REVIEW ARTICLE

Epidemiology: Redefining the Study among People

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ABSTRACT

According to the World Health Organization, epidemiology is the study of the distribution and determinants of health-related states or events (including disease), and the application of this study to the control of diseases and other health problems. Various methods can be used to carry out epidemiological investigations: Surveillance and descriptive studies can be used to study distribution; analytical studies are used to study determinants, which is aimed to describe the distribution and magnitude of health and disease related problems in human populations, with an ultimate goal to eliminate or reduce the health problem or its consequences and promote the health and well-being of society as a whole. The current review will be to redefine the epidemiological tools which are used to do the studies among people.

Keywords: Epidemiology, Epidemiological triad, Incidence, Prevalence.

INTRODUCTION

Epidemiology is the science of preventive and social medicine and has been evolved rapidly during the past decades.

Recent and advanced epidemiology has entered the most exciting phase of its evolution. By identifying risk factors of chronic disease, evaluating treatment modalities, and health services, it has provided new opportunities for prevention, treatment, planning, and improving the effectiveness and efficiency of health services. This trend is bound to increase in view of the increasing importance given to the pursuit of epidemiological studies.[1]

DEFINITIONS

- Epidemiology is that branch of medical science which treats of epidemics (Parkin, 1873).[2]

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- Epidemiology is defined as the science of the mass phenomena of infectious diseases (Frost, 1927).[3]
- Epidemiology is the study of disease, any disease, as a mass phenomenon (Greenwood, 1934).[4]
- Epidemiology is defined as the study of distribution and determinants of disease frequency in man (McMahon, 1960).[5]

Epidemiology has been defined by Last in 1988[6] 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 control of health problems.

AIMS OF EPIDEMIOLOGY

Followings are the main aims of epidemiology according to the International Epidemiological Association, epidemiology:

- To describe the magnitude and distribution of health and disease problems in various human populations.
- To identify risk factors in the pathogenesis of disease.
- To provide the data essential to the planning, implementation, and evaluation of services for the prevention, control, and treatment of disease and to the setting up of priorities among those services.

The ultimate aim of epidemiology is to lead to effective action:

- To eliminate or reduce the health problem or its consequences.
- To promote the health and well-being of society as a whole.

SCOPE OF EPIDEMIOLOGY

- Modern epidemiology is concerned with the study of not only epidemic diseases but also with both communicable and non- communicable, such as cancer, heart diseases, mental illnesses, and dental diseases, etc.
- Modern epidemiology is also concerned with study of the general health status of the human populations in relation to the environment known as epidemiology of health.

OBJECTIVES OF EPIDEMIOLOGY

The main objectives of epidemiology are:

- To collect, collate, and analyze all data relating to the roles of agent, host, and environmental factors, physical, biological, psychological, and socio-economic

factors to effectively describe the complete epidemiological situation.

- To describe and analyze the nature, occurrence and distribution of diseases following age, sex, occupation, seasonal and secular periodicity of occurrence and places, and habits.
- To help administrators to channel their public health policies to serve the various groups of population, age, sex, occupation, rural and urban; to meet the felt needs of these groups in society they serve; to appraise their action, and finally evaluate periodically to improve their social policy from time to time.

PRINCIPLES OF EPIDEMIOLOGY

There are four important principles of epidemiology:
1. Exact observation
2. Correct interpretation free from errors
3. Principle Explanation which should be reasonable, sensible & intelligent
4. Methodical construction with expert technical skills and knowledge.

CLASSIFICATION OF EPIDEMIOLOGICAL STUDY

- Descriptive studies
- Analytical studies
- Cross-sectional
- Case-control
- Cohort
- Experimental studies
- Randomized controlled trials
- Field trials
- Community trials.

STRATEGY OF EPIDEMIOLOGY

Mac Mohan and Pugh[5] has concluded the strategies for epidemiology which are as follows:

Descriptive Epidemiology

Explanation of the disease distribution, with correlation of its frequency in different populations and in different segments of the same population.

Formulation of Hypothesis

Tentative theories designed to explain the observed distribution of the disease in terms of casual associations of the most direct nature possible.

Analytic Epidemiology

Observational studies designed specifically to examine the hypothesis developed as a result of the descriptive study.

Experimental Epidemiology

Experimental studies on human populations to test in a stringent manner the hypothesis that stands the test of observational and analytic studies.

COMPONENTS OF EPIDEMIOLOGY

The three components of epidemiology are:
1. Disease Frequency
   - The basic measure of disease frequency is a rate or ratio.
   - Comparison of the rates of disease frequency between different populations will lead to important clues on the etiological factors of the disease.
   - This step is important with regard to the development of strategies for prevention or control of diseases and other health-related problems.
2. Distribution of Disease
   - The distribution of disease is not uniform in human populations.
   - The most important function of epidemiology is to study the distribution patterns of the disease in the various subgroups of the population according to the time of occurrence of the disease, the place of occurrence of the disease, and the persons who are affected with the disease.
   - This part of epidemiology, identifies the distribution of the disease and which might suggest the methods to control or prevent the disease, is known as descriptive epidemiology.
3. Determinants of Disease
   One of very important functions of epidemiology is to test an etiological hypothesis in identifying the risk factors of the disease. Hypothesis is tested using the principles and methods of epidemiology and is known as "analytical epidemiology".

EPIDEMIOLOGICAL TRIAD

The occurrence and manifestations of any disease, whether communicable or noncommunicable are determined by the interactions between the agent, the host, and the environment, which together constitute the epidemiological triad.

Agent

The agent is defined as an organism, a substance or a force, the presence of lack of which may initiate a disease process or may cause it to continue. Agents can be classified as:

Biological Agents

E.g: Bacteria, virus, fungi, etc.

Nonliving Agents

- Nutritional – E.g., Protein, fat, carbohydrate
- Chemical
  - External – e.g., lead, arsenic
  - Internal – e.g., urea in renal failure
- Physical agents – e.g., atmospheric pressure, temperature.

Host

The hosts are the humans themself. The characteristics of a human being that determine how he reacts to the agents in the environment are called "host factors". The host factors are:

- *Population characteristics*: Ethnicity, age, and sex
- *Biological characteristics*: Genetic background, physiologic and biochemical characteristics, immune status, and nutritional status.
- *Socioeconomic characteristics*: Social class, religion, education, and marital status.
- *Life style*: Living and food habits, etc.

Environment

The environment of man is of two types:

1. *Internal environment*: Organs and organ systems within the human body.
2. *External environment*: That which is outside of the individual human hosts.

Differences between Clinical and Epidemiological approaches

Sl. no.	Clinical approach	Epidemiological approach
1	Clinician studies the signs, symptoms, causes, and treatment of disease in each individual	Epidemiologist considers disease as a mass phenomenon in community
2	Clinician is only concerned about the patient disease from which he or she suffering from	Epidemiologist takes into account persons even who are not suffering from any disease
3	Clinicians are more focused on the period of disease pathogenesis	Epidemiologists are more focused on the period of pre-pathogenesis of disease
4	In clinical dentistry, patient comes to the doctor	Epidemiological studies, investigator goes into the community to find people who are suffering from the disease
5	The clinicians concern about the environment is very limited	For epidemiologist, even the environmental aspects bring about the host-parasite relationship

TOOLS OF MEASUREMENT IN EPIDEMIOLOGY

The most commonly used tools of measurement in epidemiology are:

Rate

- Rate is the frequency of a disease or characteristic expressed per unit of size of the population.
- Rate indicates the change in some event that takes place in a population over a period of time. Rate may indicate mortality, morbidity, etc., and indicates risk of a particular event occurring.

$$\text{Rate} = \frac{\text{Number of events (deaths or disease) in a specified period}}{\text{Population at risk of experiencing the event or disease}}$$

Ratio

- Ratio denotes the relation in size between two random quantities.
- In a ratio, the numerator is not a part of the denominators. For e.g.:

$$\text{Ratio} = \frac{\text{Number of school children with dental caries at a certain time}}{\text{Number of school children with gingivitis at a certain time}}$$

Proportion

- A proportion is a ratio which expresses the relation in magnitude of a part of the whole.
- In a proportion, the numerator is always a part of the denominator.
- It is usually expressed in a % ratio. For e.g.:

$$\text{Proportion} = \frac{\text{Number of school children with dental caries at a certain time}}{\text{Total number of children in the school at the same time}} \times 100$$

BASIC MEASUREMENTS IN EPIDEMIOLOGY

The most commonly used measurements in epidemiology are:

- Measurement of mortality
- Measurement of morbidity
- Measurement of disability
- Measurement of natality
- Measurement of the characteristic or attributes of the disease
- Measurement of the medical needs
- Measurement of the presence, absence, or distribution of the environmental and other factors suspected of causing the disease.

MEASUREMENT OF MORBIDITY

Morbidity is the most methodologically problematic of all possible health status indicators because as a complex medico sociological variable.

According to WHO, Morbidity is defined as "any departure, subjective or objective, from a state of physiological well-being".

Morbidity can be measured based on three units, such as:

1. Persons who were ill
2. The illness or diseases these persons experienced
3. The duration of these illnesses or diseases.

Three aspects of morbidity, such as the frequency, the duration, and the severity can be measured using the morbidity rates and ratios.

The disease frequency is measured by means of incidence and prevalence.

Incidence

Definition

Incidence can be defined as the number of new cases of a specific disease occurring in a defined population during a specified period of time.[2]

- Incidence is usually expressed as a rate, i.e., cases per population per time. It can range from zero to infinity.

$$\text{Incidence} = \frac{\text{Number of new cases of a specific disease during a given time period}}{\text{Population at risk}} \times 1000$$

Incidence rate is the rate of occurrence of new cases arising in population conveniently expressed per unit time interval, e.g., per year.

The two different varieties of incidence are:

1. Episode incidence
2. Cumulative incidence

Episode Incidence

Is the rate of occurrence of new episodes of a disease arising in population?

Cumulative Incidence

Is similar to incidence but time interval expressed as fixed period and result expressed as a proportion?

Uses of Incidence Rates

- It helps in taking action to control the disease.
- It gives clues to research into the etiology and pathogenesis of disease.
- It helps in the diseases distribution studies.
- It is useful in assessing the efficacy of therapeutic and preventive measures.
  - In the study of periodontal disease, rarely, if ever, does incident periodontal disease refer strictly to the onset of disease in previously periodontitis free adults.[2]

- Instead, it usually refers to the development of new periodontal lesions in people who may have had other periodontal lesions at baseline and to the progression of existing lesions.
- Incident periodontal disease is typically measured as a change in attachment level over time, and studies rarely differentiate between the development of new lesions and the progression of existing lesions.[2]

Prevalence

The term 'disease prevalence' is used to indicate all current cases (both old and new) existing in a given population at a given point in time, or over a period of time.

Prevalence is of two types:

1. Point prevalence
2. Period prevalence

Point Prevalence

Defined as the number of all current cases (both old and new) of a specific disease at one point in time in relation to a defined population.

$$\text{Point prevalence} = \frac{\text{Total number of all current cases (old and new) of a specific disease at a given point in time}}{\text{Estimated total population at the same point in time}} \times 100$$

Period Prevalence:

Defined as the total number of existing cases (old and new) of a specific disease during a defined period of time.

$$\text{Period prevalence} = \frac{\text{Total number existing cases of a specific disease at a given interval of time period}}{\text{Estimated mid-interval population at risk}} \times 100$$

Uses of prevalence rates

- Prevalence rates are useful in estimating the magnitude of disease or health problems in community.
- Helpful in identifying the potential high-risk populations.
- Useful in administrative and planning purposes: Assessing manpower needs in health services, delivery of health services etc.[1]

The introduction of more sensitive diagnostic tests or new treatments that enhance survival increases prevalence and also, the prevalence of a nonfatal chronic disease, such as chronic periodontitis which tends to increase with age. This increase in the prevalence with

age, which is simply caused by the accumulation of cases, is often misinterpreted as meaning that older adults are at higher risk for having disease.[2]

METHODS OF EPIDEMIOLOGY

Epidemiology as a science is organized into three distinct divisions as:[1,2]
1. Descriptive epidemiology
2. Analytical epidemiology
3. Experimental epidemiology

Descriptive Epidemiology

- A descriptive study is one that attempts to do no more than describe the pattern of occurrence of a disease or a condition relative to other characteristics of the population.
- For example, a study conducted for measuring the degree of periodontal disease in a district relative to the age, sex, and socioeconomic characteristics of the children, without attempting to explain why those particular distributions were found would be a descriptive study.
- Descriptive studies are usually the first phase of any epidemiological investigation.

Following are the steps of descriptive epidemiological study:[7,8]

Defining the Population to be Studied

- The population selected for the study has to be defined in terms of the total number and the composition of the individuals within the population in terms of characteristics, such as, age, sex, occupation, culture, socioeconomic characters, etc.
- The defined population can either be the total population in a geographic area or a representative sample taken from that population.

Defining the Disease under Study

- The disease need to be defined with which the disease or condition can be identified and measured in the defined population with a degree of accuracy. Done to differentiate hosts having disease from who do not have disease.

Describing the Disease under Study

- This step is the primary objective of a descriptive study, which is used to describe the occurrence and distribution of the disease by the time of its occurrence, the place of occurrence, and the persons who are affected with the disease.

Variables of descriptive study

- Distribution of time
- Distribution of place
- Distribution of person

Measurement of the Disease

- For the measurement of a disease in terms of its magnitude, a cross sectional (prevalence) or longitudinal (incidence) study can be used.

Cross-sectional Studies

- In cross-sectional studies the presence or absence of disease and the characteristics of the members of a population are measured at a point in time[2].
- Cross-sectional studies measure the prevalence of diseases and are hence, called as 'prevalence studies' or disease frequency surveys[2].

Advantages These studies are relatively easy and economical to carry out and are useful for investigating exposures that are fixed characteristics of individuals, such as ethnicity, socioeconomic status, and blood group.

Limitations[2]
- These studies can only identify prevalence of diseases.
- It may also show that a certain characteristic is associated with having the disease, determining whether the same characteristic preceded the disease is not always possible.

Longitudinal studies

Descriptive studies conducted over a long period of time, is known as a 'longitudinal study'.

These studies are done on samples drawn from the population and observations are made at periodic intervals and provide valuable information, however, are difficult to organize and are more time-consuming when compared to cross-sectional studies.

Comparing with known indices

By making comparisons between different populations and subgroups of the same population, it is often possible to reach a conclusion with regard to the disease etiology and also to identify groups or subgroups that are potentially at high risk for development of certain diseases.

Formulation of an etiological hypothesis

It is possible to formulate a hypothesis related to the etiology of disease by studying the determinants and distribution of a disease.

Analytical Epidemiology

Analytical epidemiology is the type of epidemiological studies that look at entire population. In analytical studies, the subject of interest is the individual within the population.

Followings are the types of analytical epidemiology:
- Case control study
- Cohort study

Case Control Study

Case control study also called as retrospective studies, are a common first approach to test causal hypothesis with following distinct features:
- The exposure and outcome of disease have occurred before the start of the study.
- The study proceeds from effect to cause in backward direction.
  - Case control studies mainly involve two populations – cases group and control group. The main concern of this type of study is about a disease or some health problem that has already developed in population.
  - Case control studies are basically comparison studies. Case and control groups must be comparable with known confounding factors, such as age, sex, occupation, social status, etc.

Basic Steps of Case and Control Study

There are mainly four basic steps.[9]
1. Selection of cases and controls
2. Matching
3. Measurement of environmentand disease exposure
4. Analysis and interpretation

Selection of cases and controls

The first step is to specify a suitable population of cases and a group of controls. The prime sources are hospitals and general population.

The control group should be very much similar to the case group except the absence of any disease.

Matching It is defined as the process by which we select controls in such a way that they are similar to cases with regard to certain patient selected variables as the control groups may differentiate from the case groups in factors, such as age, sex, occupation, social status, etc.

Measurement of environmental disease exposure

- Information about exposure should be obtained.

Analysis and interpretation Analysis is done to find out:
- Exposure rates among cases and controls to suspected variable factor.
- Estimation of disease risk associated with environment exposure.

Advantages of Case Control Studies

- Easy to conduct among population
- Rapid and inexpensive
- Require fewer samples
- No risk to subjects of study
- Allow the study of several different etiological factors
- Risk factors can be well identified
- Ethical problems are minimal with this study.

Disadvantages of Case Control Studies[10]

- As the exposure is usually assessed when the disease status is established, the relationship between the exposure and the onset of disease cannot always be determined.[2]
- Problems of bias
- Selection of an accurate control group may be difficult
- Cannot measure incidence, and can only measure relative risk
- Do not distinguish between causes and associated factors
- Cannot be advised for the evaluation of therapy or prophylaxis is of disease.

Cohort Study

Cohort is a group of persons exposed to same nature of environment.

It is usually undertaken to obtain additional evidence to refuse or support the existence or an association between suspected cause and disease.

The differentiating features of cohort studies are:
- The cohort groups are classified before to the appearance of the disease investigation.
- The study groups are observed over a period time to determine the frequency of the disease among them.
- The study proceeds leading from etiology to its effect.

Concept of Cohort Groups

In epidemiological studies, the term cohort is defined as a group of people who share a common characteristic or experience within a defined time period.

Categories of Cohort Study

Based on the time of occurrence of disease:
- Prospective cohort studies
- Retrospective cohort studies
- A combination of retrospective and prospective cohort studies.

Prospective cohort study

- It is a longitudinal follow-up of cases or population over a period of time and the disease has not yet occurred at the time of the beginning of investigation.

Retrospective cohort study[11] In this type of cohort study, the outcomes have all occurred before the start of the investigation.

The investigator goes back in past, sometimes 10 to 30 years back in time, to select his study groups from existing records of past employment, medical, or other records usually up to the present.

It is generally more economical and produces results more quickly than prospective cohort studies.

Combination of both retrospective and prospective cohort studies Both the retrospective and prospective elements are combined together in this type of cohort study.

The cohort is identified from previous records, and is assessed of date for the outcome of study. The same cohort is followed up later prospectively into future for further assessment of outcomes.

Components of a Cohort Study[12,13]

The components of a cohort study are:
- Selection of study subjects
- Obtaining data on exposure
- Selection of comparison groups
- Follow-up
- Analysis.

Advantages of Cohort Study

- Incidence can be calculated
- Several possible outcomes related to exposure can be studied together
- Provide a direct estimate of relative risk.

Disadvantages of Cohort Study

- Large numbers of population involved
- Takes more time to complete the study and obtain study results
- These studies are expensive
- The study itself may alter people's behavior.

Differences between Case Control and Cohort Studies[14-16]

Sl. no.	Case control study	Cohort study
1	Proceeds from "effect to cause"	Proceeds from "cause to effect"
2	Starts with the disease	Starts with people exposed to risk factor or suspected cause
3	Tests whether the suspected cause occurs more frequently in those with the disease	Tests whether disease occurs more frequently in those exposed than not exposed
4	Involves less number of subjects	Involves larger number of subjects
5	Yields relatively quick results	Long follow-up period often needed, involving delayed results
6	Suitable for the study of rare diseases	Inappropriate when the disease or exposure under investigation is rare
7	Generally yields only estimate of odds ratio	Yields incidence rates, odds ratio
8	Cannot yield information about diseases other than that selected for study	Can yield information about more than one disease outcome
9	Relatively inexpensive	Expensive

Experimental Epidemiology

Experimental or intervention studies are similar in approach to cohort studies excepting that the conditions in which study is carried out are under the direct control of the investigator.

Studies under Experimental Epidemiology

- Randomized controlled trials
- Terrain trials
- Community trials.
  In modern usage, experimental epidemiology is often equated with randomized controlled trials.
  Experimental studies involve:
- Deliberate application or withdrawal of suspected causative agent.
- Changing one variable of the causative chain in experimental group but not in the control group.

Aims of Experimental Studies

- To promote "scientific proof" of etiological factors.
- To provide a method of calculating the potency and capability of health services.

Classification of Experiments[17]

- Animal experiments
- Human experiments

Purposes of Animal Studies

Animal studies are done for the following purposes:

- Experimental reproduction of human disease in animals to confirm etiological hypothesis.
- To test the efficacy of various therapeutic and preventive measures, such as vaccines and drugs.
- To study the natural history of disease.
  Animal experiments are done on carefully bred animals in controlled environments.

Advantages

- Animals are bred in laboratories and manipulated easily according to wishes of the experimenter.
- They multiply rapidly and enable experimenter to carry out certain experiments which are not possible in human beings.

Limitations

- All human diseases cannot be reproduced in animals.
- Results of animal studies cannot be extrapolated to human beings.

Human Experiments

- Human experiments will always be needed to investigate disease etiology and to evaluate the preventive and therapeutic measures.
- These studies are more essential in the Investigation of diseases that cannot be reproduced in animals.

Experimental studies are of two types

1. Randomized controlled trials (i.e., those involving a process of random allocation); and
2. Nonrandomized or nonexperimental trials (i.e., those departing from strict randomization for practical purposes.

Uses of Epidemiology

According to Morris (1975),[18]
- To study historically the rise and fall of disease in the population
- Community diagnosis
- Planning and evaluation
- Evaluation of individual's risks and chances
- Syndrome identification
- Completing the natural history of disease
- Searching for causes and risk factors
  - The final purpose of epidemiology is to apply the knowledge gained from studies to "promote, protect, and restore health".[2]
  - The practice of evidence based dentistry requires clinical practitioners to use the best available scientific information in making decisions about

the care of individual patients. Much of this scientific information comes from epidemiologic studies and randomized clinical trials in particular.[2]

CONCLUSION

Epidemiological research can be particularly useful in promoting public health, because it provides evidence to enable public health practitioners to identify priorities and explore causal or risk factors. Epidemiology can expand further on the data collected by demographers and develop mortality and morbidity statistics. It can enable us to test the effectiveness of health interventions, both on the population's health and on health care delivery.

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