BANS-184

PUBLIC HEALTH AND EPIDEMIOLOGY

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June, 2021 (Reprint)

ISBN:- 978-93-91229-06-1

Printed and published on behalf of the Indira Gandhi National Open University, New Delhi, by Registrar, MPDD, IGNOU, New Delhi

Laser Typeset by: Tessa Media & Computers, C-206, Shaheen Bagh, Jamia Nagar, New Delhi-25

Printed at: Sita Fine Arts Pvt Ltd., New Delhi-110028

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Course Contents

COURSE INTRODUCTION

World Health Organization (WHO) and other health related National/International organizations have been focusing on tackling both communicable (Tuberculosis, Malaria, SARS-CoV-2, Leprosy, etc.) and non-communicable diseases (Cardiovascular Disease (CVD), Cancer, Diabetes Mellitus, Hypertension, Chronic Obstructive Pulmonary Diseases (COPD), etc.). The prevention and management of these diseases is a major public health problem in many countries across the globe. Public health refers to all organized measures (whether public or private) to prevent disease, promote health, and prolong life among the population as a whole. Its interventions aim to provide conditions in which people can be healthy and it focuses on entire populations, not on individual patients or diseases. Thus, public health is concerned with the total system and not only the eradication of a particular disease. Whereas epidemiology is the study of frequency, distribution, and determinants of diseases and other related states. Therefore, public health refers to collective actions to improve population health while epidemiology is one of the tools for improving public health.

The present course discusses the concepts and methods of public health and epidemiology.

Course Presentation

The course on Public Health and Epidemiology comprises of three blocks. Each block consists of 3 or 4 units, and the units in each block are thematically arranged.

Block I (Unit 1 through Unit 4) deals with methods of assessment of public health and to design the interventions to improve public health from the information obtained from the studies. Unit 1 focuses on the study designs of epidemiology, assessment of risk and criteria used for finding casual inference in epidemiological studies. Unit 2 examines the concepts of health and disease, and the historical background of public health. Unit 3 discusses environmental health in which the effects of biological, chemical, and physical agents in environment on health are dealt with. This unit also discusses the current legal framework, policies, and practices related to environmental health which intend to improve public health, with Indian examples. Unit 4 describes the current methods of surveillance, prevention, control and etiology of infectious and chronic diseases.

Block II (Unit 5 through Unit 7) highlights the role of various socio-cultural factors in the predisposition of illness. Methods and management of public health are also presented. Unit 5 describes how the social factors influence health and illness. Unit 6 describes the theory and various methods used in the assessment of public health. In Unit 7, the different health care programmes initiated by the Government of India and NGOs are delineated.

Block III (Unit 8 through Unit 10) focuses on the various statistical tools and epidemiological methods used in health research.

Unit 8 discusses sampling design, case studies and basic statistical techniques. Unit 9 explores data file construction and management. This unit also emphasizes on the use of SPSS and EXCEL software in the analysis of the data. In Unit 10, advanced statistical techniques like measures of association, linear regression and ANOVA are discussed.

BLOCK 1

ESSENTIALS IN EPIDEMIOLOGY AND PUBLIC HEALTH

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UNIT 1 EPIDEMIOLOGY

Contents

Learning Objectives

After reading this unit, you would be able to:

- Understand the definition of epidemiology;
- Learn the type of study designs of epidemiology;
- Appreciate how the risk is estimated; and
- Gain knowledge on definition and criteria used for causal inference.

1.0 INTRODUCTION

The term ‘epidemiology’ is derived from three Greek words namely ‘epi’(upon), ‘demos’(people) and ‘logos’(study) collectively meaning ‘study upon people’. This branch of science studies all aspects of human health and diseases.

* Contributed by Dr. SAA Latheef, Department of Genetics and Biotechnology, Osmania University, Hyderabad

Epidemiology is defined as "the study of the distribution and determinants of health- related states or events in specified populations, and the application of this study to the prevention and control of health problems."

Check Your Progress

1) What is Epidemiology?

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1.1 HISTORY OF EPIDEMIOLOGY

History of epidemiology stretches from 400 B.C. to present day. In this Unit, an emphasis is given on Indian context. Historical milestones are described against each period/year.

Period/year	Milestone
400 B.C.	Hippocrates, a Greek physician described the influence of environment on diseases. Defined the words "epidemic" and "endemic".
1334	Clinical trial concept was proposed by Petrach.
1543	Girolamo Fracastoro, a physician from Italy proposed that disease is caused by live unseen small particles.
1546	Germ theory of disease was presented in the book titled "De Contagiosis Morbis" authored by Gerolamo Fracastoro.
1646	Rene Descartes, a French scientist, proposed reductionism that is studying one factor at a time and depending on the evidence rather than imagination.
1662	Individual deaths and their causes in London were discussed. by Johan Graunt in his book entitled "His Natural and Political Observations Upon the Bills of Mortality". He also used quantitative approach on the patterns of birth, death and disease prevalence and proposed Life tables.
1668	Thomas Sydenham from England, described the concept of generic diseases.
1675	By developing microscope, Antonie von Leeuwenhoeck, a Dutch scientist showed an evidence for germ theory of disease.
1700	Bernardino Ramazzini, an Italian physician, wrote an account on the occurrence of similar cases in workers sharing same space in his book titled "De Morbis Artificum Diatriba".

1706-1777	François Bossier de Lacroix first attempted to classify the diseases.
1707	Pathological investigations of a series of sudden deaths in the city of Rome, Italy were delineated in the book entitled "De Subitaneis Mortibus" authored by Giovanni Maria Lancisi.
1713	Bernardino Ramazzini reported higher rate of breast cancer in nuns than in married women.
1747	James Lind, a Scottish physician, in first clinical trial proved that consuming of citrus fruits cures the Scurvy disease.
1775	A causal association of exposure to soot was associated with higher incidence of scrotal cancer, was proposed by Percivall Pott, an English surgeon.
1780	First dengue like illness was reported in India from Chennai.
1798	Cow pox conferring protection on smallpox, was proposed by Edward Jenner, a physician from England.
1801	Registration of deaths was introduced in England.
1802	Vaccination for smallpox was introduced in India.
1838	William Farr initiated the national system of death causes in England.
1842	Report on the Sanitary conditions of the Labouring population of Great Britain authored by Edwin Chadwik was published.
1842	Massachusetts system for registration of births, deaths and marriages were introduced in Massachusetts, United States.
1847	Ignaz Philipp Semmelweis, a Hungarian physician, proved that using of disinfected hands while treating pregnant women in obstetric clinics will prevent the occurrence of Puerparel fever.
1850	Report of Sanitary Commission of the State of Massachusetts was published by Lemuel Shattuck in United States. 1853 John Snow, an English physician presented a paper on communicable diseases.
1854	John Snow reported source of Cholera outbreak in London.
1893	First International Classification of diseases was adopted by International Statistical Institute.
1894	Yersina Pestis was discovered by Alexander Yersin, a Swiss/ French bacteriologist.
1897	First vaccine in India was developed for plague by Dr.Waldemar Mordecai Haffkine.
1911	Indian Council of Medical Research was established.
1915	Application of Iodized salt for eradication of goitre was proposed in Switzerland.

1924	Iodine salt was introduced at community level in several countries
1939	AB Hill in England published a textbook entitled "Principles of Medical Statistics".
1948	World Health Organization was established.
1948	Framingham heart study was initiated in Framingham, Massachusetts, United States with a cohort of 5209 men and women aged 30-62 years to identify risk factors for cardiovascular diseases.
1950	Three case control studies on association of smoking and lung cancers were published by Morton L. Levin and co-workers, Ernest Ludwig Wynder and Evarts Ambrose Graham and Richard Shaboe Doll and Austin Bradford Hill.
1950	Methyl mercury poisoning of fish known as Minamata Disease was reported in Japan.
1950	Dengue was first discovered in Philippines and Thailand.
1951	British Doctors Cohort study was initiated by Richard Doll and Austin Broad Ford- Hill in England.
1952	Zika virus disease in humans was first reported in Uganda and United Republic of Tanzania.
1952	Primary Health Centres were started in India.
1953	United States Veteran's study on a cohort of 220000 males was commissioned by Harold Dorn.
1953	National malaria control programme was started in India.
1954	E.Culer Hammond and Daniel Horner initiated a study on the relationship of smoking and lung cancer in New York.
1954	Salk vaccine trial was initiated in United States to test the efficacy of Salk's killed virus to prevent poliomyeolitis.
1955	National Leprosy Control Programme was launched in India.
1957	Jerry Morris, a Scottish epidemiologist published first textbook on Non-communicable disease epidemiology textbook entitled "Uses of Epidemiology".
1957	Ancel Keys initiated Seven Countries Study to study the relationship of diet and coronary artery disease.
1962	National Tuberculosis Control Programme was initiated in India.
1963-1964	First clinically proved dengue case was reported in Kolkata, India.
1964	United States Surgeon General's report on smoking and health was submitted.

1965	A. Bradford-Hill in England proposed nine points to establish the causal association of disease.
1966	The last human plague case was reported in India.
1975	Eradication of smallpox was announced in India.
1976	Ebola virus disease was reported in Sudan and Democratic Republic of Congo.
1980	Eradication of smallpox was announced by World Health Organization.
1981	First case of human immune deficiency was reported in United States.
1983	First National Health Policy was proposed in India.
1984	Guinea worm eradication programme was initiated in India.
1985	Universal Immunization Programme was started in India.
1986	HIV case first reported in India.
1992	Centre for Disease Control and Prevention, United States was established.
1992-93	First National Family Health Survey was conducted in India.
1993	Revised National Tuberculosis Control Programme was launched in India.
1997	National Polio Surveillance Programme was initiated in India.
1999	National Institute of Epidemiology was established in India.
2002	Severe Acute Respiratory Syndrome was reported in two patients in South China.
2002	Second National Health Policy was proposed in India.
2005	National Rural Health Mission was initiated in India.
2010	National Programme on prevention and control of Cancer, Diabetes, CVD and Stroke were initiated in India.
2017	Third National Health Policy was presented in India.
2017	First outbreak of Zika virus disease reported in India from Gujarat and second outbreak in Tamil Nadu.
2018	International Classification Diseases, version 11, was released.
2018	Ayushman Bharat, a national health protection scheme was launched.
2019	SARS Corona virus-2 discovered in Wuhan of Hubei Province.

1.2 TYPE OF STUDY DESIGNS

Epidemiological study designs can be broadly divided into two categories namely, Observational studies and Experimental studies.

1.2.1 Observational Studies

In observational studies, frequency and distribution of diseases or deaths are reported by time (year/month/week/day/hour/season), place (country/urban-rural/ institutions/hospitals/old age homes/ schools) and demographic characteristics (age/sex/income/education/occupation/maritalstatus/religion/caste). Observational studies are categorised into two types – (i) Descriptive and (ii) Analytical studies. In descriptive studies, only description about the disease (case reports/case series) is made whereas in analytical studies (ecological/case-control/ cross-sectional/cohort) relationship of variables (causative factors) with diseases is described.

1.2.1.1 Descriptive Studies

Descriptive studies are again of two types, case reports and case series.

1.2.1.1.1 Case Reports

In case reports, cases with unusual symptoms, signs and characteristics or death observed during clinical practice are reported by the clinician's presentations which are helpful to define new clinical disease/entity. These case reports are useful in clinical practice, formulating hypothesis and explore in epidemiological studies. Example: coagulopathy in patient with renal failure.

1.2.1.1.2 Case Series

When new clinical entities/new cases or deaths with common characteristics, symptoms or signs are compiled by single or group of clinicians they can be called case series. They are useful for definition of new cases, to understand the spectrum of symptoms and signs, when followed till the death of patients which are useful to investigate the natural history of disease. The data are usually collected from clinicians and sometimes from populations in case of sudden deaths within a defined geographical area. Data of case series can be used to know the distribution of disease by place, time, religion, ethnicity, season and socio-economic status. Acquired immune deficiency syndrome is defined as new disease after publication of case series of young men contracted with *pneumocystis carinii pneumonia* and *Kaposi's sarcoma*. Case series data can be used to formulate hypothesis. It is easy to collect, cost effective and quickly available. Case-series data cannot be used to calculate rates of disease as no denominator is available, involves no comparison group, suffers from sampling variation and recruits only selective cases. Example: case series on symmetrical acrokeratoderma (dermatosis).

1.2.1.2 Analytical Studies

Analytical studies are of four types**:**

1.2.1.2.1 Ecological Studies

In these types of studies, association between disease/outcome frequency and the level of exposure in groups of within or between populations is studied. Population, not the individual is the unit in this kind of study. Grouping can be done based on the place (birthplace/residence/factory/school), socio-economic status, time or by mixing place and time. Ecological studies are used for generation of hypothesis.

Data from public/private sources, registries/death certifying organizations and earlier surveys can be used. For example, in this type of study, investigating the incidence of cancer in different countries, one can obtain the details on age distribution and disease status from census data and tumour registries. Example: spatial spread of leprosy in India.

1.2.1.2.2 Case-control Studies

These studies investigate the aetiology of disease, suitable for studying rare and longer duration of (chronic) diseases, cost effective, require less number of subjects, easy to perform, no risk is done to subjects, multiple risk factors can be studied at the same time, no dropout of subjects is observed, has minimal ethical problems and can be completed within short duration. The unit of study is individual. Newly diagnosed cases are compared with subjects without disease. Exposure to potential risk factors in both cases and controls is evaluated by examining case sheets/enquiry of patients or patient relatives/controls or by performing biochemical tests. These studies are called retrospective (as the study deals backwards from outcome/disease to cause) and prospective (if the data collection is still in progress).

Cases are recruited from hospitals/patient registries/cross sectional study/case-series/cohort study. Controls are drawn from same geographic area/spouses/ friends, from same office/factory/institute or patients diagnosed with other disease from same hospital. Cases and control can be matched for age, sex, and ethnicity, social class (income, education and occupation) to reduce selection bias. The association between exposure (causative agent/risk factor) and disease/outcome is evaluated by Odds ratio. Demerits of case-control are difficulty in finding suitable controls, subjects may not be representative of population, prevalence/ incidence or attributable risk cannot be estimated, efficacy of therapeutics cannot be evaluated, not possible to distinguish between causative or accompanying factors, suffers from confounding(due not mismatching of subjects), recall (cases more likely recall the presence of events), selection (subjects not recruited as per standard criteria), Berkesonian (recruitment of subjects from sub population than general population) and interviewer bias. Example: Utility of anthropometric traits and indices in case-control study.

1.2.1.2.3 Cross-sectional Studies

In these studies, both exposure and outcome (disease) are investigated at the same time. No temporal associations between exposure (risk factors) and outcome can be explained. The unit of the study is individual. These studies are useful for investigating chronic diseases and fixed exposures such age, gender, ethnicity and genotype, to study multiple risk factors simultaneously. These studies are easy to conduct, give inputs on burden of disease which can be used for planning health infrastructure, allocating resources and manpower. It is inexpensive and can be completed within a short period of time. If cross sectional study is repeated on the same population it can serve as cohort study and if repeated on independent sample, it is useful to investigate the trends of the disease. For variable exposure, data on past and present exposures are recorded.

The target population is studied using representative population and the results are extrapolated to this population. These studies are also called prevalence

studies. If prevalence is standardized using the data of standard populations, the prevalence can be compared with other populations. Both disease and determinants can be studied in this type of studies. To avoid sample bias, random sampling techniques are used such as simple, systematic, clustered, stratified, multistage and mixed. The denominator is usually the population at risk or total population studied. Prevalence is presented a per cent or per 1000 subjects. Prevalence studies are of three types depending on the time involved. They are point, period and lifetime prevalence.

Prevalence studies are not suitable for studying the natural history of disease and to estimate the incidence. Subjects deceased or with severe disease are missed out in these studies. It is not possible to distinguish whether risk factor or exposure precedes the outcome/disease or exposure is resulted from the outcome. If investigator fail to gain the confidence of subjects which results in high non-response rate resulting leading to selection bias. This type of study design is not suitable for rare diseases. A statistical technique called Logistic regression analysis can be used to find the association between risk factors and disease. Example: Prevalence of coronary artery disease and coronary risk factors in Tirupati urban population.

1.2.1.2.4 Cohort Studies

These studies are called incidence/longitudinal studies. Cohort means group of population. Groups can be formed based on the date of birth (birth cohort), date of marriage (marriage cohort), decade (decade cohort), occupation (doctors/ lawyers/engineers/teachers), city population (Example: Delhi) etc. Subjects of cohorts have common characteristics/experience/condition. A group is assigned for the study, and exposed and non-exposed cohorts within the same group are identified and followed for particular period. If exposure is rare, this cohort is compared with external cohort matching all characteristics except exposure. Same cohort can be divided into subgroups based on level of exposure and outcome. Diagnostic criteria for outcome of interest are decided at the beginning of the study. Baseline data is collected from cross sectional studies, census and birth registries. Data on exposure are collected by conducting interviews, contacting subjects on mobile/through e-mail, examination of case sheets, conducting of diagnostic tests and environmental surveys such as air or water quality. Subjects with disease are excluded from this study. Both exposed and non-exposed cohort subjects are evaluated periodically on clinical status, performing diagnostic tests, reviewing cash sheets and visiting the subjects for examining the end points (outcome/disease/death) of study. Presence of outcome/disease/death is compared between exposed and non-exposed cohorts. Incidence rates, relative risk (measure of evaluating the strength of association between exposure and outcome), attributable risk (what extent disease is due to exposure) and population attributable risk (suggest to what extent disease is reduced if the exposure is eliminated) are determined and compared between both cohorts. Cohort studies are of three types namely prospective (outcome occur after initiation of the study), retrospective (outcome occurred before the initiation of the study) and mixed (outcome occurred before the initiation of study which is further assessed prospectively). If the newly identified cases in the cohort study if compared with control of the same cohort, it is called nested case-control study. Example for Prospective cohort study of overweight and obesity in rural population of West

Bengal, India and for retrospective cohort study example is maternal and neonatal outcome of gestational diabetes in the subjects of Kerala; Mixed cohort study example is retrospective and prospective cohort study on HIV sero status and incident pneumonia.

1.2.2 Experimental Studies

The experimental type of study designs is employed to find the aetiology of disease, to evaluate the effect of interventions/services and to investigate the cost and benefit analysis of the interventions. Hypotheses are tested using experimental studies. They are broadly divided into randomized or non-randomized studies.

1.2.2.1 Randomized Studies

Randomized studies are classified into randomized clinical trials, field trials and community trials.

1.2.2.1.1 Randomized Clinical Studies (Trials)

In randomized clinical trials, efficacy of medications/new treatments/new devices are investigated. This kind of study design is useful to study the effect of single intervention on multiple outcomes. Randomized clinical trials are performed in hospitals or contract research organizations. Subjects are randomized into treatment or control groups. This randomized can be done using simple (computer generated random numbers, random number tables, flipping coin, throwing dice and schuffling deck of cards), block, stratified, covariate adaptive randomization procedures and online software tools (Suresh, 2011). Randomization reduces the selection bias and ensures that both arms of subjects are equal and comparable except the intervention which causes difference in the outcome. To avoid subject's variation (subjects if knew that change is occurring because of treatment they receive would report favourably on the treatment to the investigator) and investigator bias (if investigator knows who is receiving what type of treatment may give the report on treatment outcome positively), *blinding* is done. Blinding is done in three ways i.e. single (patients not aware of treatment group he/she belongs), double (both patient and investigator not aware of the treatment group) and triple (patient, investigator and external evaluator are not aware of the treatment group). If no standard treatment is available before planning the interventional trial, placebo group is included. Placebo group receive biologically and therapeutically inert material, but they have only psychological satisfaction of receiving treatment. Randomized clinical trials are done in four phases. In Phase I trial, the tolerated dose is identified in either healthy subjects or patients; in phase II, the mechanism of action of drug, absorption, diffusion, metabolism and excretion details of drug are studied in small group patients; in phase III, the efficacy of drug in large number of patients is investigated and in the phase IV, adverse effects of drug after the release of drug in the market are evaluated (Umscheid et al. 2011). RCT meets the requirement of protocol agreed at the time clearance of ethics committee. RCT is performed when there is no information on the intervention intended for the study. RCT requires that subjects enrolled in the study are not deprived of standard treatment and the planned interventions should be best in the light of the present knowledge. At the end of

RCT, clinical endpoints such as death, decrease in the risk /improvement in clinical condition and possible adverse effects are evaluated after completion of the trial. Incidence of outcome is calculated; incidence rate is compared using relative risk and attributable risk between treated and control subjects. Statistical tools such as linear regression for continuous variables, logistic regression for dichotomous outcomes, poisson regression for number of events and cox regression for survival analysis are used. RCT can be employed in evaluating the efficiency of health services. For example, in Burlington trial it was showed that nurses and paramedical staff can perform the health care delivery duties on par with physicians (Sackett et al.1974) and impact of training on informal health care providers in correct case management in rural areas of west Bengal is an example in Indian context.

Demerits of RCT includes ethical constraints, cost intensive, require adequate sample size, inference drawn in select population may not be generalised to the general population. These studies are useful to gain understanding on the cause and effect only, not useful for studying disease mechanisms leading to improvement in clinical condition/decrease in the risk, multiple observers are needed, risk of dropout of subjects may happen due to the death, change of residence/job and loss of interest to continue in the study, only single factor can be studied at a time, subjects may not be representative of the reference population, suffers from information bias (result from the way information is collected), volunteer bias (resulting from eligibility criteria and subjective judgments of investigator) and employ surrogate than primary endpoints to enhance efficiency of the study resulting in false negative results.

1.2.2.1.2 Field Trials

This type of trials is conducted in the field i.e. general population and involves healthy subjects or groups. Effect of intervention on the multiple outcomes can be studied in this study design. Randomization is ideal choice but in practice implementing it in the field trials (FTs) is challenging. In FTs, risk factor/exposure or procedures is modified or terminated or stopped to reduce the risk of developing disease. Examples for these trials include vaccine/smoking cessation/chemo prophylactic trials. FTs are used for investigating the common or serious diseases. If the disease is rare then high risk groups are involved. FTs are cost intensive, require large number of subjects and longer period of follow-up. Example: Effect of home-based neonatal care and management of sepsis on neonatal mortality in rural areas of Gadchiroli district, Maharashtra.

1.2.2.1.3 Community Trials

The unit of these trials are communities. In the selected communities, some communities are assigned to exposure and others not. Community trials (CTs) are done for diseases which are influenced by socio-economic status such coronary artery disease (CAD). A risk factor/exposure or behaviour is interrupted in those who have it to prevent the development of the disease. CTs investigate single or multiple risk factors. Example: community trial on prevention and reduction oral diseases among children done in Chandigarh and Cuttack.

1.2.2.2 Non-randomized Studies (trials)

Ethical, financial and administrative constraints, requirement of large manpower, larger sample size and applicability of some interventions to groups than individual limits the use of RCTs and necessitates the employing of non randomized studies (trials). Owing to sampling bias, the interventional and non-interventional groups are not comparable, and the validity of the results may be doubtful. Non-randomized trials are of five types: (1) Uncontrolled trials, (2) Natural studies, (3) Interventional studies without control, (4) Pre and post interventional studies, (5) Cross over interventional studies.

1.2.2.2.1 Uncontrolled Trials (UTs)

These are useful to know the effect of intervention, dose of therapeutic agent and adverse reactions. UTs on using Pap smear test for diagnosis of cervical cancer showed reduction in mortality of cervical cancer. Example: Effect of tacrolimus ointment in Vitiligo conducted in Kolar, Karntaka.

1.2.2.2.2 Natural Trials (NTs)

When observations mimic the experiment those can be used to test the hypothesis of relation between exposure and outcome. Effect of acute stress conditions such earthquake showed higher rates of mortality from cardiac and external cause than other reasons in 1981in Athens, Greece (Trichopolous et al.1983, Park, 2013). Example: Epidemiology of injuries after earthquake in Kutch district, Gujarat.

1.2.2.2.3 Interventional Studies without Control (ISWC)

In ISWC, intervention is assigned to one human group and compared with non-interventional past group. This non-interventional past group is called historical control. Interventional group can also compare with natural population which has similar frequency and characteristics of the disease/outcome to be controlled/ prevented. Example: Study done in Hyderabad evaluating the effect of cyclosporine restriction on incidence of extended spectrum betalactamase gram negative infections in neonates compared with historical control.

1.2.2.2.4 Pre and Post Interventional Studies (trials) (PPIS)

A clinical variable of interest is chosen for this study and measured before and after the intervention in the same group. For example, measurement of blood pressure before and after administering of the antihypertensive drugs. As there is no control group, the change observed is assumed to be due to the intervention. The change in blood pressure may also be due to the reduced salt intake, involvement in physical activity or practising of meditation. Using the same study design, incidence can be compared before and after introducing of interventions in the same group under study. Example: Effect of awareness on the reduction of hypertension prevalence in Kumarokom village of Kottayam district, Kerala.

1.2.2.2.5 Cross Over Interventional Studies (trials) (COIS)

In this design same subjects receive intervention, undergo washout period to reach baseline level and then subjected to second intervention. This design reduces

inter individual variation and requires a smaller number of subjects. COIS is suitable for chronic disease patients where interventions only alleviate the suffering but not cure. Ex. Protective effect of walnut on cardiometabolism in obese.

Check Your Progress

2) Describe the types of epidemiological studies.

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1.3 RISK ESTIMATION

The aim of risk estimation is to gain knowledge, to reduce health risks due to chemical exposure and to set standards for the control of exposures. Risk is estimated in four steps and they are: (1) Hazard identification, (2) Dose-response assessment, (3) Exposure assessment and (4) Risk characterisation. Hazard identification investigate what type of harm or risk happen due to the exposure, characterisation and measurement of exposure and validation of methods is done for this purpose. Dose-response deals with the relationship of exposure to the adverse events. The exposure levels are reported as low, medium and high categories and this facilitates the comparison of results between the studies and extrapolation of results. Identification of bias in risk estimation improves the validity of results. In exposure assessment step, both qualitative and quantitative investigation of agents, source of exposure, frequency and duration and determinants of exposures is done in exposed population. This information is used for controlling or prevention of exposure in the exposed population. Risk characterisation involves combined approach which uses both exposure assessment and dose response assessment data to predict the health risk to the population. Identification of bias and measurement errors can be useful for evaluating their impact on risk characterisation. Advantages of epidemiological than animal data in risk characterisation includes less error in exposure information; give importance to the context and exposure patterns in predicting the health effects; genetic variation and better representation of host factors and generalizable than animal data.

Check Your Progress

3) Describe the steps in risk estimation?

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1.4 CAUSAL INFERENCES

Causal inference may be defined as a measurement of an effect than deciding whether effect is existing or not (Rothman et al.2005). Austin Broadford Hill in 1965 proposed nine-point criteria for deciding the observed epidemiological associations are causal or not. They are: (1) Strength: If the association between exposure and disease is stronger it is more likely to be causal, (2) Consistency: If the observed association between exposure and disease is consistent across populations and usage of different methods then it can be considered as causal, (3) Specificity: If the exposure causes single than multiple diseases it is assumed to be causal association, (4) Temporality: An association is deemed casual when the exposure precedes the occurrence of the disease, (5) Biological gradient: The dose-response relationship when observed between exposure and disease, the association can be termed as causal i.e. more the exposure to the agent the greater will be the severity of the disease, (6) Plausibility: The relationship between exposure and disease if conforms to the evidence of existing scientific literature on aetiology and mechanism of action it is considered as biologically plausible, (7) Coherence: Coherence indicates that exposure and disease association should agree with natural history and biology of the disease, (8) Experiment: Decreased risk of disease due to the modification or prevention of exposure suggests proof of causal association between exposure and disease, (9) Analogy: Analogy should be used to interpret causality for weaker association between exposure and disease. Hill criteria can aid health researchers for drawing causal association between exposure and disease. Integration of epidemiological data with data obtained from using omic tools such genomics, transcriptomics, metabolomics and proteomics may enhance the application of Hill criteria for better characterisation on the causal associations between exposure and disease.

Box 1.1: Epidemiological Study Types

I) **Observational Studies**
- A) *Descriptive study types*
  - i) Case report
  - ii) Case series
- B) *Analytical studies*
  - i) Ecological studies
  - ii) Cross-sectional studies
  - iii) Case-control studies
  - iv) Cohort studies

II) **Experimental Studies**
- A) *Randomized studies*
  - i) Randomized clinical trials
  - ii) Field trials
  - iii) Community trials
- B) *Non-randomized studies*
  - i) Uncontrolled trials
  - ii) Natural studies

iii) Interventional studies without control
iv) Pre and post interventional studies
v) Cross over interventional studies

1.5 SUMMARY

Epidemiology is the study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to the prevention and control of health problems. Information collected using epidemiological methods is used to improve public health.

Epidemiological study designs can be broadly divided into Observational and Experimental. In observational studies, frequency and distribution of diseases/ deaths are reported by time, place and personal characteristics. Observational studies are of two types and they are descriptive and analytical. In descriptive studies, only description about the disease (case reports/case series) is made whereas in analytical studies (ecological/case-control/cross-sectional/cohort), relationship of variables (causative factors) with diseases is described. The other two components, risk estimation and causal inference are also discussed in the unit.

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1.7 ANSWERS TO CHECK YOUR PROGRESS

1) Epidemiology is the study of the distribution and determinants of health-related states or events in specified populations, and the application of this study to the prevention and control of health problems.

2) Epidemiological Study designs can be broadly divided into Observational and Experimental. Observational studies are of two types, Descriptive and Analytical. Experimental studies are broadly divided in to randomized or non-randomized experimental studies.

3) There are four steps in risk estimation, and they are: (1) Hazard identification, (2) Dose-response assessment, (3) Exposure assessment, and (4) Risk characterisation.

UNIT 2 PUBLIC HEALTH*

Contents

Learning Objectives

After reading this Unit, you would be able to:

- Learn about Public Health;
- Discuss the historical development of public health; and
- Elucidate the issues of health with their social determinants.

2.0 INTRODUCTION

Human beings have a long history of searching the means for securing health and preventing diseases collectively as well as individually. Initially health was seen as a divine responsibility and illness as a supernatural phenomenon. Later on, these supernatural conceptions of health and disease were replaced by personal life habits and environmental factors. The efforts to improve the quality of life basically evolved through trial and error. It is said that with the development of community life, these efforts and interventions became more collective. Control

* Contributed by Dr. Santhosh M. R. Centre for Public Health, School of Social Work, Tata Institute of Social Sciences, Guwahati.

of communicable diseases, provisioning of medical care, drinking water, and sanitation facilities are some of the examples of these organised efforts. The urbanisation and formation of nation states also influenced these interventions. Today, we know that the improvement in health requires a secure foundation in the basic requirements such as food, shelter, income, education, peace, a stable ecosystem and sustainable resources with the operating principles of equity and justice. In fact, the discipline of public health has played an important role in integrating all these aspects for achieving health.

We know that healthcare professionals help us deal with our health problems with the help of medicines and other measures. However, at times medical advice, when it is given at the individual level, is limited by circumstances outside doctors' control. There are causal factors beyond the purview of the medical practitioners. For example, tobacco use could be linked with cancer and that if we reduce the consumption of tobacco then we can reduce the cancer cases. However, a doctor has a limited role or no role in reducing the availability or banning of tobacco. Similarly, if we take the case of Covid-19, medical professionals have a limited role or no role in ensuring social/physical distancing in the community. In these kinds of situations, macro level policy interventions, such as banning of tobacco or implementation of national lockdown would be more desirable than other individual level interventions. Here, we would need to work at micro, meso and macro levels to introduce and implement social legislations and policy decisions. Many a times, we would also need to work both within and outside the health sector in order to deal with the health issues and problems. The point to be noted here is that there are domains of health which are beyond the purview of a doctor or medical professional and even an individual patient.

2.1 WHAT IS PUBLIC HEALTH?

The term "Public health" is coined from two different terms, "public" and "health." The term 'public' has several meanings and connotations such as "community", Civic, "Municipal", "Free", "Open", "Unrestricted". The term public is also understood as something "not private. "If we look at the other term "Health" it is one of the most difficult terms to define. Health being a multidimensional concept can mean different things to different people. It is conceptualised as "freedom from any sickness or disease," "harmonious functioning of all body systems," "a feeling of "wholeness" and a happy frame of mind" etc. Health is conceptualised in distinctive ways as given in box 2.1. Researchers have found that our ideas of health and illness have an impact on our health attitudes and behaviour.

Box 2.1: Various Conceptualisations of Health

- health as something to be had
- health as a state of doing
- health as a state of being
- health as not being ill
- health as inner strength
- health as a capacity to adjust adequately to their environment
- health as a functional capacity

- health as physical fitness, stamina
- health as leading a healthy lifestyle
- health as a psychological concept
- health as a reserve

In our normal life we use a trilogy of concepts — "illness," "disease," and "sickness" — interchangeably to refer to different aspects of ill health, however these terms have different connotations. Disease is defined as a condition/ pathological process that is diagnosed by a physician or other medical expert. Whereas, Illness is defined as the ill health the person identifies themselves with. Illness being a subjective phenomenon is often based on self reported mental or physical symptoms. Sickness, on the other hand, refers to social and cultural conceptions of the health condition. These include reactions such as fear or rejection, which influence how the patient reacts. According to Marshall Marinker (1975), disease is the pathological process, deviation from a biological norm. Illness is the patient's subjective experience of ill health, sometimes when no disease can be found. Sickness is the role negotiated by the patient with the society which is prepared to recognize and sustain the patient. A diagrammatic representation of trilogy is given in Figure 2.1.

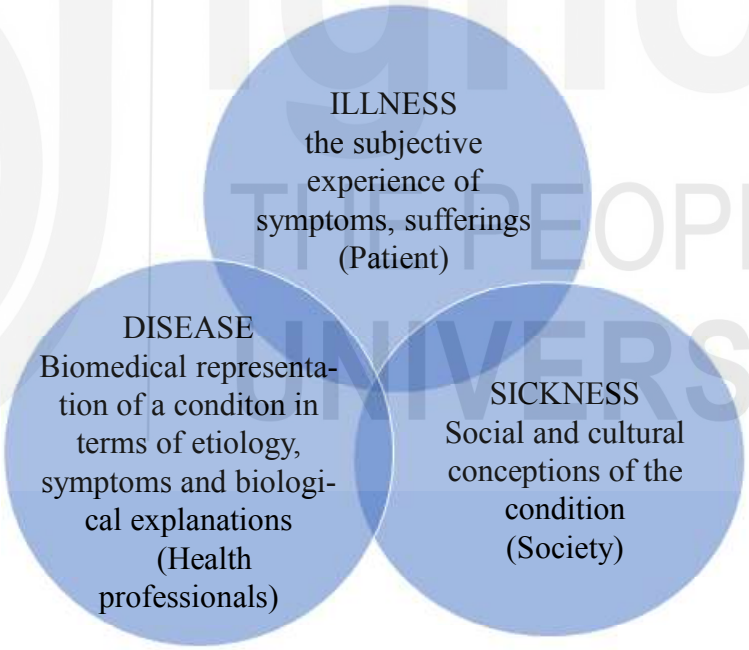

Fig. 2.1: Trilogy of "illness," "disease," and "sickness"

(**Source:** Based On Marshall Marinker's 'Three modes of unhealth', https://jme.bmj.com/content/medethics/1/2/81.full.pdf)

Here you can see that most of the conceptualisations about health and ill health revolve around individual's health. Taking from the above conceptualisations of health, there could also be ideas such as "functional capacity of larger communities/population" or "physical fitness of larger communities/population" etc. Just like there are conceptualisations to understand the health of the individuals, there are conceptualisations to understand the health of larger communities/ populations. There is enough body of knowledge and disciplinary specialisations to understand the health of the population at the macro level.

Though many people have defined public health, there is a general agreement that 'Public health' is complex, multi-disciplinary and holistic. The term public health has various connotations. When we use the term 'public health' it can mean different things depending upon the context. Different terms are used to refer to the public health activities (Box 2.2). As shown in figure 2.2 Public health is used to refer: 1) a profession, 2) an academic discipline, 3) activities of the government and 4) health of the population.

Box 2.2: Some of the terms that have been used for public health activity over time

- Social medicine
- Community medicine
- Preventive Medicine
- Community Health
- State medicine
- Hygiene
- Public medicine
- Public health medicine
- Environmental health
- New public health
- Complete medical policing

Fig. 2.2: Concept of Public Health

2.2 DEFINING PUBLIC HEALTH

In this section we shall go through various definitions of public health. Though many have defined public health, Winslow's definition of public health (Box 2.3) is considered to be the most acknowledged one.

According to World Health Organisation (2018) Public health refers to "all organized measures (whether public or private) to prevent disease, promote health, and prolong life among the population as a whole. Its activities aim to provide conditions in which people can be healthy and focus on entire populations, not on individual patients or diseases. Thus, public health is concerned with the total system and not only the eradication of a particular disease".

Public health is defined as "the science and art of promoting and protecting health and well-being, preventing ill health and prolonging life through the organised efforts of society". (The UK Faculty of Public Health n.d.)

Public Health is defined as "the art and science of preventing disease, prolonging life and promoting health through the organized efforts of society" (Acheson Report, 1988; WHO)

Modeste (1996) defined public health as "the science and art of preventing disease, prolonging life, and promoting health and efficiency through organized community effort for the sanitation of the environment, control of communicable infections, education in personal hygiene, organization of medical and nursing services, and the development of the social machinery to ensure everyone a standard of living, adequate for the maintenance of health."

"Public health is the science of protecting and improving the health of people and their communities. This work is achieved by promoting healthy lifestyles, researching disease and injury prevention, and detecting, preventing and responding to infectious diseases." (The Centers for Disease Control and Prevention (CDC. n.d.).

Beaglehole and Bonita's book "Public Health at the Crossroads" (2004), defines public health as 'Collective action for sustained population-wide health improvement'. Broadly, Public health can be defined as the science of protecting the safety and improving the health of communities through education, policy making and research for disease and injury prevention.

The Institute of Medicine in its report titled "The future of Public Health" notes that "public health is a coalition of professions united by their shared mission" as well as (by "their focus on disease prevention and health promotion; their prospective approach in contrast to the reactive focus of therapeutic medicine, and their common science, epidemiology" (IOM, 1988).

Box 2.3: Winslow's Definition of Public Health

In 1920, C. E. A. Winslow, professor of public health at Yale University, defined public health as follows: *"Public health is the Science and Art of (1) preventing disease, (2) prolonging life, and (3) promoting health and efficiency through organized community effort for:*

a) the sanitation of the environment,

b) the control of communicable infections,

c) the education of the individual in personal hygiene,

d) the organization of medical and nursing services for the early diagnosis and preventive treatment of disease, and

e) the development of social machinery to ensure everyone a standard of living adequate for the maintenance of health, so organizing these benefits as to enable every citizen to enjoy his birth right of health and longevity."

Box 2.4: What is not Public Health?

It is,

- Not a single product or service provided by one type of health professional in one place
- Not a single specialty but inter/trans-disciplinary
- A web of relationships among many different people and organizations about a wide variety of topics – a dynamic system!

Check Your Progress

1) What is Public Health?

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2.3 PUBLIC HEALTH VS MEDICAL CARE

Public health and its functions can be better understood if we compare and contrast it with medical practice. Medical care/medicine focuses on healing patients who are ill or injured. Here individuals are the target of service delivery. On the other hand, the public health is a major governmental and social activity, multidisciplinary in nature, and extending into almost all aspects of society. Important point to be noted here is that the key word is "health," not "medicine. Key focus is on prevention and not cure. While the medical practitioners treat

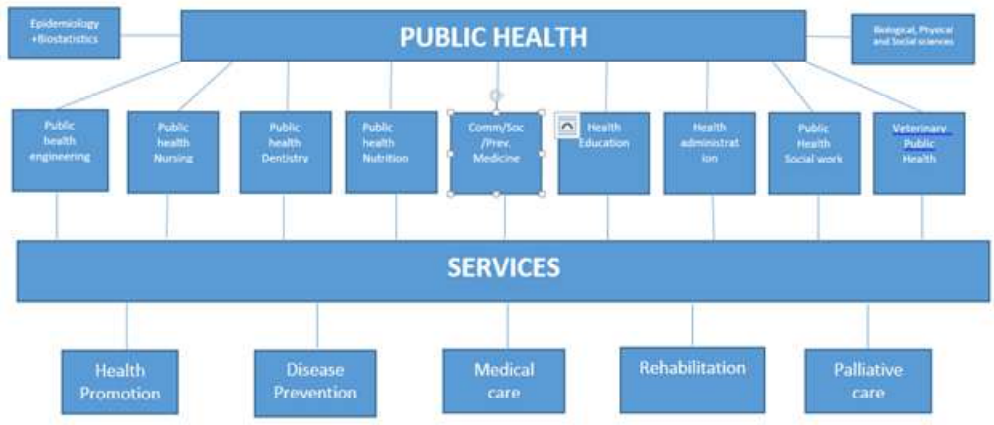

Fig. 2.3: The Public Health Concept

(**Source:** The Distinction between Public Health and Community/Social/Preventive Medicine. *J Public Health Pol* 6, 435–439 (1985). https://doi.org/10.2307/3342044)

people who are sick, public health professionals try to prevent people from getting sick or injured in the first place. Another point is that in public health, the universe of concern is the health of the public, not the discipline of medicine (Figure 2.3).

In summary, medicine is more concerned with individual patients, whereas public health regards the larger community/population as its patient. Medical care is mostly dominated by the curative care whereas public health uses a balanced approach of integrating preventive, curative, promotive, rehabilitative and palliative dimensions of care.

2.4 PUBLIC HEALTH – ORIGIN AND DEVELOPMENT

The history of public health is the history of interventions and efforts to secure health and preventing diseases at the population level. Our efforts to prevent deaths from epidemics have a long history, which goes back beyond the development of modern science. These efforts/interventions even include magico-religious ones. In ancient times people largely attributed their illnesses and deaths to supernatural forces and also performed rituals in order to appease these supernatural forces so that they withdraw their wrath and cure diseases. For example, in India, there is a practice of worshiping '*sitalamata*,' a Hindu goddess of pox diseases. It is believed that she has the power to inflict smallpox and to cure it. These beliefs and practices are even continued today. According to Dorothy Porter, mysticism dominated many ancient health and healing cultures across the world.

Population-based focus of actions has its roots from the times of Hippocrates (Figure 2.4) (460 BC-370 BC) a Greek physician, who is considered to be one of the most outstanding figures in the history of medicine. Hippocratic medicine distanced itself from the religious and mystical traditions of healing. Hippocrates had the understanding that disease was a natural event, not caused by supernatural forces. Hippocrates' "Airs, Waters and Places," a treatise on social medicine and hygiene stressed the importance of nonmedical factors in understanding the health of the population. Until the new sciences of bacteriology and immunology emerged well into the 19th century, Hippocrates's ideas provided a theoretical basis for understanding diseases in Europe and the world. Similarly, practitioners of Chinese medicine and Ayurveda in India (400 BCE) were also aware of the influences of season, diet, the winds and lifestyle for individual/ people's health.

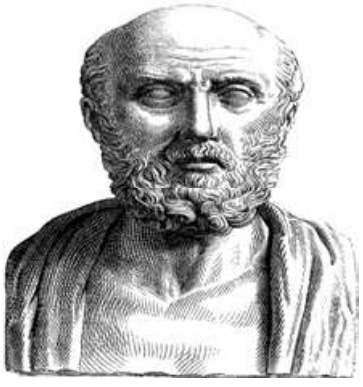

Fig. 2.4: Hippocrates

(**Source:** https://www.mdlinx.com/internal-medicine/article/1752)

Later on, in Europe two theories — Miasma Theory and Theory of Contagion- provided the framework for public health practice till late nineteenth century. Miasma theory was propounded by Galen of Pergamon (129 AD-210AD), a physician, surgeon and philosopher in the Roman Empire. Theory of '*miasma*' or bad air causing disease postulated that vapour, mist, or 'bad air', originating from decomposing material (called *miasmata*) with its foul smell, would enter the body and cause disease. Surprisingly, even bloodletting was practiced to take out the malodorous and poisonous particles entered into the human body. In medieval Europe, bloodletting was the standard treatment for various diseases such as plague, smallpox, epilepsy and gout.

On the contrary, Contagion theory originated from the ancient practice of isolating people with illnesses. The contagion theory is based on the assumption that illness is contagious. In fact, the governments even introduced Quarantine laws (Quarantine laws in Venice in 1348 with lazaretto in 1423) to prevent the contagious diseases. These quarantine laws in a way infringed the individual rights of patients to protect the public. The practice of Isolation of individuals with plague, leprosy, smallpox, etc. was also based on the contagion theory. In recent times, during SARS epidemic (2003), and COVID-19 Pandemic (2020), the quarantine as a strategy was widely used to protect the larger public.

Historians of health and medicine report that for hundreds of years the 'miasma' theory competed with the theory of contagion. Later on, the miasma theory of disease, though debatable, became central to the new convention in Public Health practice. It prompted scientists to focus their attention on environmental factors as causes of diseases. This was contrary to practice of focusing on personal health and infection. Obviously, this understanding of disease causation warranted environmental intervention. Such an understanding also called for enhanced role for government in the environmental interventions. As a result, medieval councils in the Europe started controlling cities, sewage, food and waste. Some of the health historians argue that with these efforts, "the seeds of Public Health were being sown."

Germ theory, in medicine, is the theory that certain diseases are caused by the invasion of the body by microorganisms. The French chemist and microbiologist Louis Pasteur (Figure 2.5), the English surgeon Joseph Lister, and the German physician Robert Koch (Figure 2.6) are considered to be the pioneers of germ theory. In the mid-19th century Pasteur proved that fermentation and putrefaction are caused by organisms in the air. Lister, in the 1860s revolutionized surgical practice by introducing sterilisation using carbolic acid (phenol) to exclude atmospheric germs. In the 1880s Koch identified the organisms that cause tuberculosis and cholera. The germ theory created a new understanding that certain microorganisms are the cause of a specific disease or disease process. Germ theory is considered to be a milestone towards the disease prevention in the history of public health.

Fig. 2.5: Louis Pasteur
(**Source:** https://en.wikiquote.org/wiki/Louis_Pasteur)

Fig. 2.6: Robert Koch
(**Source:** https://www.britannica.com/biography/Robert-Koch)

Vaccination is another medical intervention that affected the health of the population. In 1796 Edward Jenner (Figure 2.7) an English country doctor demonstrated vaccination against smallpox. Based on his experience in inoculation and related works, Jenner induced immunity against small pox via exposure to a harmless related disease, cowpox. Jenner speculated that a bout of cowpox produced immunity against smallpox as he knew that milkmaids never caught smallpox. Jenner inserted pus taken from Sarah Nelmes, a milkmaid with cowpox, into a cut made in the arm of James Phipps, the son of his gardener. Several days later, when Jenner exposed the boy to smallpox, he was found to be immune. Jenner called his new method 'vaccination' after the Latin word for cow (vacca).

Fig. 2.7: Edward Jenner

(**Source:** 1749-1823) (https://circulatingnow.nlm.nih.gov/2018/08/07/edward-jenner-and-the-happy-immunity/)

In 1853, 30 years after Jenner's death, smallpox vaccination was made compulsory in England and Wales. Using vaccination, it took more than a century to eradicate the smallpox, a disease that killed millions of people. Vaccination has greatly reduced the burden of infectious diseases such as measles, whooping cough, tetanus, rubella, flu, polio, yellow fever, pneumococcal disease, and meningococcal disease.

Box 2.5: Vaccination Vs Immunization

Vaccination: The act of introducing a vaccine into the body to produce immunity to a specific disease.

Immunization: A process by which a person becomes protected against a disease through vaccination. This term is often used interchangeably with vaccination or inoculation.

Source: https://www.cdc.gov/vaccines/vac-gen/imz-basics.htm

The development of science and technology had its impact on health. For instance, the invention of microscope and consequent discovery of micro-organisms drastically changed the understanding of diseases and its causal agents. The newly emerged germ theory and existing contagion theory sowed the seeds of new paradigm for dealing with diseases. Germ theory, postulated by Louis Pasteur and Robert Koch, dominated the explanations of disease causations. It held the notion that microorganisms cause diseases and it is possible to control diseases using antibiotics and vaccines.

Emergence of Epidemiology as a new discipline also played an important role in the historical development of public health. Though, in 1662 John Graunt published "Natural and political observations …made upon bills of mortality" and established the field of epidemiology, it became a full-fledged science only in the 19th century. In the middle of the 18th century, James Lind's scurvy study; which hypothesised that scurvy was caused by lack of fruit intake, also contributed to the development of epidemiology. Though, Edward Jenner's inoculation with cowpox prevented smallpox in 1790s it did not give much insight into the causal factors of the disease.

However, the major push for epidemiological studies came with John Snow, a young surgeon-apothecary from Newcastle, who worked on Cholera. Snow's research on causes of cholera deaths led him to a water pump on the corner of Broad Street and Cambridge Street, at the epicentre of the epidemic. He found that nearly all the deaths had taken place within a short distance of the pump. Snow later used a dot map to illustrate the cluster of cholera cases around the pump. Snow also examined the sample water taken from these pumps under a microscope and found that it contained "white, flocculent particles." From this examination he theorised that the water from these pumps was the source of infection. Once Snow informed authorities about his findings regarding cholera deaths, they reluctantly agreed to remove the pump handle as an experiment and consequently, the spread of cholera dramatically stopped. Snow's intervention to combat cholera is seen as "a nail in the coffin of the miasma theory and a vindication of the new science of epidemiology." Later on, the science of epidemiology became an indispensable part of public health.

In 1842, Edwin Chadwick (Figure 2.8) published a report titled "The Sanitary Condition of the Labouring Population". Chadwick's report argued that impure water supplies, inefficient sewerage, and slum housing were causing the unnecessary and preventable deaths of about 60,000 people every year in the industrial towns. He felt that "the greatest proportion of the deaths of heads of families occurred from removable causes. The expense of public drainage, of

supplies of water laid on in houses, and the removal of all refuse... would be a financial gain, as it would reduce the cost of sickness and premature death." The increasing industrialization and urbanization, also lead to the development of urban slums and unsanitary conditions and unsafe work places. In this context, the removal of filth from towns and cities became a major focus in the struggle against infectious diseases. Chadwick also suggested that the government should take the responsibility of providing piped water and removing sewage. Chadwick's report in fact triggered 'the great sanitary awakening' in Europe. The sanitary movement that followed thereafter was an important milestone in the history of public health.

Fig. 2.8: Edwin Chadwick

(**Source:** 1800 –1890) (https://en.wikipedia.org/wiki/Edwin_Chadwick)

Following the Chadwickian model, Lemuel Shattuck, a Massachusetts bookseller and statistician, conducted a survey on sanitary conditions and published "Report of the Massachusetts Sanitary Commission" in 1850. Shattuck's Report recommended a "Plan for a Sanitary Survey of the State," and a comprehensive public health system for the state. Shattuck report also recommended new census schedules; regular surveys of local health conditions; supervision of water supplies and waste disposal; special studies on specific diseases (including tuberculosis and alcoholism); education of health providers in preventive medicine; local sanitary associations for collecting and distributing information; and the establishment of a state board of health and local boards of health to enforce sanitary regulations. Shattuck's report is considered as one of the most farsighted and influential documents in the history of the public health. Even now, many of the principles and activities proposed by Shattuck are considered fundamental to public health practice. Most importantly, Shattuck also established the fundamental usefulness of keeping records and vital statistics for addressing the public health issues.

According to the book 'The future of public health,' "sanitation changed the way society thought about health. Illness came to be seen as an indicator of poor social and environmental conditions, as well as poor moral and spiritual conditions. Cleanliness was embraced as a path both to physical and moral health. Cleanliness, piety, and isolation were seen to be compatible and mutually

reinforcing measures to help the public resist disease. At the same time, mental institutions became oriented toward "moral treatment" and cure" (IOM. 1988).

In the 20th Century the developments in anatomy, physiology, bacteriology and vaccination gave a new direction for managing the health of the population. This particular period in the history of medicine is known as "Bacteriological Era". The invention of penicillin and other antibiotics especially in the first half of the 20th century gave the medical profession a new direction (see figure 2.9 for the timeline of discovery of antibiotics).

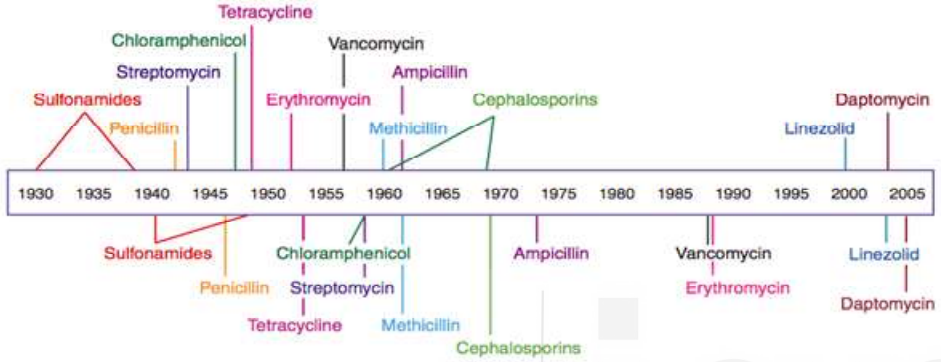

Fig. 2.9: Timeline of Discovery and Development of Antibiotics

(**Source:** https://evolutionmedicine.com)

Governments with and without the support of international organisations such as World Health Organisation (WHO; established in 7th April 1948) started launching national programmes to contain diseases such as Malaria and Tuberculosis. In the similar fashion, governments also launched immunisation programmes at a large scale. For Instance, with the support of vaccination campaigns, surveillance and prevention measures, small pox was eradicated by 1980 at the global level. According to Institute of Medicine (1988), "during the past 150 years, two factors have shaped the modern public health system: first, the growth of scientific knowledge about sources and means of controlling disease; second, the growth of public acceptance of disease control as both a possibility and a public responsibility."

The Alma-Ata Declaration of 1978 (Box 2.6) emerged as a major milestone of the 20th century in the field of public health. The declaration identified primary health care as the key to the attainment of the goal of Health for All by 2000AD.

Box 2.6: Alma Ata Declaration

The Declaration of Alma-Ata was adopted at the International Conference on Primary Health Care, Alma Ata, Kazakhstan, 6–12 September 1978. It expressed the need for urgent action by all governments, all health and development workers, and the world community to protect and promote the health of all people of the world. The declaration clearly stated that "health, which is a state of complete physical, mental and social wellbeing, and not merely the absence of disease or infirmity, is a fundamental human right and that the attainment of the highest possible level of health is a most important world-wide social goal whose realization requires the action of many other social and economic sectors in addition to the health sector".

It further stated that "Governments have a responsibility for the health of their people which can be fulfilled only by the provision of adequate health and social measures. A main social target of governments, international organizations and the whole world community in the coming decades should be the attainment by all peoples of the world by the year 2000 of a level of health that will permit them to lead a socially and economically productive life. Primary health care is the key to attaining this target as part of development in the spirit of social justice.

Source: https://www.who.int/publications/almaata_declaration_en.pdf

For many decades, the concept of public health was largely equated with the 'sanitary idea' of environmental reform. This idea also incorporated the methods of preventive medicine such as immunisation. Though, there have been considerable gains in terms of life expectancy and quality of life, many countries still faced the scourges of communicable diseases, as well as the pandemics of non-communicable diseases such as diabetes and cancer. In the changing context, new conceptualisation of health and disease also emerged. The realisation that health and disease is complex and they are rooted in social, physical, and cultural environment in which people lived, gave rise to the "social model of health." This model also advocated a multi-causal approach to health and illness. The social model of health considers a wide range of factors that influence health and wellbeing, such as environmental, economic, political, social and cultural. The current practice of public health is largely based on the social model of health. The contributions of Rene Dubos (distinguished American microbiologist and eminent medical historian), Thomas McKeown (British Medical Historian) and Ivan Illich (Croatian-Austrian philosopher and critic of the institutions of modern Western culture) in the 1960s and 70s also played also an important role in the development of social model of health. For instance, McKeown attributed the modern rise in the world population from the 1700s to broad economic and social changes rather than to medical interventions.

Box 2.7: Key Terms

Clinical Care: Prevention, treatment, and management of illness and the preservation of mental and physical well-being through the services offered by medical and allied health professions; also known as health care.

Public Health Systems: It refers to all public, private, and voluntary entities that contribute to the delivery of essential public health services within a jurisdiction. The public health system includes: 1) Public health agencies at state and local levels, 2) Healthcare providers, 3) Public safety agencies, 4) Human service and charity organizations, 5) Education and youth development organizations, 6) Recreation and arts-related organizations, 7) Economic and philanthropic organizations, and 8) Environmental agencies and organizations.

An Epidemic or Outbreak: Occurrence in a community or region of cases of an illness, specific health-related behaviour, or other health-related event clearly in excess of normal expectancy. Both terms are used interchangeably; however, epidemic usually refers to a larger geographic distribution of illness

or health-related events. An outbreak is a greater-than-anticipated increase in the number of endemic cases. The term outbreak also can be used to refer to even a single case in a new area. If it's not quickly controlled, an outbreak can become an epidemic. Therefore, an epidemic affects a large number of people within a community, population, or region.

A Pandemic: An epidemic of disease that has spread across a large region; for instance, multiple continents, or even worldwide. For example, In the beginning COVID-19 was limited to Wuhan, China, then it was an epidemic. However, the massive geographical spread turned covid-19 into a pandemic.

An Endemic: A disease that is constantly present in a region or population. Usually the term is used to refer to something that belongs to a particular people or country. For example, Malaria in Africa countries.

Check Your Progress

2) What are the old theories of disease causation?

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2.5 THE SCIENCES OF PUBLIC HEALTH

This section briefly introduces the sciences of public health. It is important to remember the aspect of multi/interdisciplinarity of public health is crucial to the concept. Health being multifactorial, multidimensional, and multifaceted requires a multidisciplinary team work to address the problems and issues at the population level. Many professional disciplines are involved in the public health practice. It also requires disciplinary knowledge of both physical and social sciences. Therefore, the scientific knowledge on which public health is based spans a broad range of professional disciplines. Today, public health involves the application of many different disciplines: Biology, Psychology, Computer science, Sociology, Medicine, Economics, Geography, Anthropology, Public Policy/Health Policy, Mathematics, Engineering, Business, Education.

2.6 CORE DISCIPLINES WITHIN PUBLIC HEALTH

The goal of public health is the biological, physical, and mental well-being of all members of society. To achieve this broad challenging goal, public health professionals need to have a wide range of disciplinary understanding. This multi/ interdisciplinary/ understanding is required to anticipate, identify and prevent problems, identify strategies to resolve these problems, implement these strategies, and finally, evaluate their effectiveness. The details of core disciplines of public health are given below:

2.6.1 Epidemiology

It is the study of frequency, distribution, and determinants of health-related states or events in specified populations, and the application of this study to the control of health problems. Epidemiologists examine the 5 W's: diagnosis or health event (what), person (who), place (where), time (when), and causes, risk factors, and modes of transmission (why/how).

2.6.2 Nutrition

It is the science of food, the nutrients and other substances therein, their action, interaction and balance in relation to health and disease. Nutrition science also includes the study of behaviour and social factors related to food choices.

2.6.3 Environmental Health

This core discipline of public health draws strongly on the natural sciences. Environmental health scientists monitor the levels of contaminants in the environment and seek to understand the impact of environmental factors on health.

2.6.4 Health Education

Health education is a social science that draws from the biological, environmental, psychological, physical and medical sciences to promote health and prevent disease, disability and premature death through education-driven voluntary behaviour change activities. Health education is any combination of learning experiences designed to help individuals and communities improve their health, by increasing their knowledge or influencing their attitudes.

2.6.5 Behavioural Science

It is a branch of science (such as psychology, sociology, or anthropology) that deals primarily with human action and often seeks to generalize about human behaviour in society. With the knowledge about human interaction, decision making, and group processes public health professionals persuade people to make healthy choices. Both in the theory and practice, health education and behavioural sciences are closely interrelated.

2.6.6 Health Services Administration/Management

This discipline is all about getting people to work harmoniously together and to make efficient use of resources in order to achieve objectives. Health Services Administration involves planning, directing, and coordinating medical and health services. The business of health care is the domain of health service managers.

2.6.7 Biostatistics

It is the application of statistics to biological and medical problems. Statistical methodologies are among the most important tools used by researchers in any fields especially when you are dealing with problems of the larger population.

2.6.8 Health Economics

It is concerned with the alternative uses of resources in the health services sector and with the efficient utilization of economic resources such as human resource, material and financial resources.

2.6.9 Demography

It is the study of population, especially with reference to size and density, fertility, mortality, growth, age distribution, migration, and the interaction of all those with social and economic conditions.

2.7 PUBLIC HEALTH APPROACHS

As opposed to clinical approach; which focuses on the diagnoses and treatments of illness in individuals, the public health approach involves: 1) defining and measuring the problem, 2) determining the cause or risk factors for the problem, 3) determining how to prevent or ameliorate the problem, and 4) implementing effective strategies on a larger scale and evaluating the impact. The public health approach starts with a problem ends with a response or intervention. The figure 2.10 provides a diagrammatic representation of the public health approach.

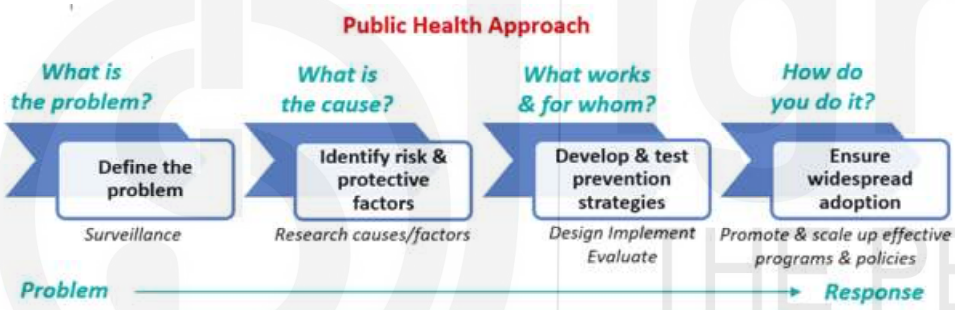

Fig. 2.10: Public Health Approaches

(**Source:** https://www.nasbla.org/advocacy/public-health)

As discussed earlier, public health shapes the context within which people and communities can be safe and healthy. For this purpose, you may have noticed from the above discussions that public health practitioners use different approaches. Firstly, it uses a Population-based approach in which groups of people or larger community becomes the "target/audience". Active surveillance is used as an approach to monitor communities for patterns of diseases and health conditions. For example, during covid-19 pandemic active surveillance was used with the help of health service system as well as community networks. At times, medical policing is also used as an approach in which individual rights are curbed in order to keep the public healthy. Banning of tobacco smoking in public places by law is an example of medical policing. Using a social justice approach, public health advocates equity for all and reaches out to vulnerable populations.

2.8 FUNCTIONS OF PUBLIC HEALTH

In this section we will try to learn about the question "What do public health professionals do?" Public health involves "both activities undertaken within the formal structure of government and the associated efforts of private and voluntary organizations and individuals." The three core functions of public health are: (1)

Assessment; (2) Policy development; and (3) Assurance. Based on this, public health professionals deliver the essential services (refer Box 2.8 for details). According to Griffiths, S; Jewell, T and Donnelley, P. (2005), the practice of public health falls within the three domains – Health Protection, Health improvement and Health Service improvement (please refer figure 2.11 for more details).

Box 2.8: Public Health: Core Functions and Essential Services

Assessment

- Surveillance of disease/injury.
- Monitoring trends; analyzing causes; and identifying needs.

Policy Development

- Inform, educate, and empower people about health issues.
- Mobilize community partnerships and actions to identify and solve health problems.
- Develop comprehensive public health policies and plans that support individual and community health efforts.
- Promote scientific basis of decision-making.
- Develop and implement strategic approach.

Assurance

- Enforce laws and regulations that protect health and ensure safety.
- Link people to necessary health services and assure the provision of health services when otherwise unavailable.
- Assure a competent health workforce.
- Evaluate effectiveness, accessibility, and quality of personal and population-based health services.
- Research for new insights and innovative solutions to health problems.

(**Source:** https://www.cdc.gov/nceh/ehs/ephli/core_ess.htm)

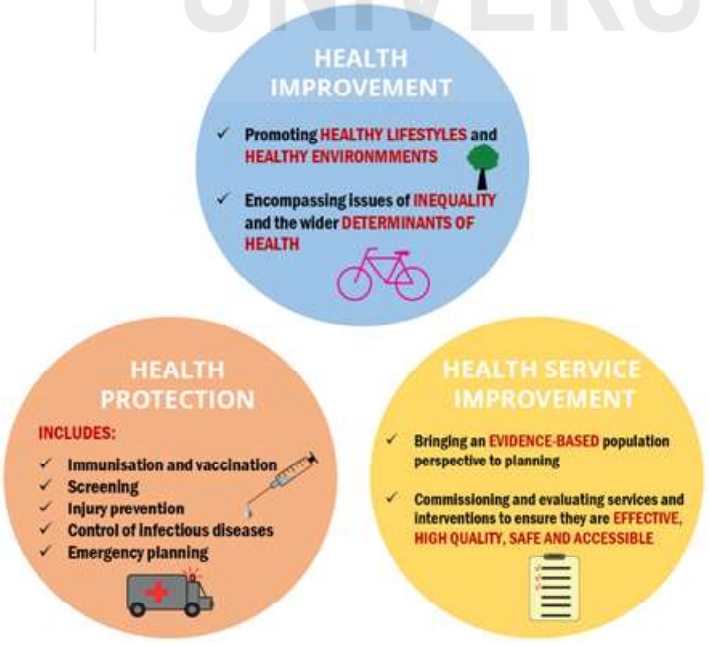

Fig. 2.11: Three Domains of Public Health

(**Source:** Griffiths, S; Jewell, T and Donnelley, P. (2005) 'Public health in practice: the three domains of public health', Public Health, 119(10):907–13).

Check Your Progress

3) What are the various core disciplines of Public Health?

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2.9 PUBLIC HEALTH INFRASTRUCTURE IN INDIA

We all know that health infrastructure is an important factor in the provisioning of health care services and other related welfare services in a country. Thus, infrastructure is seen as the basic support for the delivery of public health activities. In India, health service infrastructure includes details of allopathic hospitals, hospital beds, Indian System of Medicine & Homeopathy hospitals, sub-centres (SCs), Primary Health Centres (PHC), Community Health Centres (CHC), blood banks, eye banks, and mental hospitals. Public health care infrastructure in India is organised in multiple levels as depicted in the figure 2.12. At top of the structure, we have tertiary care institutions like medical colleges and at the bottom we have primary health centres and Sub-centres to cater to the health needs of the people.

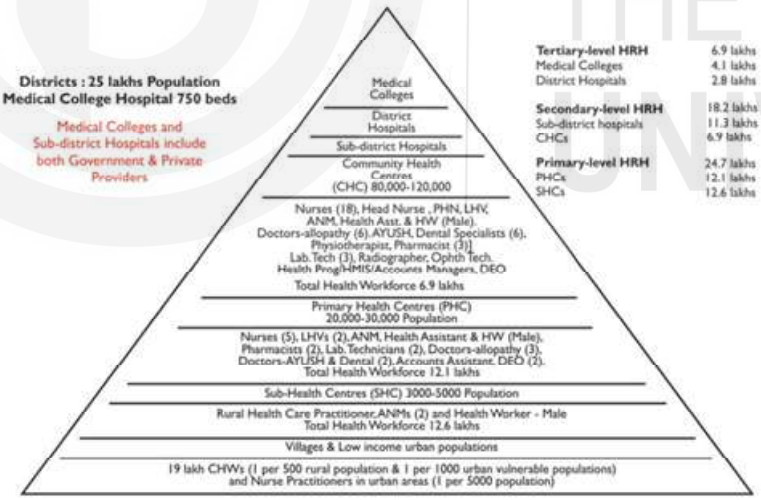

Fig. 2.12: Public Health Care Infrastructure in India

(**Source:** NHM as reproduced by Chokshi M. et.al. (2016) – Public health-care infrastructure in India).

2.10 PUBLIC HEALTH IN INDIA: AN OVERVIEW

At the time of independence, India's health status was one of the worst in the world. The life expectancy at birth was estimated at 36.7 years in 1951. The infant mortality rate was as high as 146 per 1,000 in 1951. Poor socio-economic development opportunities coupled with deadly diseases kept mortality rates

very high. However, the improved access to healthcare services along with improved living conditions such as food supply, housing facilities, sanitation and hygiene, led to a gradual decline in deaths from infectious diseases such as smallpox, malaria, pneumonia, tuberculosis, diarrhoea, poliomyelitis, typhoid, cholera, and plague in the post independent India. Over a period of time both the life expectancy and other mortality indicators showed significant improvement. According to the latest reports the life expectancy has crossed to 67 years. Though Infant mortality rate (33 per 1000) and maternal mortality ratio (122 per one lakh live births) have come down significantly since independence it is still unacceptably high. Many diseases, such as polio, guinea worm disease, yaws, and tetanus, have been eradicated. If we look at the recent history, there have been significant improvements in the overall health status especially in the last twenty years. The recent improvements in healthcare services can partly be attributed to the National Health Mission (For details please see the box 2.9).

Box 2.9: National Health Mission (NHM)

The National Health Mission (NHM) encompasses its two Sub-Missions, the National Rural Health Mission (NRHM) and the National Urban Health Mission (NUHM). The main programmatic components include Health System Strengthening, Reproductive-Maternal- Neonatal-Child and Adolescent Health (RMNCH+A), and Communicable and Non-Communicable Diseases. The NHM envisages achievement of universal access to equitable, affordable and quality health care services that are accountable and responsive to people's needs.

National Rural Health Mission

The National Rural Health Mission (NRHM) was launched by the Hon'ble Prime Minister on 12th April 2005, to provide accessible, affordable and quality health care to the rural population, especially the vulnerable groups. The Union Cabinet vide its decision dated 1st May 2013, has approved the launch of National Urban Health Mission (NUHM) as a Sub-mission of an over-arching National Health Mission (NHM), with National Rural Health Mission (NRHM) being the other Sub-mission of National Health Mission.

NRHM seeks to provide equitable, affordable and quality health care to the rural population, especially the vulnerable groups. Under the NRHM, the Empowered Action Group (EAG) States as well as North Eastern States, Jammu and Kashmir and Himachal Pradesh have been given special focus. The thrust of the mission is on establishing a fully functional, community owned, decentralized health delivery system with inter-sectoral convergence at all levels, to ensure simultaneous action on a wide range of determinants of health such as water, sanitation, education, nutrition, social and gender equality. Institutional integration within the fragmented health sector was expected to provide a focus on outcomes, measured against Indian Public Health Standards for all health facilities.

National Urban Health Mission

The National Urban Health Mission (NUHM) as a sub-mission of National Health Mission (NHM) has been approved by the Cabinet on 1st May 2013.

NUHM envisages to meet health care needs of the urban population with the focus on urban poor, by making available to them essential primary health care services and reducing their out of pocket expenses for treatment. This will be achieved by strengthening the existing health care service delivery system, targeting the people living in slums and converging with various schemes relating to wider determinants of health like drinking water, sanitation, school education, etc. implemented by the Ministries of Urban Development, Housing and Urban Poverty Alleviation, Human Resource Development and Women and Child Development.

Source: https://nhm.gov.in/index4.php?lang=1&level=0&linkid=445&lid=38

Presently, India is undergoing a health transition; demographically as well as epidemiologically. Demographic transition is characterised by mortality decline, natural increase in population size, fertility decline, urbanization and population aging. Whereas, epidemiological transition can be characterized by low mortality, high morbidity, and by the double burden of communicable diseases and non-communicable diseases (NCDs). Though India still has heavy burden of communicable diseases such as TB and Malaria, NCDs such as heart disease, cancer, diabetes, and chronic pulmonary diseases are now the leading cause of death in India, contributing to nearly 60% of deaths. Experts have argued that presently India suffers from the triple burden of disease-communicable diseases; non-communicable diseases (NCDs) and malnutrition. The recent reports show that more than one third of the world's malnourished children live in India. In spite of government's efforts to address the malnutrition issues through massive national level programmes such as POSHAN Abhiyan, malnutrition still remains as one of the biggest developmental challenges in India.

Inadequate water, sanitation and hygiene (WASH) services have a ripple effect on almost everyone's life. According to UNICEF "Just a few years ago, in 2015, nearly half of India's population of around 568 million people suffered the indignity of defecating in fields, forests, bodies of water, or other public spaces due to lack of access to toilets. India alone accounted for 90 per cent of the people in South Asia and half of the 1.2 billion people in the world that defecated in the open. By 2019, according to the latest estimates, the number of people without access to toilets has reduced significantly by an estimated 450 million people. A tremendous achievement, only possible because of the Swaccha Bharat Mission (SBM) (Clean India Campaign)," Though the SBM is seen as a big success by international organisations such as UNICEF, its real impact on infant and child health is yet to be fully understood.

Health and nutritional statistics in India and elsewhere reflect social and economic inequities. Therefore, it is important to bear in mind that the health and nutritional inequities in India are further exacerbated by the social inequities arising out of class, caste, religion and regional disparities. Many researchers have pointed out the evident association of appallingly low health status with poor, female gender, rural place of residence, tribal ethnicity, scheduled castes (SC) and specific minority groups.

2.11 SUMMARY

Public health practice comprises of organised efforts to improve health of the communities. Public health intervention strategies are targeted to populations rather than to individuals. Therefore, public health practice is population-based. Throughout the history, public health efforts had been directed to control of communicable diseases, reduction of environmental hazards, and provision of safe drinking water to prolong human life. As it emphasises collective responsibility for health protection and disease prevention, it also recognises the key role of the state. Another important point to be kept in mind is that the epidemiological understanding is crucial to the practice of public health. Relying on the social model of health, public health professionals approach the health with the understanding that socio-economic, environmental and biologic factors interact to determine health. Therefore, a multidisciplinary/interdisciplinary understanding of health and disease is important in the practice of public health. The recent public health interventions to combat covid-19 pandemic clearly show us the importance of recognising the interlinkages between various underlying factors that influence health and disease.

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2.13 ANSWERS TO CHECK YOUR PROGRESS

1) Public health is the science of protecting and improving the health of people and their communities. Public health can be defined as the science of protecting the safety and improving the health of communities through education, policy making and research for disease and injury prevention.

2) There are two theories for disease causation namely Miasma theory and theory of Contagion. Miasma theory was created by Galen. The theory of 'miasma' or bad air causing disease postulated that vapour, mist, or 'bad air', originating from decomposing material (called miasmata) with its foul smell, would enter the body and cause disease. Surprisingly, even bloodletting was practiced to take out the malodorous and poisonous particles entered into the human body. The other one Contagion theory originated from the ancient practice of isolating ill people. The contagion theory is based on the assumption that illness is contagious. In fact, the governments even introduced Quarantine laws (Quarantine laws in Venice in 1348 with lazaretto in 1423) that in a way infringed the individual rights to protect public. The practice of Isolation of individuals with plague, leprosy, smallpox, etc. was also based on the contagion theory.

3) The core disciplines of public health are:

1) Epidemiology, 2) Nutrition, 3) Environmental Health, 4) Health Education, 5) Behavioural Sciences, 6) Health Services Administration/Management, 7) Biostatistics, 8) Health Economics and 9) Demography.

UNIT 3 ENVIRONMENTAL HEALTH*

Contents

Learning Objectives

After reading this unit, you would be able to:

- Understand the importance of environmental indicators for holistic understanding of health;
- Elucidate about the importance and effect of environment on human health; and
- Get an insight of efforts made in India by the legislature and judiciary to improve environment and human health.

* Contributed by Dr. Aakriti Grover, Department of Geography, Central University of Tamilnadu, Neelakudy

3.0 INTRODUCTION

Environmental health is a combination of two broad dimensions, that is, environment and health. The environment encompasses everything that surrounds us while health is a result of influence of environmental factors on us. Everything that surrounds us, be it air, water, soil etc. have influence on our physical, mental and social health. Hence, we cannot overlook the human health problems without understanding environment.

3.1 DEFINITIONS OF ENVIRONMENT AND HEALTH

As per the Merriam Webster dictionary, environment is defined as 1: the circumstances, objects, or conditions by which one is surrounded. 2a: the complex of physical, chemical, and biotic factors (such as climate, soil, and living things) that act upon an organism or an ecological community and ultimately determine its form and survival; 2b: the aggregate of social and cultural conditions that influence the life of an individual or community (https://www.merriam-webster.com/dictionary/environment).

Health, on the other hand, can be interpreted in various ways. There is no one strict definition of heath till now and that makes the concept complex. To a medical practitioner, health is only about being free from any illness or disease. For a very long time, health was defined in this manner only and to be honest, it is a very narrow viewpoint because one may be having a disease but may still feel healthy and happy. It just depends on the personal willpower and state of mind.

The modern definition of health was given by World Health Organization (WHO) in 1948 and surprisingly it has not been modified since then. WHO considers health to be a state of complete physical, mental and social wellbeing. This definition follows the holistic approach whereby it takes into account all forms of health: physical, mental and social to be necessary for being healthy. The definition is praised for its wholesomeness but at the same time there are many drawbacks of this definition like: one, no one can be completely perfectly healthy as per this definition; what is wellbeing is still not clear; using this definition, we cannot measure the level of health and hence it is not an operational definition. However, it is best suited as it encompasses all facets of health.

Alternatively, many scholars have given the definition of health with focus on adaptation and adaptive capacity to overcome physical, emotional and social health challenges. The upcoming preferred view on health is 'the ability to adapt and to self manage.'

3.2 UNDERSTANDING OF ENVIRONMENTAL HEALTH

Having learnt the two terms independently, now let us try to understand the concept of environmental health. In 1989, the WHO defined it 'as comprising of those aspects of human health and disease that are determined by factors in the environment. It also refers to the theory and practice of assessing and controlling factors in the environment that can potentially effect health'.

A more recent attempt at defining the term emerged from a meeting of WHO European member states in 1993. Their proposed definition was: 'Environmental health comprises of those aspects of human health, including quality of life, that are determined by physical, biological, social and psycho-social factors in the environment. It also refers to the theory and practice of assessing, correcting and preventing those factors in the environment that can potentially affect adversely the health of present and future generations.'

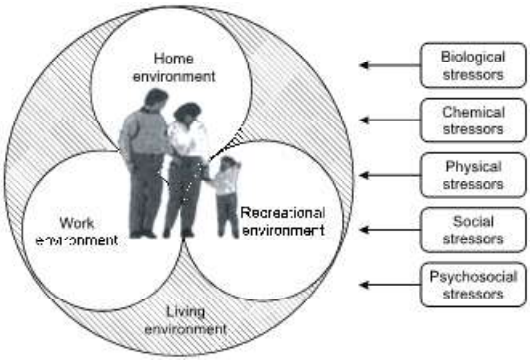

Fig. 3.1: The Interface of Environment Health

(Source: Basnestt, 2004; MacArthur and Bonnefoy, 1998)

The above definitions focus on three kinds of environments: home, work and recreation. All of them are different from each other and therefore the kind of stresses or challenges are also different. Overall, in the living environment of any person, stressors like biological, chemical, physical, social and psychological influence the state of health (Figure 3.1).

It is believed that to achieve Sustainable Development Goals, policy makers should work to improve the environmental health. This can be done at three levels: to repair past damage, to control present risk and to prevent future problems.

Check Your Progress

1) What is environmental health?

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3.3 WHY IS ENVIRONMENTAL HEALTH IMPORTANT?

The health of environment is important because it relates to us, that is health of human beings. It does not exist in isolation; rather, very strong inter-relationships can be scientifically observed and proved between the two.

The health impacts from the environment can be both short term/acute or long term/chronic. The acute conditions may include cold or flu, oil spill, food poisoning or heart attack. These are relatively short lived and have sudden onset. On the other hand, chronic conditions develop or worsen over a long period of time. The causes of chronic conditions are can be more than one so it is difficult to understand the real cause, for instance, asthma, cancer and diabetes. Somebody, who is a non-smoker, may be continuously exposed to air pollution on daily basis as he/she live near a factory or a traffic junction and therefore may face chronic respiratory diseases. In reality, it is not one environmental factor responsible for diseases. There may be other factors contributing like indoor pollution, housing conditions, living conditions, lifestyle, diet, genetics and many others.

3.4 GLOBAL BURDEN OF DISEASES

The effect of environmental degradation and its effect on human health is very difficult to measure as it is not only illness or disease but also loss of productivity, income and expenditure on health care that are important indicators of degrading human health. Efforts to quantify the environmental burden of disease have been spearheaded by Smith, Corvalán & Kjellström (1999). Their results provide the basis for estimating the environment's impact on health. As per their results, diarrheal diseases are 80–90% attributable to environmental causes, followed by acute respiratory infections, estimated to be 40–60% environmental. Malaria and cancer also contribute substantially to the environmental burden of disease (Figure 3.2).

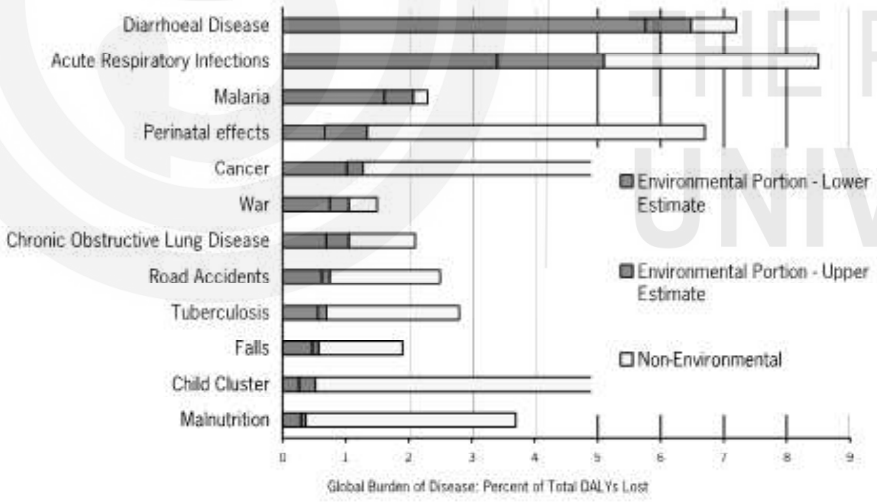

Fig. 3.2: Environmental Contribution to Global Burden of Diseases by Selected Disease Groups

(**Source:** Kjellén, M (2001), Smith et al. (1999)

The Global Burden of Diseases (GBD) study was started by WHO in 1990 and the latest recorded report was released in 2016 using the 2015 data. The GBD aims to systematically understand, analyze, project and measure the causes and impacts of diseases on human life expectancies. To measure the burden of disease the metric used is called DALY*. Ischemic heart disease, neonatal disorders, stroke, lower respiratory infections, diarrhea, road injuries, and chronic obstructive pulmonary disease (COPD) accounted for more than 1 million deaths each worldwide in 2017 (Figure 3.3).

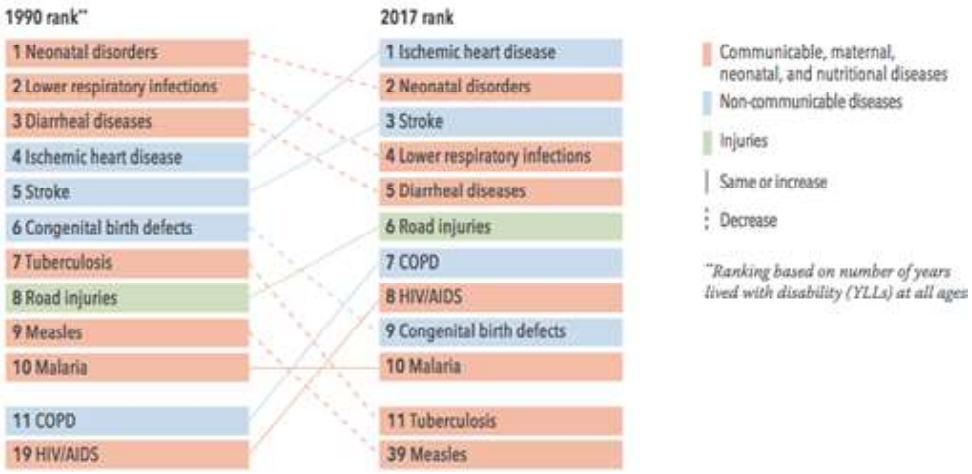

Fig. 3.3: Leading causes of early death, 1990 and 2017

(Source: IHME, The Lancet (2018)

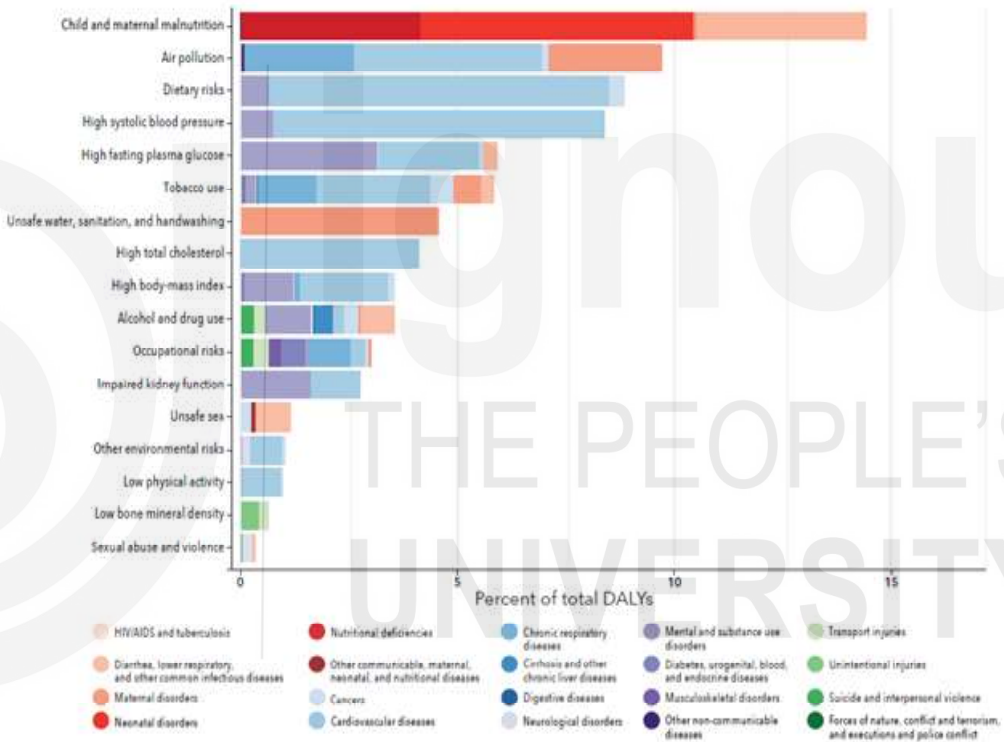

Fig. 3.4: Contribution of Various Risk Factors in DALY (in percentage), 2016

(**Source:** Indian Council of Medical Research, Public Health Foundation of India and Institute of Health Metrics and Evaluation (2017).

The risk factors are the drivers of diseases and injuries that cause pre mature death and disability. The top risk factors that are causing the disease burden in 2016 were malnutrition (14.6 %), air pollution (9.8 %), dietary risks (8.9 %), high blood pressure (8.5 %) and high plasma fasting glucose (6 %) (2016) (ICMR et al. 2017) (Figure 3.4).

**Note*: The Disability Adjusted Life Year (DALY) is a health gap measure that extends the concept of potential year of life lost due to premature death (PYLL) to include equivalent years of "healthy" life lost by virtue of being in states of poor health or disability.

3.5 DETERMINANTS OF HEALTH

Broadly, physical, social and individual factors influence human health. Physical may include factors like air, water, soil, food availability, pollution, noise etc.; social includes health care facilities, education, race, income etc. and individual includes behaviors and genetics. Other than these government policies, subsidies, programmes for betterment of environment and accessibility to health services are necessary.

There are chemicals, toxins, radiation, diseases causing micro-organisms and plants, pesticides and heavy metals in our physical environment that can cause damage to human health. These environmental substances related to air affect the lungs, food affects the digestive system, water and soil related substances affect digestive system and skin. All these are released by human activities of agriculture, transportation and industrialization. Health conditions that may be linked to environment are cancers of liver, bladder, lungs; asthma and respiratory diseases; diseases of the nervous system; Parkinson's diseases, Alzheimer's diseases; autism, birth defects and developmental disabilities. These illnesses are not solely caused due to environmental conditions, rather may be aggravated due to them. Various population characteristics like age, gender, race and ethnicity and socio-economic environment may also influence human health.

3.6 EFFECTS OF BIOLOGICAL, CHEMICAL, AND PHYSICAL AGENTS ON WATER, AIR, FOOD AND LAND RESOURCES

The environment, as discussed, can be divided into three components: Biological composed of plants, animals, rodents, viruses and other life forms; Physical made of non-living things like air, water, soil, housing, waste, radiation etc. and social environment that include customs, culture, habits, income, religion, occupation, education, lifestyle etc. There are various agents (biological, chemical and physical) in the environment that influence human health through the physical environment that is discussed below.

3.6.1 Effects of Biological, Chemical, and Physical Agents in Water on Human Health

Water borne diseases are one of the main causes of illness and disease in India and many other developing countries. Safe and wholesome water is free of pathogens, chemical substances and is pleasant to taste. But due to the human activities like industrial discharge, urbanization, agricultural sources of pollution and municipal sewage water becomes polluted and unsafe for consumption.

3.6.1.1 Classification of Water Borne Diseases According to Causative Agents

a) Physical and Chemical Pollutants: The chemical pollutants are derived from human activities such as agriculture, industries and urban growth. These can be organic (detergents, tar, plastic, pesticides) or inorganic (nitrites, phosphates, chlorides, fluorides, salts etc.) in nature. These pollutants include

detergent solvents, cyanides, heavy metals, minerals and organic acids, nitrogenous substances, fertilizers, soaps, oil spill, chlorine, bleaching agents, dyes, pigments, sulphides, ammonia, toxic and biocidal organic compounds of great variety. Chemical pollutants may affect human health not only directly, but also indirectly by accumulating in aquatic life (e.g. fish) used as human food (https://shodhganga.inflibnet.ac.in/bitstream/10603/99825/11/11_chapter%202%20final. pdf).

b) Biological agents can be broadly divided into two types: Pathogenic (Bacteria, virus, nematodes, worms, protozoans) and nuisance organisms (Slime, mollusc, algae, Asellus, nematodes). Biological water borne diseases are caused by biological agents / infective agent that may include viral (Viral Hepatitis A, Hepatitis E), Bacterial (Typhoid, dysentery), Protozoal (Amoebiasis), Helminthic (Roundworm, Threadworm) or Leptospiral (weil's disease). The hosts maybe aquatic like Cyclops (Guinea worm, fish tape worm). Malaria-stagnant water and Mosquito-Plasmodium vivax is a good example here. Other than these, many biological diseases causing agents thrive in water that are cause of concern such as disease carrying insects breeding in or near water, like: malaria, filaria, arboviruses, onchocerciasis, African trypanosomiasis.

c) Physical: Changes in temperature, turbidity, colour and suspended and floating matter in water bodies are responsible for human health illnesses. These changes may take place due to mixing of waste water and industrial effluents with rivers and ground water or addition of silt, sand, metal pieces, rubber, wood chips, paper, foam, scum, carcasses and sewage through various human activities.

3.6.1.2 Effects of Water Pollution on Human Health

a) Occurrence of pesticides in water adversely affects human health and research reveals its strong linkages with cancer (leukemia, lymphoma, brain, kidney, breast, prostate, pancreas, liver, lung and skin cancers), neurological disorders, birth defects, fetal death and altered fetal growth.

b) Thermal pollution results in excessive heat production, which are detrimental for human health and aquatic organisms.

c) Marine pollution that is caused by oil spill, waste disposal, esp. plastic is extremely damaging for marine and human life. Tons of plastic wastes are found in stomach of dead whales, asbestos and other animals.

d) Radioactive waste produced for harnessing nuclear energy or defense purposes and the left over waste from the experiments conducted are dumped into oceans. This waste has extremely long life and has effect on health of ecosystem.

e) Pollutants like zinc cause vomiting, renal damage, cramps; copper - hypertension, sporadic fever, uremia, coma; barium - excessive salivation, colic, vomiting, diarrhoea, tremors, paralysis of muscles or nervous system, damage to heart and blood vessels; cadmium - vomiting, diarrhoea, abdominal pains, softening of bones, fractures, skeletal deformations, damage of kidney, hypertension, tumor formation, heart disease, impaired

reproductive function, genetic mutation; mercury — impairment of vision and muscles, paralysis; lead — high rate of miscarriages, affects skin, and respiratory system, damages kidney, liver and brain cells; arsenic — cancer of skin, lungs and liver, chromosomal aberration and damage, gangrene, loss of hearing, injury to nerve tissue, liver and kidney damage; fluoride - rippling scourge (sponging)/fluorosis of bones, teeth; chromium – cancer; manganese - sexual impotence, muscles fatigue, eye blindness (https://shodhganga.inflibnet.ac.in/bitstream/10603/99825/11/11_chapter%202%20final.pdf).

3.6.2 Effects of Biological, Chemical and Physical Agents in Air on Human Health

Our immediate surroundings comprise of air upon which all life forms depend for oxygen. Besides this, air helps in cooling of body, transmit sense of hearing and smell and also may spread disease-causing agents. Pollution of air by dust, smoke, toxic gases and chemical vapours has resulted in sickness and death.

Air is a mechanical mixture of gases. The normal composition of external air by volume is approximately as follows: Nitrogen - 78.1 per cent; Oxygen - 20.93 per cent; Carbon dioxide - 0.03 per cent. The balance is made up of other gases that occur in traces, e.g., argon, neon, krypton, xenon and helium. In addition to these gases, air also contains water vapour, traces of ammonia and suspended matter such as dust, bacteria, spores and vegetable debris. Air is rendered impure by· (1) Respiration of humans and animals (2) Combustion of coal, gas, oil, etc. (3) Decomposition of organic matter and (4) Trade, traffic and manufacturing processes which give off dust, fumes, vapours and gases.

3.6.2.1 Physical, Chemical and Biological Agents

The physical agents like temperature, humidity, wind velocity and atmospheric pressure of the outdoor air many cause discomfort and air borne diseases. As we know that temperature of air varies in different parts of the day and also in the different seasons and the factors which influence the temperature are latitude of the place, altitude, direction of wind and proximity to sea. The temperature of the ground surface is always higher than that of the air. All these factors may cause extreme temperatures leading to heat stress or cold waves. Heat stress or excess of heat exposure has been well documented and may cause heat stroke, heat hyperpyrexia, heat cramps, heat syncope and heat exhaustion. On the other extreme, cold stress may cause numbness, loss of sensation, muscular weakness, desire for excess sleep, coma and even death. Frostbite and trench foot are common diseases caused in higher latitudes. Humidity or moisture is always present in the atmosphere. The amount of moisture which air can hold depends upon its temperature. Humidity levels, amount of precipitation, wind velocity also influence human health physically and mentally.

Chemical agents like dust, soot, smoke, other organic and inorganic particles emanating from houses, factories and vehicles, etc. are main sources of air pollution. These can be summarized as:

a) Automobiles: Motor vehicles are a major source of air pollution throughout the urban areas. They emit hydrocarbons, carbon monoxide, lead, nitrogen

oxides and particulate matter. In strong sunlight, certain of these hydrocarbons and oxides of nitrogen may be converted in the atmosphere into "photochemical" pollutants of oxidizing nature. In addition, diesel engines, when misused or badly adjusted are capable of emitting black smoke and malodorous fumes.

b) Industries: Combustion of fuel to generate heat and power produces smoke, sulphur dioxide, nitrogen oxides and fly ash. Petrochemical industries generate hydrogen fluoride, hydrochloric acid and organic halides. Many industries discharge carbon monoxide, carbon dioxide, ozone, hydrogen sulphide and sulphur dioxide. Industries discharge their wastes from high chimneys at high temperature and high speed.

c) Domestic Sources: Incomplete combustion due to lack of oxygen is a major source of toxic gases.

d) Miscellaneous: These comprise burning agricultural refuse, incinerators, pesticide spraying, natural sources (e.g., wind borne dust, fungi, molds, bacteria) and nuclear energy programmes. Add an example of the effect on health.

Biological Agents: Bacteria and viruses may pollute the air and may be carried to some distances along with dust particles. They may be inhaled or swallowed with water, milk or food polluted with infected dust. The chances of spread of disease in this way are remote because of great dilution and because of exposure to ultraviolet light in the open. This mode of infection may be responsible for wound infections with tetanus bacilli. It may also lead to inhalation of tubercle bacilli and scales of measles and chickenpox (Park, 2015).

3.6.2.2 Housing and Air Pollution

Other than the outdoor air, indoor air is influenced by various housing characteristics. "Housing", in the modern concept includes not only the 'physical structure' providing shelter, but also the immediate surroundings, and the related community services and facilities. It has become part of the concept of "human settlement", which is defined as "all places in which a group of people reside and pursue their life goals; the site of the settlement may vary from a single family to millions of people".

Healthy housing should provide physical protection and shelter; be adequate for cooking, eating, washing, and excretory functions; prevent the spread of communicable diseases; provide for protection from hazards of exposure to noise and pollution; and should be free toxic or harmful materials promoting good health.

Due to poor housing, respiratory infections (common cold, tuberculosis, influenza, diphtheria, bronchitis, measles, whooping cough, etc.), skin infections (scabies, ringworm, impetigo, leprosy), rat infestation (Plague), arthropods (from Houseflies, mosquitoes, fleas and bugs) related diseases might be caused. It also has influence on the psychology and mental health and wellbeing of residents. Additionally, cluttered houses may be causes of accidents due to overcrowding and suffocation.

3.6.2.3 Indoor Air Pollution: Sources and Impacts

The indoor environment is also very critical as this is the place where we spend substantial time. Apart from chemical air pollutants, physical characteristics of house are important in determining the influence of indoor air pollution and its impacts. These include ventilation, number of windows, exhaust fans, temperature and humidity. The major sources of indoor air pollution worldwide include combustion of solid fuels indoors, tobacco smoking, outdoor air pollutants, emissions from construction materials and furnishings, and improper maintenance of ventilation and air conditioning systems. Major indoor pollutants are fine particles, carbon monoxide, nitrogen oxide, polycyclic aromatic hydrocarbons (PAH), sulfur dioxide, arsenic, fluorine, lead, asbestos, radon and biological pollutants. In 2004, nearly 2 million deaths were attributed to household air pollution from the use of open fires and simple stoves for cooking–accounting for 2.7% of the global disease burden.

Women, elders and children are most exposed to indoor pollutants. However, the extent and magnitude of consequent health risks, however, remain poorly understood. It is estimated that 4.3 million people die every year prematurely from illness attributable to the household air pollution caused by inefficient use of solid fuels. Among these deaths 12 per cent are due to pneumonia, 34 per cent from stroke, 26 per cent from Ischaemic Heart Disease, 22 per cent from COPD and 6 per cent from lung cancer (Park, 2015). Acute lower respiratory infections (ALRI) caused are due to particulate matter inhaled from indoor air pollution and chronic obstructive pulmonary diseases (COPD) are caused due to exposure to household air pollution.

3.6.2.4 Effects of Air Pollution

Worldwide, air pollution is one of the top five risk factors responsible for human mortality. Urban air pollution causes over 1.2 million deaths per year. The health effects of air pollution are both immediate and delayed. The immediate effects are mainly borne by the respiratory system, the resulting state is acute bronchitis. Irritation in eyes, nose, suffocation, breathlessness are immediate effects while chronic bronchitis, lung cancer, bronchial asthma, emphysema, and respiratory allergies are delayed impacts. It is linked with cardiovascular disease, diabetics and neuropsychological disorders also. Air pollution leads to destruction of plant and animal life; corrosion of metals; damage to buildings; cost of cleaning and maintenance and repairs and aesthetic nuisance. It also reduces visibility in towns that may cause transport accidents.

Check Your Progress

2) What is smog?

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3.6.3 Effects of Biological, Chemical and Physical Agents in Food Resources on Human Health

Unclean environment has the potential to contaminate food and water that are consumed by human causing widespread diseases. Environmental cleanliness and maintaining personal hygiene is therefore necessary to reduce food borne diseases. Food borne diseases include food-borne intoxications and food-borne infections consumed by human beings, commonly referred to as food poisoning. Use of chemicals to ripen fruits/antibiotic and hormone injections for better yield are in turn consumed and enter into our food cycle.

As per the Global burden of diseases, food borne diseases are one of the major causes of illness and death. Diarrheal diseases alone are responsible for 3-5 million illnesses and nearly 1.5 million deaths annually (Directorate General of Health Services, 2017). Contaminated and infected food diseases are spread through various biological causative agents. For instance, Anthrax, Cholera, Dysentery and Typhoid fever by bacteria, Amoebiasis and Clonorchiasis by parasites.

Types of Food Borne Diseases

a) Food borne diseases of infectious origin

The pathogenic organisms transmitted through contaminated foods are bacteria, viruses, protozoa and helminthes. Foods that are contaminated may not look, taste or smell any different from foods that are safe to eat. A review of recorded foodborne disease outbreaks in India from 1980 to 2016 shows *Staphylococcus aureus (grows on food), Listeria monocytogenes (grow inside the refrigerator or in ready-to-eat food), Vibrio sp, Salmonella sp, E. coli, Yersinia enteroclitica and* Norwalk-like virus are some important microbial pathogens responsible for foodborne illnesses. Of these, *Salmonella* is the most common cause of food borne illnesses (Directorate General of Health Services, 2017). In India, milk and milk products, poultry, sea foods and street foods are major causes of infections.

Cases of Nipah virus infection (transmitted from animals to humans) can be transmitted through contaminated food or directly between people. The virus can also cause severe disease in animals such as pigs, resulting in significant economic losses for farmers.

Nipah virus has caused severe disease and death in people, making it a public health concern in Malaysia, Bangladesh, Cambodia, Ghana, Indonesia, Madagascar, the Philippines and Thailand (https://www.who.int/news-room/fact-sheets/detail/nipah-virus). In India, the Nipah virus outbreak was confirmed in Kozhikode and Malappuram districts of Kerala in 2017. Recently, SARS-Cov-2, originating from bats has caused heavy loss of life in many countries, and as a result is declared a pandemic.

b) Food borne diseases due to chemical contamination

Chemical contamination of food may result from industrial sources or agricultural practices through which heavy metals such as mercury, lead and cadmium may enter the food chain. To increase the food production, the government initiated rampant use of pesticides and fertilizers that replaced

the traditional agricultural practices for soil replenishment and use of manure. On the negative side, the excessive and repeated use of chemicals in agricultural fields eventually have led to several short term and long term effects on land and food. The chemicals discharged also enter the water resources through ground water leading to contamination of water as well as soil affecting both land and water resources.

Food poisoning may also occur due to consumption of contaminated food like wild mushroom contaminated with *Amatoxin.* Besides this, chemical food poisoning occurs through adulteration. Adulteration is a mal-practice involving addition of prohibited ingredients (solid, liquid or coloring) to food products. Now-a-days if you scrap apple with edge of knife wax would come out. This is adulteration wherein the apple is made to look fresh and red by chemicals. Similarly, green color is added to peas and other green vegetables and this can be noticed if we soak them in water for 30-40 minutes. Many fruits and vegetables are reported to be injected with chemicals like urea for faster growth. All these methods are unethical and unhealthy and may cause liver and kidney damage. Arsenic is another predominant chemical that has entered our food chain. The paddy rich areas like West Bengal and districts of the Ganga belt reveal high concentration of arsenic. Arsenic is highly toxic chemical and long term intake can lead to arsenic poisoning (arsenicosis), diabetes, cardiovascular diseases and cancer.

Adulteration of milk and milk products with detergents, foreign proteins, sugar; turmeric powder with Metanil Yellow; Honey with sugar; food grains with stones, jute, insects; coffee powder with tamarind seed, chicory powder; and tea leaves with dye, gypsum are common practices noted by FSSAI (Food Safety and Standards Authority of India) in India. Recently in 2018, FSSAI reported that 68 per cent of milk and milk products in India are not up to the standards.

The poultry and meat industry too use excess chemicals and antibiotics that are extremely harmful for human health. One must be careful to purchase non-vegetarian food from reputed shops only as the animals and birds are kept in highly unhygienic places, given lower quality feed and over-injected with chemicals.

3.6.4 Effects of Biological, Chemical and Physical Agents in Land/Soil Resources on Human Health

Due to static nature of land, the pollution caused on land is much more harmful. It takes longer time to replenish and may stay at a location for many years. Solid waste is a major problem in urban areas, more so as the population is constantly rising. The domestic, agricultural and industrial sources together with e-waste, hospital waste, radioactive waste adds to the woes of land pollution.

Different types of wastes impact physical, mental and social health such as biological agents which pollute water and food and cause alimentary infections like cholera, typhoid, dysentery, infective hepatitis, polio, ascariasis and hookworm disease, etc.; Mosquitoes transmit insect-borne diseases like malaria and filaria; Common house flies transmit infections; dust may harbor tubercle bacilli and other germs (which cause diseases if inhaled.

Types of Land Pollution

Land pollution can be classified into different types based on the source of pollutants. These can broadly be industrial and urban waste, agricultural waste, radioactive waste and biological waste.

Industrial and urban waste

All kind of industries, be it small scale or large scale are responsible for industrial waste, though most polluting are the iron and steel, coal metal mines and metal processing industries. The industrial waste is quite harmful as it may be toxic in nature.

Since industrial areas are also urban areas, waste from households is disposed off in large quantities that are dumped on landfill sites. These sites are breeding grounds of various vector borne and infectious diseases.

Agricultural waste

Though agriculture seems to be a cleaner economic activity, it's a myth. To increase the food production for rising population, modernization of agriculture was introduced but nothing comes with a cost. Fertilizers, pesticides and farming practices cause soil pollution that affects the productivity of soil for long term. Fertilizers (especially nitrates), when repeatedly used, are washed to the water system contaminate ground water. Pesticides like chlorinated hydrocarbons and organophosphorus compounds too are very harmful. The traces of pesticides are detected to enter into the crops too. For example, Lindane has been detected in carrots. Besides these, soil conditioners and fumigants such as mercury, arsenic and lead compounds stay in soil permanently and enter the crops causing major health hazards. The allied agricultural activities including cattle farming and poultries are also not devoid of generating land pollution. Generally, the waste is not suitably dumped that causes nuisance of smell and sight in addition to public health problems.

Radioactive waste

The sources of radioactive waste are laboratories, industries or nuclear explosion. With rising power demands, nuclear energy production is on a constant rise that impedes the environmental health. This waste is safely dumped in oceans or on land but since the effects of radioactive substances is long lasting, they are potential health hazards, especially for scientists.

Biological agents as source of waste

Open defecation by humans and animal excreta contaminate the soil with bacteria and parasites. Additionally, discharge of untreated or incompletely treated sewage on land and dumping of sewage sludge also cause soil pollution. Maintaining hygiene is thus necessary to reduce ill-health caused by land pollution.

3.7 ECOLOGICAL MODEL OF POPULATION HEALTH

Ecological model of population health is also called as the social-ecological model. The ecological model of health has its origins in the fields of psychology and

human development, in the mid-20th century work of Lewin, Barker, and Bronfenbrenner, and others who began to understand behaviour in a context of the interplay of the individual and the environment. This work was taken up by public health fields like health promotion, health psychology, epidemiology, and maternal and child health. The Institute of Medicine (IOM) has defined the ecological model as "a model of health that emphasizes the linkages and relationships among multiple factors (or determinants) affecting health." (Institute of Medicine, 2003).

Check Your Progress

3) What is ecological model?

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What are these factors affecting health? Well, there are too many to list in detail, ranging from the micro level to the macro level. Typically, they're grouped into categories roughly like this (Figure 3.5):

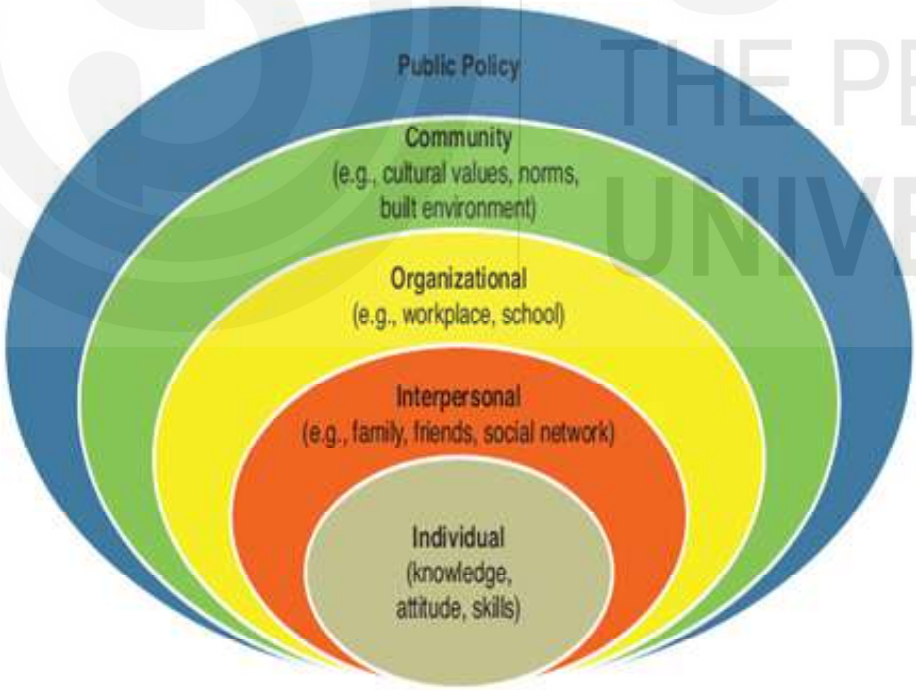

Fig. 3. 5: Determinants of Health

(**Source:** Institute of Medicine, 2003)

- Intrapersonal/individual factors, which influence behavior such as knowledge, attitudes, beliefs, and personality.
- Interpersonal factors, such as interactions with other people, which can provide social support or create barriers to interpersonal growth that promotes healthy behavior.

- Institutional and organizational factors, including the rules, regulations, policies, and informal structures that constrain or promote healthy behaviors.
- Community factors, such as formal or informal social norms that exist among individuals, groups, or organizations, can limit or enhance healthy behaviors.
- Public policy factors, including local, state, and federal policies and laws that regulate or support health actions and practices for disease prevention including early detection, control, and management

3.8 CURRENT LEGAL FRAMEWORK POLICIES, AND PRACTICES ASSOCIATED WITH ENVIRONMENTAL HEALTH TO IMPROVE PUBLIC HEALTH: INDIAN EXAMPLES

As we already discussed that the World Health Organization (WHO) defined health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity", it is well-reminded that environmental health can affect human health. Therefore, governments and organizations shall create policies where they see the issues arising in the health of their jurisdiction related to the environment.

3.8.1 Health Sector in India

The health sector in India is organized under three categories based on ownership: public, government, private or individual owned. Charitable institutions, religious organisations like churches and NGOs and public sector bodies like atomic energy, railways and armed forces also own part of health facilities.

3.8.2 Role of Government of India in Preservation and Promotion of Public Health: Health Missions, Plans, Programmes and Policies

The central government provides a broader framework for specific programmes to be undertaken like small pox, malaria, tuberculosis, HIV AIDS, leprosy and others. These programs are implemented at the state level uniformly. The states also implement all centrally funded programs like the family planning, Swachh Bharat Mission and universal immunization. The Union Ministry of Health and Family Welfare is responsible for implementation of various programmes, undertaking research and providing funds.

3.8.2.1 Health Missions

With respect to missions on health, National Rural Health Mission (NRHM) and National Urban Health Mission (NUHM) have had significant achievements. Recently, the Swachh Bharat Mission aims to achieve sanitation facilities, cleaner environment and surroundings for all. AMRIT launched in 2015 aims to reduce the expenditure incurred by patients on treatment of non-communicable diseases like cancer and heart diseases. The world's largest health insurance scheme, Ayushman Bharat Yojana (National Health Protection Mission), was launched in 2018. It promises health cover worth Rs. 500,000 to every poor family for treatment of serious ailments.

3.8.2.2 Landmark Health Policies, Plans and Programmes in India

The first comprehensive health policy and plan document, Health Survey and Development Committee Report that is also called the Bhore Committee Report was prepared in 1946. Post-independence, in 1983 the first health policy was formulated and adopted. But before 1983, schemes made under the Five Year plans were fulfilled. These had specific targets like in 1950s and 1960s the focus was on managing the epidemics. Widespread national level campaigns were started to overcome the loss by malaria, small pox, tuberculosis, leprosy, filaria, cholera and others. The fifth plan focused on accessibility of health services in the rural areas through the Minimum Needs Programme. The aim was on eradication of communicable diseases, provision of safe drinking water and sanitation. The sixth plan was influenced by the international declaration 'Health for all by 2000 AD' that is universal health care that is affordable and as per the needs of the people.

On the eve of the 10th plan the draft of National Health Policy (NHP) was announced and called for feedbacks from the public. Finally in 2002, NHP document was released with the objective of achieving acceptable standards of good health of Indian population, decentralization, equity, accessibility of health services and provision of affordable private health care (Duggal, 2014). The role of traditional medicines was also acknowledged by this policy. Further, in the 11th plan, the central theme with respect to the health sector is 'inclusive growth'. The 12th plan was prepared after the consultation of public. It called for Universal Health Coverage through Essential Health Package and to assess the social determinants of health.

The National Health Policy 2017 came after 14 years gap. The policy aims at providing health care in 'assured manner' to all. The Make in India model governs the manufacturing of drugs and devices. AYUSH (Ayurveda, Yoga and Naturopathy, Unani, Siddha and Homeopathy) is given special emphasis, especially yoga (Planning Commission 2013a, 2013b; Government of India 2017).

Other than the NHPs, many other policies were announced from time to time that are closely linked with improving the health status of people. These are National Population Policy, National Nutrition Policy, National Water Policy and National Environmental Policy to name a few. The list is given below (Table 3.1):

Table 3.1: National Health Policies / other Related Environmental Health Policies in India

Year	Name of Policy
1983	National Health Policy
1993	National Nutrition Policy
2000	National Population Policy
2002	National Policy on Indian System of Medicine and Homeopathy
2002	National Health Policy
2005	National Rural Health Mission

2006	National Environment Policy
2012	National Water Policy
2017	National Health Policy

Other than these, Ministry of Health and Family Welfare launched Pradhan Mantri Swasthya Suraksha Yojana (PMSSY) in 2006, Janani Shishu Suraksha Karyakram (JSSK) and Janani Suraksha Yojana for insuring the health care. Various programmes undertaken by the Ministry of Social Justice and Empowerment / Ministry of Child Development and Women are Integrated Child Development Services (ICDS) scheme, Mid-day Meal (MDM) Programme, Special Nutrition Programme, National Nutritional Anaemia Prophylaxis Programme (NNAPP), Reproductive and Child Health Programme and School Health Programme. With respect to supply of clan drinking water, Ministry of drinking water and sanitation introduced the Rajiv Gandhi National Drinking Water Mission (RGNDWM) (Lakshminarayanan 2016; Patel 2015; Grover and Singh 2020).

3.8.2.3 Lacunae and Gaps in Policies and Programmes in India

Although innumerable direct and indirect plans, programmes and policies have been made with respect to health system in India, the success has been limited. Various reasons can be cited for this, such as, shortage of health care workers, infrastructure, poor governance, low affordability, neglected preventive, promotive, rehabilitative and public health measures, inadequate funds (only 0.9% of the GDP was allocated to heath care as per National Health Policy, 2002), social inequality, privatization and minimal involvement of local bodies like Panchayats.

3.9 SUMMARY

From the above discussion it is clear that human health cannot be studies with a watertight compartment view in which health is improved by medical intervention only. Rather, health is interplay of various factors of which environment is very important. If we improve the surroundings and living conditions, the human health and wellbeing can be improved easily. So, policies, programmes and actions of government should focus on improving and cleaning environment that will promote prevention of diseases instead of focusing on curing the diseases. Truly, prevention is better than cure and it is cheaper and healthier option too!

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3.11 ANSWERS TO CHECK YOUR PROGRESS

1) Environmental health comprises of those aspects of human health, including quality of life, that are determined by physical, biological, social and psycho-social factors in the environment. It also refers to the theory and practice of assessing, correcting and preventing those factors in the environment that can potentially affect adversely the health of present and future generations.

2) Air pollution is a growing menace in Delhi since last 4-5 years, especially during the festival of Diwali during the month of October end–November. There are multiple reasons cited for sudden increase in pollution levels including vehicular pollution, burning of crackers, burning of agricultural suffrage in Punjab and Haryana, changing winds, construction activities and industrial effluents. The major cause of concern is the particulate matter (SPM and RSPM) that causes respiratory and cardiovascular diseases, burning of eyes and nose, skin illness and even cancer. This is particularly concern for children, pregnant women and aged population.

3) The ecological model emphasizes the importance of the social and physical environments that strongly shape patterns of disease and injury as well as our responses to them over the entire life cycle.

UNIT 4 EPIDEMIOLOGY OF DISEASES*

Contents

Learning Objectives

After reading this Unit, you will be able to:

- Learn the definitions of chronic and infectious disease;
- Understand methods used for studying the aetiology of chronic and infectious diseases;
- Know the surveillance methods for infectious and chronic diseases;
- Gain knowledge on prevention and control of chronic and infectious diseases; and
- Appreciate the temporal and geographic diversity of Malaria and Leishmaniasis.

* Contributed by Dr. SAA Latheef, Department of Genetics and Biotechnology, Osmania University, Hyderabad.

4.0 INTRODUCTION

Oxford English dictionary defines disease as a condition of the body or some part or organ of the body in which its functions are disrupted or deranged. Human diseases broadly can be divided into communicable or infectious or chronic or non-communicable diseases. In this unit definitions, aetiology, surveillance of chronic and infectious diseases, geographical and temporal trends of selected protozoan diseases such as malaria and visceral leishmaniasis (Kala-azar) are described.

4.1 DEFINITIONS

Chronic disease is defined as those diseases which are of longer duration and slow progression. Chronic diseases include cardiovascular diseases, arthritis, obesity, cancer, diabetes, stroke and chronic obstructive pulmonary disease. John Murray Last (1988) in the dictionary of epidemiology defined *infectious diseases* as an "illness caused by a specific infectious agent or its toxic product that results from transmission of that agent or its products from an infected person, animal, or reservoir to a susceptible host, either directly or indirectly through an intermediate plant or animal host, vector or inanimate environment. An infectious disease occurs due to the interaction of agent, host and environmental factors. Agent (bacterium, virus, protozoan, fungus and helminth) is usually microorganism that is capable of producing the infection; host (animal, bird, human and arthropods) is the organism that houses an infectious agent and environment may include water, food, milk, clothes, blood, cutley, parenteral solutions and medical tools or instruments. Examples of infectious diseases are malaria, dengue, ebola, human immunodeficiency virus, severe acute respiratory syndrome, tuberculosis, COVID-19, and hepatitis B.

Some of the infective agents (microorganisms capable of causing diseases) were shown to be responsible for chronic diseases (*streptococci* bacteria in rheumatic heart disease, *human papilloma virus* in cervical cancer and hepatitis B in hepatocellular carcinoma).

Box 4.1: Definitions of Terms

- If the infectious disease cases were reported more than usual and restricted to small geographical area it is called *outbreak.*
- If occurrence of infectious disease was reported at unexpected frequency in particular geographical area it is termed as *epidemic.*
- If the infectious disease occurrence was observed as per expected frequency in particular period of time and geography it is known as *endemic.*
- If the incidence of infectious disease was spread different countries and large populations it is labelled as *pandemic*.

Outbreaks are of four types namely point source or common source (source of infection is common to infected persons, example: food poisoning), continuous common source (continuous exposure to infection (water contamination),

propagated or progressive (transfer of infective agent from person to person, ex. Pertussis or Shigellosis) and intermittent (exposure intermittent). Outbreaks come to light while reviewing observations of unusual clustering or increase in the cases or case definition is alerted by the personnel working in health departments or investigation of suspicious case or reported by the patient themselves.

Box 4.2: Steps in the Investigation of Outbreak

(Centers for disease control and prevention, Atlanta, Unites States of America, 2012)

1) Establishing the existing of outbreak (checking if more cases are occurring in specific geographic area in a given period, whether they have common cause, related or unrelated cases).
2) *Verifying the diagnosis* by evaluating the diagnosis with clinical and laboratory findings, interviewing the affected patients for information on exposure and reporting frequency .
3) *Constructing a working definition of case/disease* based on clinical criteria. If needed case definition may be restricted by time, place and person.
4) *Finding information on additional cases* (locality of the affected people, demographic details, signs and symptoms, risk factors and source of report) to determine the extent of problem for particular geographical area and population, by sending formal letter, or interviewing patients by email or mobile phone/visiting facilities, using media and conducting a survey.
5) *Developing hypothesis using descriptive epidemiology*: For characterising the outbreak by time, place and person, the descriptive epidemiology is performed. A special type of histogram known as *epidemic curve (EC)* is used to study the time course of the disease which requires data on the onset of illness/date of onset of the case. EC provide information on the spread of cases whether it is epidemic or endemic, magnitude of cases, whether outbreak is due to common/continuous/intermittent exposure or spread from person to person, prediction of future cases, determining the how much time health personnel took to identify a problem, effect of intervention, time period in which persons exposed, incubation time (period from exposure to onset of illness) and whether outbreak is in upswing or peaked or over. Spot map is used to know the geographical spread of the affected person, source and mode of spread of infection and site of exposure. Area map is used to compare incidence between geographical regions. Collection of information on age, sex, race and medical status can be useful for examining their susceptibility to disease and obtaining information on leisure activities, medication, occupation, behavioural characteristics such as tobacco and alcohol consumption and sex with several partners may throw a light on their possible exposure. Descriptive epidemiology may also be used to calculate incidence, burden of disease, planning health infrastructure and identifying high risk individuals. Understanding the disease, visiting patients and interviewing patients and local health staff and using the data of descriptive epidemiology, hypothesis can be formulated.

6) *Evaluation of hypothesis* is done by evaluating the results of environmental and laboratory tests and if results are not convincing or, epidemiologically studied by matching the hypotheses with established facts and quantifying relationships with analytical epidemiological methods such as case-control and retrospective epidemiological methods between exposure and disease and investigating causal associations.

7) *Draw final conclusions*: If the results of the analytical studies are not convincing hypothesis can be revised. By discussing with patients, thinking for new vehicles or modes of transmission or repeating the case-control studies by selecting matching controls to find specific vehicle or exposure.

8) *Comparing the results of epidemiological, laboratory and environments studies*: Epidemiological, laboratory and environmental studies should complement each other and provide the comprehensive evidence.

9) *Communicating findings:*The findings of studies should be communicated both orally and in typed report by the investigator with justifiable recommendations to initiate action to the personnel involved in executing the control and prevention of outbreaks.

10) *Implementing control and preventive measures*: The control and preventive measures should be initiated at the earliest to protect the health of the public. Confidentiality should be maintained in the implementation of control measures (the disclosure of patient information leads to the stigmatization and rejection of patients from society resulting in treatment failure) and to maintain the trust of the patients. Some interventions advice blocking of transmission by isolation of infected person(s) (ex. Influenza, corona virus positive cases); elimination of vehicle to prevent from food poisoning (discarding of contaminated food); sterilization of surgical instruments and tools avoid post surgery acquired infections; changing the environment to prevent faecal-oral transmission; changing the behaviour (promoting hand washing) help to avoid future contaminated risks; filtering of air prevent from airborne diseases; spraying control the population of mosquito and protect from West Nile virus; promoting using of bed nets prevent from mosquito bites (malaria); wearing of masks and gloves by the Dentist prevent infection from Dentist to patient or vice-versa; wearing of long pants and sleeves and usage of mosquito repellents prevent from West Nile virus and Lyme disease; encouraging of vaccination offer protection against infection; and administration of chloroquine by travellers visiting malaria endemic regions preventfrom infection (malaria).

4.1.1 Aetiology of Chronic Diseases

For studying aetiology of chronic diseases, analytical (ecological, case-control, cohort) and experimental epidemiological methods (randomized controlled trials, field, community and natural trials) are used.

Table 4.1: Epidemiological Study Designs and Study Designs Used for investigating the Aetiology of Chronic and Infectious Diseases

Type of Epidemiological study designs	Epidemiological study designs used to study aetiology of chronic and infectious diseases
I) Observational studies 1) Descriptive studies a) Case reports b) Case series 2) Analytical studies a) Ecological studies b) Case-control studies c) Cross-sectional studies d) Cohort Studies II) Experimental studies 1) Randomized studies a) Randomized controlled studies b) Field trials c) Community trials 2) Non- randomized trials a) Uncontrolled trials b) Natural trials c) Interventional studies without control d) Pre and post interventional studies e) Cross over interventional studies	A) Chronic diseases I) Analytical studies a) Ecological studies b) Case-control studies d) Cohort Studies II) Experimental studies 1) Randomized studies a) Randomized controlled studies b) Field trials c) Community trials 2) Non- randomized trials a) Natural trials B) Infectious disease 1) Analytical studies a) Case-control studies b) Cohort Studies (retrospective)

4.1.2 Ecological Study

In this type of study, population is the unit of the study. Ecological study measures group level data, environmental variables of the area and global measures (population crowding and characteristics of groups). Ecological studies are carried out when the disease is rare, data on individuals are not available, study is planned to investigate the effect of risk factors on population or group level exposure to disease or risk factors, population health is to be monitored and comparisons to be made between populations. Comparative geographical (Example: Association of dietary factors and incidence of cancer in 23 countries and mortality rate in 32 countries), longitudinal/time trend (Example: longitudinal ecological study on the association of seasonal influenza deaths and climatic conditions for the period of 1999-2011 in United States) and studies on migrant populations (Example:

comparison of incidence of psychosis in Norwegian immigrants to Unites States to people in Norway) are three types falls under ecological studies aimed at studying the aetiology of diseases. Information on outcome and exposures are obtained from registries, public and private organizations and surveys done earlier. For example in ecological studies on cancer collect frequency of exposure from public or private sources and disease rates from cancer registries, surveillance programmes, and death certification systems(Silva, 1999). Another example is association between income and cancer mortality, mortality data is obtained from registers of deaths and income details from cross sectional or census data (Bhopal, 2002).

Check Your Progress

1) What types of epidemiological studies used for investigation of aetiology of infectious and chronic Diseases?

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4.1.3 Case-control Study

In this type of study, the unit of investigation is individual. Newly diagnosed patients (based on the accepted standard criteria for each disease) are compared with the control subjects without disease. Exposure to infectious agent, treatment, prevalence of variables associated with disease are enquired with patients or patient attendants or information is collected from case sheets or by evaluating biochemical tests or measurements with instruments (blood pressure, weight etc.) In case of controls except examining case sheets, the same procedure is followed. Patients are recruited from disease registries, hospitals, cross sectional/ cohort studies/case series in a geographic area. Controls are drawn from voter lists, same geographic area, spouses, friends, same office/factory/institute colleagues or those with other than disease under investigation. Patients and controls are matched for age, sex, ethnicity and socio-economic status to minimize the confounding effect of the variables on the association of variables with disease/ outcome. Association of multiple variables (categorical or continuous) with one outcome/disease is evaluated by using Odds ratio and p value which is obtained by performing logistic regression analysis. In small sample size studies, both Odds ratio and relative risk are considered same.

Box 4.3: Odds Ratio

It is a measure used for assessing the strength of association between exposure and outcome. Odds ratio is used in case-control, cohort and cross sectional studies. Odds is indicated as OR and defined as Odds of event occurring in group compared to odds of same even occurring in another group. For example in one cross sectional study examining the association between high total cholesterol (>200mg/dl) and hypertension in logistic regression found p value of 0.01 and OR ratio of 2.194. This means that association between high total cholesterol and hypertension is significant and those with high total cholesterol have 2 time risk of developing hypertension when compared to those having normal cholesterol levels. OR values ranges from 0 to in infinity. OR=1 indicates no risk, OR>1 increased risk of event occurring and OR<1 decreased risk of event occurring.

4.1.4 Cohort study

Multiple effects of exposure on outcomes or effect of multiple exposures on outcome are evaluated in this study. Cohort (group) having similar characteristics are formed based on city/ occupation/ decade date of birth/marriage. They are studied for particular period of time. Within the cohort, exposure and non-exposure groups are formed. Cohort studies can be prospective (Example: Effect of socio-demographic factors on prevalence, incidence and remission of overweight including obesity in adults from 2008-2017 in Birbhan, West Bengal) retrospective (Example: Retrospective study on maternal and foetal outcomes among patients with gestational diabetes in Kerala during the period of four years) and mixed (Example: A retrospective cohort study on the evaluation of completeness of immunization and prospective cohort study to assess the immunization knowledge and practice of parents in Mosul, Iraq) depending on the outcome developed after starting the study (Prospective cohort study) or before starting the study (retrospective cohort study) or before starting study and continued further (Mixed cohort study). Before initiation of the study, the characteristics of subjects are collected from registries or, census/cross sectional surveys and definition of the outcomes are decided. Exposure data are collated from enquires with subjects, periodical evaluation of clinical and biochemical tests and environmental samples. Relative risk of developing outcome in exposed and unexposed group is investigated.

4.1.5 Randomized Controlled Trials

Experimental study design is one type of epidemiological study design. Experimental study design is of two broad types: (1) Randomized and (2) Non-randomized. Randomized control trials fall under randomized experimental study design (Table 4.1). Aetiology of the outcome/disease can be established or refuted by conducting randomized controlled trials. In randomized controlled trials subjects are randomized (assigned) to intervention or no intervention groups. Blinding is done to remove bias in the enrolled subjects and the investigator. It can be single (subjects enrolled in the study do not know their categorization in the study), double (both enrolled subjects and investigator are not aware of assignment of study groups) and triple (enrolled subjects, investigator and

evaluator of study results are not aware of allocation of study groups) blinded. Study objectives, endpoints (death/survival/decreased risk or improvement in condition or adverse effects) are decided, hypothesis is formulated, and ethical clearance is obtained. Study is carried for the intended period and finally the occurrence of outcome is compared in subjects with and without intervention using relative and attributable risk and the predictors of the outcome are evaluated by regression or logistic regression analyses.

Example 1: Randomized control trial on the, aetiology of retrolental fibroplasias (RLF) (premature retinopathy, a cause of blindness) (Kinsey and Hemphil, 1955; Parker,2013). Premature babies weighing 1500g or less were randomized into interventional or non-interventional groups. Interventional group received 50% oxygen for 28 days or non-interventional group given oxygen when the clinical situation demanded. All non-interventional babies who had received some oxygen developed retrolental fibroplasias while no case was detected in among babies who not received oxygen.

Example 2: *Randomized trial on the effect of vitamins on prevents of coronary revascularization/myocardial infarction/stroke/deaths in women*.

In randomized control trial, vitamin C (500mg) daily, vitamin E (600IU) and beta-carotene (50mg) every other day was administered to 8,171 female aged ≥ 40 years with history of cardiovascular disease or ≥ cardiovascular disease risk factors, and were followed for an average of 9.4 years on the clinical endpoints of the coronary revascularization events, occurrence of myocardial infarction, stroke, or death due to cardiovascular disease. In the follow-up period, 1450 women had one or more cardiovascular disease events refuting that vitamins had role in offering protection against cardiovascular events.

4.1.6 Field Trials

Health populations or groups are involved in this kind of trials. Multiple outcomes can be investigated by introducing interventions such as cessation of the exposure to risk factor or by modifying the treatment, the development of health risk is prevented. In this type of studies aetiology of disease can be proved. Example of this type of studies is smoking cessation and prevention of lung cancer.

4.1.7 Community Trials

Exposure to risk factor or behaviour is altered to prevent the development of diseases which are influenced by socio-economic variables. If significant reduction in the risk of disease is achieved, the strength of evidence on aetiology will be established. Communities are involved in this type of trials. Examples for this type of trials are Community trial on the protective effect of BCG vaccine in healthy people of west of Madras (1979) and community based intervention on awareness, treatment and control of hypertension in Kerala (Thankappan et. al. 2013).

4.1.8 Natural Trials

Natural (for example: earthquakes) or human caused disasters or epidemics when mimic experiments hypothesis of cause can be investigated. For example

earthquakes induced cardiovascular mortality investigated in Greece in 1981; John Snow observations on deaths in two areas in which two companies supplied water resulted in the discovery that Cholera is waterborne disease; and dropping of atom bombs on Hiroshima and Nagasaki in Japan led to the studies on the effect of radiation on the incidence of cancer.

4.2 INFECTIOUS DISEASES

4.2.1 Aetiology of Infectious Diseases

Aetiology of infectious disease is investigated by using analytical epidemiological methods such as retrospective cohort studies and case-control studies.

4.2.1.1 Retrospective Cohort Study

This kind of study design is useful for studying the outbreak in small size sample. Members of the defined population are contacted to know their exposure to sources and vehicles and determine the risk of developing as patient for the disease under investigation. Relative risk and attributable risk are calculated. Relative risk compare the attack rate in exposed when compared unexposed group to test the relationship between exposure and disease. If relative risk is higher than one (1) it indicates stronger association between exposure and disease. Population attributable risk is the per cent of illness in the study population due to exposure, but it is not considered as sensitive tool in the investigation of outbreaks as it fails to account for cross-contamination of items or sampling of spouse. Chi-square is also calculated to find larger association between exposure and disease. Reporting of confidence interval for p value is done to increase the precision of association between exposure and disease.

4.2.1.2 Case-control Study

For rapid investigation of outbreak this study design is of choice. Patients and controls without disease are compared and enquiry on the exposure is done from both groups. If exposure is higher among patients than control then exposure considered to be associated with disease. Controls should be representative of the population; they can be neighbours, friends of the patients or patients with other disease from the same hospital. Odds ratio in the case and control is calculated to test the relationship between exposure and disease. Odds ratio > 1 indicates stronger association between exposure and disease/outbreak. To calculate the statistical significance, chi-square is calculated and to increase the precision of reporting association between exposure and disease, the confidence interval is reported for p-value.

4.3 SURVEILLANCE

Centers for disease control, United States of America, in 2012 defined surveillance as any effort to monitor, observe or determine health status, diseases or risk factors within a population. The characteristics of surveillance are to give information on temporal trends and to initiate control measures (treatment or quarantine) in the affected individuals. Characteristics and natural history of disease will guide the conductance of surveillance. Objectives of surveillance,

strengths and limitations of sources and methods for conducting surveillance will determine what type of data needed; which sources and methods are suitable for carrying out surveillance. When there is less time, diagnosis is difficult, outbreak already occurred, characteristics of affected are known and geographic boundaries are defined, surveillance is done using less specific criteria known as syndromic surveillance. Surveillance can be done continuously or periodically. If reports on diseases sent by healthcare providers to health authorities it is *active surveillance* or *passive surveillance* when it happens vice versa or sentinel surveillance when certain prearranged healthcare providers sent reports to health authorities of certain conditions only. Health problems may differ from country to country but communicable diseases are given importance for surveillance due to their immediate and increased risk to the health of the public.

In surveillance, location of health problem and affected persons are identified, case is defined, available data on health problem is collected, period of surveillance is determined and health problem is measured, collected data is interpreted and informed to those who are involved in the control of the disease who in turn initiate the measures for the control of the disease and evaluate the effectiveness of interventions.

Data for surveillance is collected from population (by carrying out surveys from representative sample (health care providers, patients or public) and results are extrapolated to the entire population),institutional level (case sheets, health care providers, registries of marriage, birth, deaths/disease/treatment/after treatment/ preventive medicine/at risk or exposed/information/skill and research, secondary data, clinical laboratories, outpatient and inpatient departments, notifications of certain disease (by specific agency for control of specific conditions), country/ state/local health related data, income tax and administrative departments; in case of chronic disease surveillance, data from death certificates, autopsy reports, census and natality statistics, demographic/economic/geological/geographical/ meteorological/agricultural data, disease and at risk registries, linked hospital records, discharge summaries, mortality data, surveys/ mass public/occupational screened/ high risk follow-up data, longitudinal or migrant studies) and monitoring of environment (air, water and animal vectors).

In India, Integrated disease surveillance Programme (IDSP) was launched in 2004 with the assistance of World Bank for rapid response and detection of outbreaks. Initially nine States implemented the IDSP now expanded to all States and Union territories. The main objectives of IDSP is integration and decentralization of surveillance activities, develop human resources, application of information communication technology for collection of surveillance data and equip adequately public health laboratories. IDSP consists of three tier organisations of National, State and District surveillance units which is manned by surveillance officers and assisted by epidemiologists, microbiologists, data entry operators and data managers. On 13 priority diseases in districts and five disease added by States, using syndromic, presumptive and lab confirmatory approaches and S,P, L formats, data is collected from public or private institutions on weekly basis. Paper format is used up to district unit from there surveillance data is transmitted to State and Central units electronically. In case of rising trend of any illness, rapid response team investigate, diagnose and control the outbreak (IDSP web site and Phalkey et al. (2013).

In case of non-communicable diseases (NCDs) risk factors, World Health Organization in 2002 proposed STEP wise approach (1-3) for surveillance of NCD risk factors by measurement of questionnaire, physical and biochemical variables. In step 1, data on demography (age, gender, marital status, religion etc.), behavioural traits such as smoking/alcohol/salt/fruit usage, physical activity and history of high blood pressure/high cholesterol/diabetes/cardiovascular disease/cancer or coverage of screening and advice received. Measurements of body weight, height, waist circumvents, and blood pressure is done in step 2, whereas assays on glucose, total cholesterol and urinary sodium are included in step 3. In an expanded list, core questions on behavioural risk factors in step 1, measurement of hip circumference and heart rate in step 2 and investigation of serum/plasma triglycerides and high density lipoprotein cholesterol are recommended. In India, to provide information on high priority risk factors to States, for planning health infrastructure, non-communicable diseases were added to the IDSP programme. In this programme, household level information such as presence of durable goods, ownership of live stock and agricultural lands and religion were collected and the individual information contained two sections. First section included demographic (age, occupation, gender, education and marital status) and behavioural (history of diabetes/ raised blood pressure, tobacco/ alcohol consumption, physical activity, diet) variables while the second section contained details such as measurement of pulse rate, blood pressure, height, weight and waist circumference). People aged 15-64 years were included in the IDSP non-communicable disease risk factor survey (Ministry of Health and Family Welfare, 2009).

Surveillance data is reported in either frequencies or rates. The denominator can be general population of state/country/local or population at risk. Patterns for seasonal, temporal or geographical occurrence of the disease are reported. For infectious disease, data of weeks/months/multiple years, if needed, is required and for chronic diseases data of multiple years is used. Adjustment of sample size is performed for reporting rates of disease by place. Analysis of diseases is also done using personal characteristics such as age, gender, occupation, workplace, behavioural traits and travel history. Depending on the prevalence/ incidence of specific diseases, interventions are planned.

Check Your Progress

2) What is surveillance?

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4.4 PREVENTION AND CONTROL

Chronic Diseases

For chronic diseases, prevention can be done at four levels namely primordial, primary, secondary and tertiary. Primordial prevention aims to avoid the development of risk factors that contribute to the chronic diseases. In this type of prevention the role of government is major such as making policies for promoting healthy nutrition by increasing taxation on junk food; encouraging physical activity by constructing foot paths in roads and educating public on the benefits of physical activity; and discouraging smoking and alcoholic consumption by imposing heavy tax on these products. In primary prevention, incidence of disease is reduced by reducing average risk (ex. serum cholesterol levels) at population level and exposure to the risk in high risk groups (example chronic smokers and subjects with hypercholesterolemia). Secondary prevention attempts to reduce the development of disease by early identification and effective intervention. This type prevention is applicable when natural history of the disease is known and disease can be diagnosed easily and early. Examples include pap smear test for screening of cervical cancer and administering of Statins to individuals with hypercholesterolemia. Tertiary prevention deals with the arresting progression or complication of disease in patients by initiating measure to reduce pain/ disability/impairment and improve adjustment to the conditions, wellbeing and resume their livelihood activities. Examples are patients of myocardial infarction, stroke and poliomyelitis (Bonita et al, 2006).

World Health Organization (2000) proposed three strategies for prevention and control of chronic diseases such as surveillance, primary prevention and strengthening of health care systems. Surveillance details for chronic disease are given under the heading of surveillance. Primary prevention is mainly deals with reducing prevalence of risk factors in population. This can be done by Government by increasing taxation on tobacco, alcohol and junk food products, instructing the food industries to reduce salt, saturated fat and trans fats in food items, enforcing ban on public smoking, withdrawing advertisements on smoking/ alcohol/junk food items in Television and Cinema halls, creating physical activity friendly environment in schools, public places and residential areas, increasing the number of health personnel and basic medical facilities, vaccinating infants for Hepaptitis B and human papilloma virus in girls, promoting awareness on the benefits of preventive measures and identifying and administering drugs to high risk groups can reduce the prevalence of risk factors for chronic diseases. Apart from government role, individuals have to adopt health lifestyles.

In health care systems of lower to middle income countries, infrastructure has to be improved; availability of medical specialists and paramedical staff has to be increased; facilities for diagnosis and treatment of chronic disease for continuous care have to be developed; essential drugs should be made available especially generic drugs; there is a need to train paramedical staff and improve the ability of doctors; promoting of wider application of mobile apps for data acquisition, diagnosis and treatment, is needed; and country specific actions should be initiated for the prevention and control of chronic diseases. Government of India has started national programme for prevention and control of cancer, diabetes, cardiovascular diseases and stroke in the year 2010 and set 10 targets to prevent

and reduce NCDS by the year 2025. These are reducing mortality from chronic diseases by 25%; arrest the rise of prevalence of obesity and diabetes; reduce the prevalence of insufficient physical inactivity by 10%, decrease the high blood pressure by 25%; reduce the mean salt/sodium intake by 30%; decrease the usage of alcohol 10%, tobacco (30%) and solid fuel (50%); increasing the eligibility of persons to receive drug therapy and counselling to prevent heart attacks and strokes by 50% and enhance the availability of essential NCD and basic technologies to treat major NCDs in public and private health care centres

Infectious Diseases

Measures which reduce the incidence and prevalence and consequence of disease can be called disease control. The methods for this purpose are dictated by availability of tools, cost, efficiency and reliability. Prior to the epidemiological studies, disease control measures for infectious diseases (eliminating or controlling the reservoir, interrupting the transmission and protecting the host) should be initiated. If the source of reservoir is animal that can be killed and disposed off. In case of humans in order to reduce the load of infective agent, first illness is identified, notified to the health authorities responsible for initiating control measures and for disease (yellow fever, cholera, plague, typhus fever, malaria, paralytic polio, plague, small pox, severe acute respiratory syndrome, COVID-19, swine flu and relapsing fever) which are covered under international health regulations should be notified to the WHO. This enables the early detection of the outbreak and lead to the initiation of control measures. After notifying the disease to the concerned organization an epidemiological study is conducted to know the infective agent, source, vehicles/vectors, hosts and spread of the outbreak. To protect the transfer of infective agent from infected person to susceptible persons, affected persons are isolated till the communicability of infection ends using hospital/ring (encircling the infected with immune persons)/ chemical isolation methods. Treatment is given either to individual or group of infected persons to reduce communicability of infection/duration of illness and to prevent the risk of developing secondary cases. Limiting the movement and isolation of persons infected or suspected to be exposed to infection for the period of incubation to monitor the illness and to prevent the spread of infection to the susceptible persons in the community is known as "quarantine'. This can be done absolutely, partially or segregating for special purposes.

Box 4.4

In India, Patients with COVID-19 (caused by infection of SARS Corona Virus-2) are maintained in isolation, their mobility is restricted and monitored (quarantained) in health care delivery centres for 14 days. Suspect cases of COVID-19 are also quarantined for 14 days.

Interrupting the transmission of infection is done by changing the components of environment and preventing the spread of infection from infected/carrier to susceptible persons such as treatment of water (chlorination), discarding of contaminated food, adequate cooking and refrigeration of food items, promoting personal hygienic practices such as hand washing and following standard practices for the disposal of secreted fluids and excreted materials, destroying the breeding areas of vectors and killing of infected animals.

Control and prevention of infectious diseases can be explained by discussing examples of tuberculosis, cholera and malaria. In tuberculosis, control measures including finding patient sputum positive for tuberculin tests (Mantoux intradermal or Heaf test), treatment with directly observed treatment, short course chemotherapy (DOTS) consisting of Isoniazid, Rifampicin, Pyrazinamide, Ethambutol and Streptomycin and prevention by BCG (Bacille Calmette Guerin) vaccination. Control measures of cholera consisting of finding a patient stool positive for Vibrio cholera, treatment with dehydration fluid and antibiotics, defining the extent of the outbreak, mode of transmission, providing boiled or chlorinated water and building effective sanitary latrines to the community, promoting the use of cleaned utensil, sale of safe and hygienic food, proper individual food handling practices, eating of boiled and hot food, use of cresol and bleaching powder for disinfection, advising the contacts of cases for using the tetracycline as chemoprophylaxis and vaccination with cholera vaccines (Dukoral and Sanchol and mORCVAX) as a preventive measure. Malaria control consists of diagnosis with microscopy of thick and think blood films and rapid diagnostic test (detection of parasite antigen with dipstick format), treatment with chloroquine for *Plasmodium Vivax* cases and artemisinin combination therapy followed by primaquine for *Plasmodium Falciparum*, advising of chemoprophylaxis with anti-malarial drugs to travellers from non-endemic area and also to soldiers, police personnel and labours employed in endemic areas, spraying of insecticides (fenitrothion and malathion) in indoor areas of houses, using of pesticides either in fog or mist form, promoting the usage of mosquito repellents, bed nets and protective clothing, oiling or dusting of standing water collections with paris green, using of mosquito breeding reducing site techniques such as alteration of salt content of water, intermittent irrigation, management of water level, filling or drainage and flushing or deepening and employment of personal protection or bioenvironmental measures (Park, 2013).

The host is protected by active or passive or combined active and passive immunity, chemoprophylaxis, general measures (legislative actions for initiating and implementation of programmes towards enhancing health of the people, disease surveillance (individual/local and national population), and public health improving activities (starting public health promotion/awareness, providing adequate funding to health care delivery centres, developing good health infrastructure, ensuring the availability of essential supplies and instrumentation, recruiting adequate physicians and skilled paramedical staff and issuing advisories to the travellers on personal hygiene, safe food, immunization, chemoprophylaxis and disinfection).

Active immunization (administering inactivated or detoxified or purified components or live attenuated vaccines to produce antibodies to neutralize infective agent) is vaccinating against infection causing agents to improve the immunity levels especially of infants, young children and persons residing in areas to endemic to infectious diseases(ex. Yellow fever). For successful immunization programmes, vaccine should be given at an age beneficial to recipients, should be cost-effective, involve few visits and in tune with the cultural aspects and working patterns of the recipient community. In 1974, World Health Organization started immunization as an expanded immunization programme covering measles, tuberculosis, polio, tetanus, whooping cough and diphtheria.

India initiated immunization programme in 1978 and now in practice as universal immunization programme covering tetanus, tuberculosis, hepatitis B, polio, diphtheria, pertussis, measles and Japanese encephalitis diseases and targeting pregnant women, infants and children.

Passive immunization involves administration of normal or hyper immune human immunoglobulins or antisera or antitoxins to non-immune persons to provide short term immunity for 1-6 weeks when exposed to infection or likely to be exposed to infective agent. For some infective diseases such as diphtheria, tetanus, rabies, both active and passive immunization strategy are used.

In chemoprophylaxis, drugs are administered to prevent the development of infectious disease and this approach is followed for plague, meningitis, malaria, influenza, diphtheria, conjunctivitis and cholera.

Check Your Progress

3) Describe the levels of prevention in chronic disease?

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4.5 TEMPORAL AND GEOGRAPHICAL TRENDS OF SELECTED PROTOZOAN DISEASES

Protozoan are primitive unicellular nuclei containing organisms and use flagellum or cilia for locomotion. They depend on other organisms for food source (parasites) except Euglena. Examples include amoeba, plasmodium, paramecium etc. Around 70 protozoan pathogens and among them, 90 species are known to cause infection in humans. The rise in protozoan diseases are attributed to widespread living habitats, deforestation, increased international travel and increasing number of immune compromised individuals. In Indian context, malaria and visceral leishmaniasis (Kala-azar) are significant protozoan disease and data for geographical and temporal trends are available which are discussed in this unit.

Table 4.2: List of Protozoa and Diseases Caused by them

Protozoa	Disease
Plasmodium falciparum, Plasmodium vivax, Plasmodium ovale and Plasmodium malariae	Malaria
Leishmania donovani, Leishmania infantum, Leishmania chagasi	Leishmaniasis
Giardia lamblia, Giardia duodenalis, Giardia Intestinalis	Giardiasis
Entamoeba histolytica	Amoebiasis

Cyclospora cayetanensis	Cyclosporiasis
Cryptosporidium	Cryptosporidiosis
Babesia microti, Babesia divergens and Babesia bovis	Babesiosis
Blastocystis hominis	Blastocystis
Toxoplasma gondii	Toxoplasmosis
Balantidium coli	Balantidiasis
Trypanosoma brucei gambiense, Trypanosoma brucei rhodesiense, Trypanosoma cruzi, Trypanosoma evansi	Trypanosomiasis
Dientamoeba fragilis	Dientamoebiasis
Trichomonas vaginalis	Trichomoniasis
Acanthamoeba	Acanthoameoba keratitis

4.5.1 Malaria

It is caused by the infection of species of *Plasmodium* and transmitted to human by the bite infected species of female Anopheline mosquito. Malaria develops after 8-21 days of biting of infected mosquito depending upon the type of Plasmodium species, climatic conditions and host immunity. Fever, vomiting, headache and flu like symptoms are observed, when red blood cells are destroyed it results in anaemia, fits and loss of conscious. Cerebral malaria occurs when parasites are transferred to brain. If pregnant gets infected with malaria it can cause abortion or stillbirth. Severe complications of malaria include renal failure, hypoglycaemia, fluid, electrolyte and acid-base disturbances, circulatory collapse, pulmonary edema, malaria hemoglubinuria and hyperpyrexia. Above 5000 feet above sea level, <16 degree centigrade, malaria is not found and high incidence is observed during the months of July to November.

Plasamodium species complete life cycle in two phases, schizogony (asexual phase) in human and sporogony, sexual phase in mosquito. Four *Plasmodium* species namely *Plasmodium falciparum, Plasmodium vivax, Plasmodium ovale and Plasmodium malariae* are responsible for the spread of malaria through the world. Sixty to 65% of malaria in India is casued by *P. falciparum*, 35-40 % by *P. vivax* and 1% by *P. malariae*. *P. malarieae* is confined to Karnakta and Orissa. Infection from P. Vivax is considered as severest form of malaria.

About 95% of population of India is endemic to malaria. Orissa, Jharkhand, Madhya Pradesh, Chhattishgarh, West Bengal and north- east contribute 60% of malarial burden. Passive surveillance data is collected from primary health centres, malaria clinics, secondary and tertiary care centres, community health centres and visits of ASHA (Acredited Social Health Activist) workers. Diagnosis is based on the micoroscopic examination of blood films prepared on slides, flouroscent antibody test and rapid diagnosis test of antigen detection of malaria causing parasite.

Box 4.5: Accredited Social Health Activist

ASHA must be women in the age group of 25-45 years belonging to the village she works from and has minimum qualification of 10th standard.

Act as interface between community and healthy care systems.

Undergo training to acquire knowledge and skills for performing roles assigned to her.

Create awareness on nutrition, sanitation, hygienic practices, for women on contraception, birth preparedness, safe delivery, antental and postnatal check-up, breast and complementary feeding, immunization and prevention of sexually transmitted diseases.

Motivate villagers for effective utilization and make accountable to the health care systems.

Provide first-aid, promote immunization and sanitisation facilities and participate in referral and escorting in reproductive, child health and health promotion activities

Deliver Oral rehydration sachets, iron/folic acid/ chloroquine tablets, birth delivery kits, iron pills and condoms to the community members.

(**Source**: National health mission, Ministry of Health and Family Welfare, Government of India webpage)

4.5.1.1 Temporal Changes

Year wise incidence of malaria from 1995 to 2019 is available on the webpage of NVBCP (National Vector Borne Disease Control Programme, Delhi). Incidence of malaria declined from 2.93 million in 1995 and maintained around 2 million till 2002 then declined steadily to 0.33 in 2019. *Plasmodium falciparum* incidence was 1.15 million in 1995 and maintained around 1million till 2001 then declined steadily to 0.15 million in 2019. Death rate was around 1000 from 1995 to 2010 peaking around 1707 in 2006 due to Malaria epidemic in Assam then steadily decreased to 50 in 2019. Annual parasite index showed decreased trend from 2001 to 2019. Slide positivity rate (% of slide positive for malaria) (2.31 million) and slide *falciparum rate* (% slides positive for *falciparum*) (1.11 million) were also found to be decreased from 2001 onwards steadily to 0.26 million and 0.12 million in 2019.

4.5.1.2 Geographic Diversity of Vectors

About 60 species of anopheline are reported as vectors of malaria in India. Six species of Anophenline mosquito such as *Anopheline culicifacies, Anopheline stephensi, Anopheline fluviatilis, Anopheline minimus, Anopheline dirus and Anopheline epirotics* are reported to be primary vectors of malaria in India. *An. Culicifacies* has 5 sibling species A-E and responsible for 60-65% of malaria burden. *A* species is vector for *P. Vivax* and *P. Falciparum* and endemic especially where there is high population of cattle and rural and semi-urban areas. B species is vector for *P. falciparum* and endemic where cattle population is low. *An.stephensi* has three variants (form, intermediate and *mysorensis*). Form variant found in urban, intermediate form in urban and rural areas, whereas *myorensis* in

rural areas. Except the latter the first two forms are vectors and found in urban and industrial areas, *An.fluviatilis* is found in forest frings, forests and hilly areas and has 4 sibling species (S,T,U and V). S sibling is an effective vector. *An.minmus* is a vector and spread in foot hills of north-east and *An.epiroticus* is restricted Andaman and Nicobar whereas *An. dirus* is a vector found in north-east part of India.

4.5.2 Visceral Leishmaniasis (Kala-azar)

Lesishmaniasis is included as one of the 17 diseases under the category of neglected tropic disease by World Health Organization to give more attention for its elimination. There are several forms of this disease such as cutaneous, mucocutaneous and visceral. These are caused by infection of parasites like *Leishmania mexicana, Leishmania brazaliensis and Leishmania donovani*. The latter form of disease is also known as kala-azar is prevalent in India and considered to be fatal if not diagnosed properly or treated. Human acquire this infection by the bite of infected female sandfly belonging to the genus *Phlebotamus argentipus*. Parasite occurs in two morphological forms i.e. amastigotes and promastogotes. Sandfly get the parasite from the infected human (amastigotes form) and parasite developed into flagellate in the sandfly (promastogotes form) and transmit to the healthy human through biting. Mud walls, plants in and around human habitations and dampness of the houses contribute to the survival of the vector (sandfly). Reticuloendothelial system (descents of lymphoid lineage from bone marrow which participate in phagocytosis (killing of the foreigner organisms)) is the primary target of this parasite but also found in spleen, liver and bone marrow. In post kala-azar disease when the parasite invades the skin cells and cause dermal lesions it is called post kala-azar dermal leishmaniasis. Discolouration of skin in face, hands, abdomen and feet (kala-azar); spleen and liver enlargement, recurrent fever, anaemia, weight loss, loss of appetite, pallor, loss of hair, dry, thin and scaly skin and lymphodenopathy are cardinal symptoms of this condition. Kala-azar is diagnosed based on the detection of IgM antibodies produced against leishmania in infected person using enzyme linked immune sorbent assay, rapid dipstick and direct agglutinin tests. Rural and low economic strata people showed higher incidence of this parasite. This disease is spread in 10 states namely West Bengal, Uttar Pradesh, Bihar, Assam, Delhi, Kerala, Punjab, Sikkim, Uttarakhand and Jharkhand. About 54 districts of India are affected with this parasite.

4.5.2.1 Temporal Changes

Incidence of kala-azar in 10 states from NVBCP website from the year 2013-2019 showed steadily decline in incidence from 13869 to 3128 and deaths from 20 to nil in the period of 2013-2019. Post kalazar dermal leshmaniasis (PKDL) reported from 2013-2019 for four states (Bihar, Jharkhand, West Bengal and Uttar Pradesh) showed steady increase from 499 cases in 2013 to 1982 in 2017 then declined to 1245 in 2018 and 817 in 2019.

4.5.2.2 Geographical Diversity

Among the 10 states for which incidence data available, Bihar contributed large number of cases followed by Jharkhand, West Bengal and Uttar Pradesh from

2013-2019. The same trend continued in PKDL also except for the years 2014 and 2015 during this period West Bengal occupied second place in the contribution of cases.

Box 4.6

IgM detection by ELISA Method: IgM is one type of immunoglobin produced in response to the exposure to the antigen of infection causing agent (Leishmania) In this test the antigen of lesihmania is coated on the walls of the microassay plate. Test sample is added to the well of the microassay plate that will result in the formation of antigen-antibody complex. Enzyme labelled antibody will be added to the mixture which will bind to the Fragment crystalizable portion of test. Substrate specific to the enzyme is added that will catalyze the substrate to give end product. The colour intensity of end product is directly proportional to the concentration of antibody in the test sample that can be measured using ELISA reader at particular wavelength.

rk39 dipstic(K39) test: K39 is epitope (part of an antigen detected by antibody) present on the amastigotes of Leishmania. By using ELISA as described for IgM, IgG antibodies (type of immunoglobins formed when exposed to the antigen of Leishmania) present in the test sample can be detected and quantified. In field, K39 impregnated nitrocellular strips used for rapid testing. When sample added to the strip it will bind with dye conjugate and move through capillary action, bind with K39 antigen present on the membrane and give red line indicating the presence of leishmaniasis.

Direct agglutination test: In this test, trypsin digested, stained and formalin fixed amastigotes of Lesihmania used as antigen which when combine with test sample containing antibodies form agglutination due to the binding of antigen-antibody.

Source: https://microbeonline.com/antibodyantigen-detection-tests-for-the-diagnosis-of-kala-azar-visceral-leishmaniasis/ and Park, 2013).

4.6 SUMMARY

In this unit, definition of chronic disease and different terms used in infectious diseases, types of outbreaks, steps outlined by Centers for disease control and prevention. United States, for investigation of outbreak, methods employed for studying aetiology as well as surveillance and prevention of chronic and infectious diseases, details of disease, geographical and temporal trends of two significant protozoan diseases of India such as malaria and visceral leishmaniasis (kala-azar) are described.

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4.8 ANSWERS TO CHECK YOUR PROGRESS

1) For studying aetiology of chronic diseases, analytical (ecological, case-control, cohort) and experimental epidemiological methods (randomized controlled trials, field, community and natural trials) are used. Aetiology of infectious disease is investigated by using analytical epidemiological methods such as retrospective cohort studies and case-control studies.

2) Surveillance is any effort to monitor, observe or determine health status, diseases or risk factors within a population.

3) For chronic diseases, prevention can be done at four levels namely primordial, primary, secondary and tertiary.

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