such associations.

9. USES OF EPIDEMIOLOGY

While the study of disease distribution and causation remains central to epidemiology; the techniques of

epidemiology have a wider application covering many more important areas relating not only to disease but also health and health services. In more utilitarian terms, epidemiology has been defined as "a means of learning, or asking questions....and getting answers that lead to further questions". In this context, Morris *(10)* has identified seven distinct uses of epidemiology, five of which extend epidemiology beyond the search for causes of disease and bring it closer to day-to-day concerns of modern medicine. These are :

1. To study historically the rise and fall of disease in the population

Winston Churchill said : "The farther back you look, the farther forward you can see". The first use of epidemiology relates to this aspect, that is, study of the history of disease in human population. It is well known that the health and disease pattern in a community is never constant. There are fluctuations both over short and long periods of time. For example, the first contribution of epidemiology to the study of coronary heart disease was that it was an "epidemic". Later many others such as accidents, cancer and diabetes were found to be "epidemic". As old diseases (e.g., smallpox) are conquered, new ones (e.g., Legionnaires' disease, Lassa fever, AIDS) have been identified, in which epidemiology has played a major role. Epidemiology provides a means to study disease profiles and time trends in human population. By a study of these trends we can make useful projections into the future and identify emerging health problems and their correlates.

2. Community diagnosis

One of the uses of epidemiology is community diagnosis. Community diagnosis generally refers to the identification and quantification of health problems in a community in terms of mortality and morbidity rates and ratios, and identification of their correlates for the purpose of defining those individuals or groups at risk or those in need of health care. By quantification of health problems, we lay down priorities in disease control and prevention. Secondly, quantification of morbidity and mortality can serve as a benchmark for the evaluation of health services at a later date. Thirdly, the quantification of health problems can be a source of new knowledge about disease distribution, causation and prevention. Community diagnosis has also been effectively extended beyond population distributions and profiles of illness to include an understanding of the social, cultural and environmental characteristics of the community *(91)*. Epidemiology therefore has been described as a "diagnostic tool" of community medicine.

3. Planning and evaluation

Planning is essential for a rational allocation of the limited resources. For example, in developing countries, too many hospitals have been built and equipped without knowledge of the particular disease problems in the community. Epidemiologic information about the distribution of health problems over time and place provides the fundamental basis for planning and developing the needed health services and for assessing the impact of these services on the people's problems. The application of epidemiological principles to problems of health care constitutes the "new epidemiology" *(92)*. Examples of planning include planning facilities for medical care (e.g., number of hospital beds required for patients with specific diseases, health manpower planning); planning facilities for preventive services (e.g., screening programmes, immunization campaigns; provision of sanitary services); and planning for research.

Evaluation is an equally important concern of epidemiology. Any measures taken to control or prevent a disease must be followed by an evaluation to find out whether the measures undertaken are effective in reducing the frequency of the disease. Evaluation of a control method such as hepatitis vaccine requires more than the demonstration of its effectiveness in reducing disease frequency. We have to measure the cost of its large-scale application in terms of the cost of the vaccine, trained personnel, storage, transport and other factors. The value of one method in relation to others is assessed by cost-effectiveness studies. It is now being recognized that not only vaccines, but in time all health services will have to submit to evaluation *(93)*. The development of randomized controlled trial has made it possible to evaluate treatment modalities on a firm scientific basis. Such trials have raised doubts about the utility of multiphasic screening, certain operative procedures (e.g., tonsillectomy, varicose vein, stripping), prolonged hospitalization of patients with myocardial infarction, etc. Clearly it is not enough to know that a programme provides some benefit; we need to know how much benefit and at what risk and cost *(93)*.

4. Evaluation of individual's risks and chances

One of the important tasks of epidemiologists is to make a statement about the degree of risk in a population. Besides the incidence rate and specific rates which are measures of absolute risk, the epidemiologists calculate relative risk and attributable risk for a factor related to or believed to be a cause of the disease. The risk of bearing a mongol child and of some hereditary disorders are classic examples of evaluating individual's risks and chances. The risk assessment for smokers and non-smokers, for selected causes of death (e.g., cancer CHD) is another well-known example.

5. Syndrome identification

Medical syndromes are identified by observing frequently associated findings in individual patients. It is worth recalling that, although approximately 3000 so-called syndromes are described in the contemporary paediatric literature, a primary defect is known only in about 20 per cent of these *(94)*. Epidemiological investigations can be used to define and refine syndromes. By observation of groups, such studies have been able to correct misconceptions concerning many disease syndromes. For example, there was less appreciation of the two main types of peptic ulcer (gastric and duodenal) till 1920. But the "poverty" gradient in the certification of the gastric ulcer and its absence in duodenal ulcer led to differentiation of gastric and duodenal ulcers. Another example is that of Patterson-Kelly syndrome of association between dysphagia and iron-deficiency anaemia, but when the association was tested by epidemiological methods, it was not found *(10)*. Clinical studies using plasma renin levels have suggested that aetiologically, prognostically and therapeutically distinct syndromes of essential hypertension may exist. It has been the subject of hot debate *(95, 96)*.

6. Completing the natural history of disease

Epidemiology is concerned with the entire spectrum of disease in a population. The picture of disease constructed on the basis of hospital patients is quite different from that found in the community. The epidemiologist by studying disease patterns in the community in relation to agent, host and environmental factors is in a better position to fill up the gaps in the natural history of disease than the clinician. For example an outstanding contribution by epidemiology to the natural history of atherosclerosis is the recognition that one-

third to two-thirds of all deaths due to ischaemic heart disease are sudden, i.e., occur in less than one hour. Hospital studies could never have come to this conclusion, for most victims do not reach the hospital. This gave tremendous impetus to the development of intensive coronary care units *(97)*. Epidemiological investigations have yielded a large amount of data on risk factors in relation to chronic disease. The impact of these findings on our knowledge of the natural history of chronic disease remains to be elucidated. Since the epidemiologist is concerned with all cases in the defined population, regardless of severity or source of medical care, his perspective of disease is consequently the broadest.

7. Searching for causes and risk factors

Epidemiology, by relating disease to interpopulation differences and other attributes of the population or cohorts examined, tries to identify the causes of disease. The contributions of epidemiology have been many in this regard. Numerous examples can be cited : epidemiological studies have incriminated that rubella is the cause of congenital defects in the newborn, that thalidomide is a teratogenic agent, cigarette smoking is a cause of lung cancer, exposure of premature babies to oxygen is the cause of retrolental fibroplasia, etc. in the case of chronic disease, hopes of finding a single cause remains unfulfilled, but an important conceptual change has occurred – that is, search for risk factors. The concept of "risk factors" gave renewed impetus to epidemiological research. The search for causes and risk factors will be a ceaseless effort, as our ignorance about disease aetiology, particularly chronic disease, is profound, not to speak of the "new" diseases which are appearing.

INFECTIOUS DISEASE EPIDEMIOLOGY

Infectious disease epidemiology is a fundamental part of the whole of epidemiology. In fact, the subject of epidemiology originally developed from the study of epidemics of infectious diseases. There is a renaissance in the study of communicable diseases, stimulated by (a) changes in the pattern of communicable diseases, (b) by the discovery of "new" infections, and (c) by the possibility that some chronic diseases have an infective origin. The development of vaccines and antibiotics was not followed, as predicted, by the virtual disappearance of infectious disease. Its prevention and control needs epidemiological knowledge and experience *(98)*. This section focuses on infectious disease epidemiology.

Selected definitions

Definitions are essential for any kind of epidemiological activity, e.g., disease reporting, measurement of mortality and morbidity, etc. Clear-cut definitions of the terms such as "infection", "epidemic" and "surveillance" are needed in the study of infectious diseases. A few selected definitions pertaining to infectious disease epidemiology are given below :

INFECTION

The entry and development or multiplication of an infectious agent in the body of man or animals *(2,99)*. It also implies that the body responds in some way to defend itself against the invader, either in the form of an immune response (evidence of this may not be readily available) or disease. An infection does not always cause illness.

There are several levels of infection : *colonization* (e.g., *S. aureus* in skin and normal nasopharynx); subclinical or *inapparent infection* (e.g., polio); latent infection (e.g., virus of herpes simplex); and manifest or *clinical infection*.

CONTAMINATION

The presence of an infectious agent on a body surface; also on or in clothes, beddings, toys, surgical instruments or dressings, or other inanimate articles or substances including water, milk and food. *Pollution* is distinct from contamination and implies the presence of offensive, but not necessarily infectious matter in the environment. Contamination on a body surface does not imply a carrier state *(99)*.

INFESTATION

For persons or animals the lodgement, development and reproduction of arthropods on the surface of the body or in the clothing, e.g., lice, itch mite *(99)*. Some authorities use the term also to describe invasion of the gut by parasitic worms, e.g., ascariasis *(2)*.

Infested articles or premises are those which harbour or give shelter to animal forms, especially arthropods and rodents *(99)*.

HOST

A person or other animal, including birds and arthropods, that affords subsistence or lodgement to an infectious agent under natural (as opposed to experimental) conditions. An *obligate* host means the only host, e.g., man in measles and typhoid fever. Hosts in which the parasite attains maturity or passes its sexual stage are primary or *definitive* hosts; those in which the parasite is in a larval or asexual state are secondary or *intermediate* hosts. A *transport* host is a carrier in which the organism remains alive but does not undergo development *(2,99)*.

INFECTIOUS DISEASE

A clinically manifest disease of man or animals resulting from an infection *(99)*.

CONTAGIOUS DISEASE

A disease that is transmitted through contact *(2)*. Examples include scabies, trachoma, STD and leprosy.

COMMUNICABLE DISEASE

An illness due to a specific infectious agent or its toxic products capable of being directly or indirectly transmitted from man to man, animal to animal, or from the environment (through air, dust, soil, water, food, etc.) to man or animal *(100)*.

EPIDEMIC

(Epi = upon; demos = people). The "unusual" occurrence in a community or region of disease, specific health–related behaviour (e.g., smoking) or other health–related events (e.g., traffic accidents) clearly in excess of "expected occurrence". The amount of disease occurring in the past, in the absence of an epidemic, defines the "expected" frequency. Some use the term "outbreak" for a small, usually localized epidemic in the interest of minimizing public alarm, unless the number of cases is indeed very large *(13)*.

The above definition covers not only the usual epidemic diseases such as measles, chickenpox and cholera which are compressed in time, but also the modern "slow" epidemics of non-communicable diseases (e.g., CHD, lung cancer) in which the time scale of the epidemic is shifted from days or weeks to years *(13)*. The slow growth of these epidemics conceal their size.

The key words in the definition of an epidemic are : in excess of "expected occurrence". There is no agreement on what constitutes a significant excess. For example, in the US, a disease such as cholera is not normally present in the

population. Therefore, even one case of cholera would constitute a "potential" epidemic in US. But in a country like India or Bangladesh, where cholera is always present in some population subgroups, a few hundred cases a year may be the "usual" or expected incidence (endemic situation). For cholera to be considered as an epidemic in India, hundreds of cases (i.e., cases above the endemic frequency) would have to occur. An arbitrary limit of two standard errors from the endemic frequency is used to define the epidemic threshold for common diseases *(3)*.

ENDEMIC

(En=in; demos=people). It refers to the constant presence of a disease or infectious agent within a given geographic area or population group, without importation from outside) may also refer to the "usual" or expected frequency of the disease within such area or population group. For instance, common cold is endemic because somebody always has one.

The term "hyperendemic" expresses that the disease is constantly present at a high incidence and/or prevalence rate and affects all age groups equally; and the term "holoendemic" a high level of infection beginning early in life and affecting most of the child population, leading to a state of equilibrium such that the adult population shows evidence of the disease much less commonly than do the children, as in the case of malaria *(2)*.

An endemic disease when conditions are favourable may burst into an epidemic (e.g., hepatitis A, typhoid fever). As new control or preventive measures are applied, the endemic status of a disease may change.

SPORADIC

(The word sporadic means scattered about. The cases occur irregularly, haphazardly from time to time, and generally infrequently *(2)*.) The cases are so few and separated widely in space and time that they show little or no connection with each other, nor a recognizable common source of infection, e.g., polio, tetanus, herpes zoster and meningococcal meningitis. A sporadic disease may be the starting point of an epidemic when conditions are favourable for its spread. Many zoonotic diseases are characterised by sporadic transmission to man *(101)*.

PANDEMIC

(An epidemic usually affecting a large proportion of the population *(2)*, occurring over a wide geographic area such as a section of a nation, the entire nation, a continent or the world e.g., influenza pandemics of 1918 and 1957, cholera El Tor in 1962 (still continuing)) and acute haemorrhagic conjunctivitis in 1971 and 1981.

EXOTIC

(Diseases which are imported into a country in which they do not otherwise occur, as for example, rabies in UK.) An example is the occurrence of epidemic polyarthritis in visitors to Fizi, due to Ross River virus (an alpha virus presumed to have been introduced by infected mosquitoes harboured in aircraft *(101)*.

ZOONOSES

(An infection or infectious disease transmissible under natural conditions from vertebrate animals to man) May be enzootic or epizootic – e.g., rabies, plague, bovine tuberculosis, anthrax, brucellosis, salmonellosis, endemic typhus, hydatidosis, etc. In recent years several new zoonoses have emerged, e.g., Kyasanur forest disease, Monkeypox, Lassa fever, etc.

The term zoonoses has been further amplified as follows : (a) *anthropozoonoses* : that is, infections transmitted to man from vertebrate animals, e.g., rabies, plague, hydatid disease, anthrax and trichinosis; (b) *zooanthroponoses* : that is, infections transmitted from man to vertebrate animals, e.g., human tuberculosis in cattle; and (c) *amphixenoses* : that is infections maintained in both man and lower vertebrate animals that may be transmitted in either direction, e.g., *T.cruzi*, and *S.japonicum (102)*.

EPIZOOTIC

An outbreak (epidemic) of disease in an animal population (often with the implication that it may also affect human populations) *(2)*. Only a few zoonotic agents cause major epidemics. Notable among these are the agents of anthrax, brucellosis, rabies, influenza, Rift valley fever, Q fever, Japanese encephalitis and equine encephalitis. The study of epizootic diseases is given the name of epizootiology.

EPORNITHIC

An outbreak (epidemic) of disease in a bird population *(2)*.

ENZOOTIC

An endemic occurring in animals e.g., anthrax, rabies, brucellosis, bovine tuberculosis, endemic typhus and tick typhus.

NOSOCOMIAL INFECTION

Nosocomial (hospital acquired) infection is an infection originating in a patient while in a hospital or other health care facility. It denotes a new disorder (unrelated to the patient's primary condition) associated with being in a hospital *(2)*. That is, it was not present or incubating at the time of admission or the residual of an infection acquired during a previous admission. It includes infections acquired in the hospital but appearing after discharge, and also such infections among the staff of the facility *(99)*. Examples include infection of surgical wounds, hepatitis B and urinary tract infections.

OPPORTUNISTIC INFECTION

This is infection by an organism(s) that takes the opportunity provided by a defect in host defence to infect the host and hence cause disease. The organisms include *Herpes simplex*, *Cytomegalovirus*, *Toxoplasma*, *M. tuberculosis*, *M. avium intracellulare*, *pneumocystis*, etc. (For example, opportunistic infections are very common in AIDS). Infection by an organism that is not normally pathogenic, but can cause disease if resistance is lowered.

IATROGENIC (PHYSICIAN–INDUCED) DISEASE

Any untoward or adverse consequence of a preventive, diagnostic or therapeutic regimen or procedure, that causes impairment, handicap, disability or death *(103)* resulting from a physician's professional activity or from the professional activity of other health professionals *(2)*. The disease may be serious enough to prolong the hospital stay, require special treatment or actually threaten life. Most of the episodes are related to drug therapy, immunization or diagnostic procedures, e.g., reactions to penicillin and immunizing agents, aplastic anaemia following the use of chloramphenicol, childhood leukaemia due to prenatal X-rays, hepatitis B following blood transfusion, etc. These are all preventable. In short, iatrogenic disease is a hazard of health care.

SURVEILLANCE

Surveillance has been defined as "the continuous scrutiny of the factors that determine the occurrence and distribution of disease and other conditions of ill health. Surveillance is

essential for effective control and prevention, and includes the collection, analysis, interpretation and distribution of relevant data for action *(104)*.

Surveillance also connotes exercise of continuous scrutiny of health indices, nutritional status, environmental hazards, health practices and other factors that may affect health. Thus we have epidemiological surveillance *(105)*, nutritional surveillance *(106)*, demographic surveillance *(107)*, serological surveillance, etc.

The main purpose of surveillance is to detect changes in trend or distribution in order to initiate investigative or control measures *(2)*.

ERADICATION

Termination of all transmission of infection by extermination of the infectious agent through surveillance and containment *(2)*. Eradication is an absolute process, an "all or none" phenomenon, restricted to termination of an infection from the whole world. It implies that disease will no longer occur in a population. To-date, only one disease has been eradicated, that is smallpox.

The term *elimination* is sometimes used to describe "eradication" of disease (e.g., measles) from a large geographic region or political jurisdiction *(2)*. In the state of our present knowledge, diseases which are amenable to eradication are measles, diphtheria, polio and guineaworm.

DYNAMICS OF DISEASE TRANSMISSION

Communicable diseases are transmitted from the reservoir/source of infection to susceptible host. Fig.16 illustrates the medical model of an infectious disease. Basically there are three links in the chain of transmission, viz, the reservoir, modes of transmission and the susceptible host.

Sources and reservoir

The starting point for the occurrence of a communicable disease is the existence of a reservoir or source of infection. The **source** of infection is defined as "the person, animal, object or substance from which an infectious agent passes or is disseminated to the host" *(99)*. A **reservoir** is defined as "any person, animal, arthropod, plant, soil or substance (or combination of these) in which an infectious agent lives and multiplies, on which it depends primarily for survival, and where it reproduces itself in such manner that it can be transmitted to a susceptible host" *(99)*. In short, the reservoir is the natural habitat in which the organism metabolizes and replicates.

The terms reservoir and source are not always synonymous. For example, in hookworm infection, the reservoir is man, but the source of infection is the soil contaminated with infective larvae. In tetanus, the reservoir and source are the same, that is soil. In typhoid fever, the reservoir of infection may be a case or carrier, but the source of infection may be faeces or urine of patients or contaminated food, milk or water. Thus the term "source" refers to the immediate source of infection and may or may not be a part of reservoir.

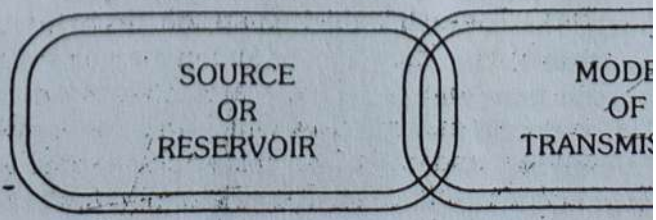


FIG. 1
Chain of In

The term *homologous reservoir* is applied when another member of the same species is the victim, as for example man is the principal reservoir for some enteric pathogens, e.g., *vibrio cholerae*. The term heterologous is applied when the infection is derived from a reservoir other than man, as for example animals and birds infected with salmonella.

The reservoir may be of three types :

1. Human reservoir
2. Animal reservoir, and
3. Reservoir in non-living things.

1. Human reservoir

By far the most important source or reservoir of infection for humans is man himself. He may be a case or carrier. Man is often described as his own enemy because most of the communicable diseases of which man is heir to are contracted from human sources.

a. CASES

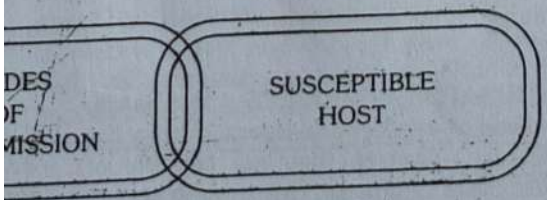
A case is defined as "a person in the population or study group identified as having the particular disease, health disorder or condition under investigation" *(2)*. A variety of criteria (e.g., clinical, biochemical, laboratory) may be used to identify cases. Broadly, the presence of infection in a host may be clinical, subclinical or latent. These variations in the manifestations of disease are referred to as "spectrum of disease" or "gradient of infection" (see page 37).

(1) The *clinical* illness may be mild or moderate, typical or atypical, severe or fatal depending upon the gradient of involvement. Epidemiologically, mild cases may be more important sources of infection than severe cases because they are ambulant and spread the infection wherever they go, whereas severe cases are usually confined to bed.

(2) The *subclinical cases* are variously referred to as inapparent, covert, missed or abortive cases. They are equally important as sources of infection. The disease agent may multiply in the host but does not manifest itself by signs and symptoms. The disease agent is, eliminated and contaminates the environment in the same way as clinical cases. Persons who are thus sick (unbeknown to themselves and others) contribute more than symptomatic patients to the transmission of infection to others and what is more, they do not appear in any of the statistics. Subclinical cases play a dominant role in maintaining the chain of infection (endemicity) in the community.

Subclinical infection can be detected only by laboratory tests, e.g., recovery of the organism, antibody response, biochemical and skin sensitivity tests.

Barring a few (e.g., measles), subclinical infection occurs in most infectious diseases. In some diseases (e.g., rubella, mumps, polio, hepatitis A and B, Japanese encephalitis, influenza, diphtheria), a great deal of subclinical infection occurs. Since subclinical infections occur frequently during a person's life time, they are responsible for the immunity shown by adult humans to a variety of disease-producing microbes.



(3) The term *latent infection* must be distinguished from subclinical infection. In latent infection, the host does not shed the infectious agent which lies dormant within the host without symptoms (and often without demonstrable presence in blood, tissues or bodily secretions of the host). For example, latent infection occurs in herpes simplex, Brill–Zinser disease, infections due to slow viruses, ancylostomiasis, etc. The role of latent infection in the perpetuation of certain infectious agents appears to be great *(108)*.

In epidemiological terminology, the term **primary case** refers to the first case of a communicable disease introduced into the population unit being studied. The term **index case** refers to the first case to come to the attention of the investigator; it is not always the primary case. **Secondary cases** are those developing from contact with primary case. A **suspect** case is an individual (or a group of individuals) who has all of the signs and symptoms of a disease or condition, yet has not been diagnosed as having the disease or had the cause of the symptoms connected to the suspected pathogen.

Whatever may be the "gradient of infection", all infected persons, whether clinical or subclinical, are potential sources of infection, because the disease agent is leaving the body through frequent stools, vomiting, coughing, sneezing or other means and is potentially available for transfer to a new host.

b. CARRIERS

In some diseases, either due to inadequate treatment or immune response, the disease agent is not completely eliminated, leading to a carrier state. A carrier is defined as "an infected person or animal that harbours a specific infectious agent in the absence of discernible clinical disease and serves as a potential source of infection for others" *(2)*. As a rule carriers are less infectious than cases, but epidemiologically, they are more dangerous than cases because they escape recognition, and continuing as they do to live a normal life among the population or community, they readily infect the susceptible individuals over a wider area and longer period of time, under favourable conditions. The "Typhoid Mary" is a classic example of a carrier.

The elements in a carrier state are : (a) the presence in the body of the disease agent (b) the absence of recognizable symptoms and signs of disease, and (c) the shedding of the disease agent in the discharges or excretions, thus acting as a source of infection for other persons.

Carriers may be classified as below :

A. Type
- (a) Incubatory
- (b) Convalescent
- (c) Healthy

B. Duration
- (a) Temporary
- (b) Chronic

C. Portal of exit
- (a) Urinary — typhoid
- (b) Intestinal
- (c) Respiratory
- (d) Others

A. **By type** : (a) INCUBATORY CARRIERS : Incubatory carriers are those who shed the infectious agent during the incubation period of disease. That is, they are capable of infecting others before the onset of illness. This usually occurs during the last few days of the incubation period, e.g., measles, mumps, polio, pertussis, influenza, diphtheria and hepatitis B. (b) CONVALESCENT CARRIERS : That is, those