money spent on their treatment and rehabilitation has increased the importance of prevention of injuries. Injuries may be sustained on roads by mechanical transport accidents, in factories or workshops, during training, during operational and tactical maneuvers, in daily routine tasks due to poor training, unsafe and careless working methods, at homes, during organized games and sports. All have their definite epidemiology and preventive aspects. It was also the leading cause of death in all the three services in the year 2005.

**The Past and the Present**

A study of the past campaigns shows that more men are lost by sickness than by enemy action and that the majority of the diseases are preventable even during active warfare. Diseases have decimated armies even before reaching the scene of operations, and expeditions have been abandoned owing to the ravages of diseases in camps. Injuries (NEA), malaria, hepatitis, psychiatric illnesses and tuberculosis are the major causes of morbidity.

**Future challenges**

The end of the cold war has substantially altered the nature of the threat to global security, and along with it the military strategic responses of the nations of the world. Military forces were formerly preoccupied with the potential for large scale, high intensity armed conflicts. The primary strategic concern now seems to have shifted to the containment of various regional ethnic and religious conflicts and to the prevention of terrorist attacks against national interests, both at home and abroad. The use of weapons of mass destruction (biological, chemical and nuclear) among warring factions or by terrorists against national targets is regarded as a distinct possibility. The effect of these trends has been to increase the mission diversity of our Armed Forces to include not only fighting war, but also peacekeeping, humanitarian assistance, and disaster relief missions, which, in turn, require the medical capacity to provide highly flexible and mobile support over long distances and in widely diverse environments. To meet these

challenges, Military medical officers, besides being well-versed in general preventive medicine, should also be conversant with the following subspeciality areas of military preventive medicine.

## Conclusion

Preparedness of Armed Forces for war depends largely on its training, equipment and its physical fitness. Physical fitness is largely the outcome of good nutrition, physical training, and absence of illness. Therefore, prevention of illness and injuries occupy a prominent position in the life and efficiency of the Armed Forces in a country. It is amply proved from the campaigns described earlier that

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