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Review Article

Concept of epidemiology – a detailed review

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ABSTRACT

Epidemiology may typically be demonstrated as a branch of science; which has undergone multifaceted changes through the long span of time. It has contributed immensely to the human society to raise widespread community awareness. It has also played a significant role in imparting knowledge about health, citing relation to various infectious diseases. Therefore; in relation to the incessant evolution, it is thoroughly important to understand the 'concept' of 'epidemiology'; as to analyse chiefly the numerous risk factors; responsible for the different infectious diseases; thereby ushering in a better; disease-free; healthy tomorrow for the mankind.

Keywords: Epidemiology, Study, Population, Health, Prevention, Biostatistics, Hypothesis, Ratio, Diseases, Science

INTRODUCTION

The term "epidemiology" is derived from the Greek word "epidemic; - "epi" means- among or upon; "demos" meaning "study population" or "people" and "logos" means "scientific study".

Hence, it is the scientific study of the disease pattern in the human population.[1] It may be indicated as a multidisciplinary subject involving those of the physician, biologists, public health experts and health educators.[2]

Definitions

"The science of the mass phenomenon of infectious diseases or the natural history of infectious diseases" – (Frost, 1927).[1]

"The science of infective diseases, their prime causes, propagation and the prevention" – (Stallbrass, 1931).

"The study of the disease, any diseases, as a mass phenomenon" – (Greenwood, 1935).[2]

"The study of condition known or reasonably supposed to influence the prevalence of disease" – (Lumsden, 1936).

"Epidemiology as, study of the distribution and determinants of diseases frequency in man" – (Macmohan and Pugh).[1]

"The study of the distribution and determinants of health-related states or events in specified population and the application of the study to control of health problems" – (Last, 1988).[3]

Therefore, it may be determined as the scientific study of the disease pattern in the human population.

History

Hippocrates (460 BC) - "Environment and human behaviors affect health. John Graunt (1662): "He quantified births, deaths and diseases".[2] Lind (1747): Scurvy could be treated with fresh fruit". William Farr (1839): "Established application of vital statistics for the evaluation of health".[3] John Snow (1854): "He tested a hypothesis on the origin of epidemic of cholera".

Alexander Louis (1872): "Systematized application of numerical thinking" (quantitative reasoning).[3]

Scope of epidemiology

Originally, "epidemiology" was concerned with investigation and management of epidemics of communicable diseases. At a later period, "epidemiology" was extended to endemic communicable diseases and non-communicable infectious diseases.

In recent times; "epidemiology" can be applied to all diseases and other health related events.[4]

Aim and objectives of epidemiology

According to the IEA, there are three objectives of epidemiology- to describe and analyze diseases occurrence and distribution in the human populations, to identify the etiological factors in the pathogenesis of diseases and to provide the data essential to the planning, implementation and evaluation of services for the prevention, control and treatment of diseases, and to the setting up of priorities among those services.[5]

Applications of epidemiology in public health

Applications of epidemiology in public health involves preventing disease and promoting the health, community health assessment. Improving the diagnosis, treatment and prognosis of various clinical diseases and evaluating health interventions and programmes.[5-7]

Uses of epidemiology

Uses of epidemiology involves investigation of causation of disease.[1] Study of the natural history and prognosis of diseases.[7] Evaluation of the interventions. Planning health services, public policy and programs.[6]

Components of epidemiology

Study is the systematic collection, analysis and interpretation of data. Frequency is the number of times an event takes place. Distribution is the distribution of an event by person, place and time. Determinants are factors the presence or absence of which affect the occurrence and the specific level of the event. Disease and other health related events is a broader science. Human population diagnoses and treats communities or the populations, and applications - these studies have direct and practical applications for the prevention of diseases and health promotion.[7]

DETERMINANTS AND DISTRIBUTION-IDENTIFYING THE CAUSE AND THE RISK FACTORS FOR DIFFERENT DISEASES

Testing of the hypothesis- biostatistics and analytical epidemiology.

Distribution

For a particular disease, it follows a specific 'pattern' - time, place, person and etiological factors due to different risk factors.[8]

Tools of measurement

The significant tools are: rate - occurrence of some specific event in a population during a given time period, ratio - a relationship of size of two random quantities, and proportion - a ratio, which indicates the relation in a magnitude of part of whole.[8]

Epidemiological approach

Asking questions related to the health events

What is the event? Where did it happen? When did this happen? Who all are affected? Magnitude of the event? Why did this occur?

Related to health approach

What measures can be incorporated for reducing the problem? How can it be prevented in future? What actions are to be taken by the community? What resources are essential? What activities are to be organized? What sort of difficulties may arise?[9]

TYPES OF EPIDEMIOLOGY

Descriptive epidemiology

It is usually the very first phase of any epidemiological investigation, which is used to aid in the conceptualization and the quantification of the disease. It is also referred to as the study, which attempts to do no more than description of the pattern of occurrence of a disease or a condition, relative to the age, sex and the socioeconomic characteristics of the individuals.[9]

Necessary steps to be followed involved defining the population to be studied, defining the disease under study, describing the disease in terms of - time, place and person. Measurement of the disease, comparing with known indices, formulating an etiological hypothesis.[9]

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. The "defined population" can either be the total population in a geographic area or a representative sample, considered from that population. The participation of the people of the community chosen for the study serves as the most essential ingredient of descriptive epidemiology.[10]

Defining the disease to be studied

The disease under study is to be demonstrated, with an "operational definition". It should be precise and valid as to help the epidemiologist to identify the people with and without diseases. The diagnostic methods should be acceptable and applicable to the population. It should be able to indicate the criteria for the measurement of the disease, thereby resulting in accuracy.[10]

Describing the disease under study

The step mainly indicates the description of the occurrence and distribution of the disease and the persons affected by the disease.[11]

Time distribution

Short-term fluctuations, periodic fluctuations and long-term fluctuations or the secular trends.[12]

Place distribution

It involves international variations, national variations, rural urban variations and local distributions.

Migrant studies

Migrants' studies involved occurrence and local population.

Person distribution

Age, bio-modality, gender, ethnic group, occupation, socioeconomic status, marital status and behavior.

Measurement of the disease

It involves cross sectional studies (prevalence studies) and longitudinal studies.[11]

Comparing with known disease

The main aim is to make comparisons between different populations and ask questions. It is often possible to reach a conclusion; with regard to the disease etiology and also to identify groups or certain subgroups.[12]

Formulation of an etiological hypothesis

It is the final step of descriptive epidemiology.

Hypothesis– requirements

It involves consideration of the cause, the population to whom the hypothesis applies, the expected effect - disease and the time elapsing between exposure to the cause and observation of the effects.[12]

Uses of descriptive epidemiology

Provides data with regard to the types of disease problems and their magnitude in the community. Provides information on the etiology of a disease and helps in the formulation of an etiological hypothesis. Provides the data required for the planning, organizing and evaluating preventive and curative services. Leads the path for further research with regard to a particular disease problem.[13]

Analytical epidemiology

It is the second major type of epidemiological studies, the individual is chiefly focused which in turn focuses on the entire population; which thereby helps to establish a relation between the exposure to the risk factors and the occurrence of the disease.

Mainly of two types case control- 'case reference' and cohort study- 'follow-up'.

Case – control diseases

It is the first approach for testing a casual hypothesis.[13] It has three salient features: both exposure and outcome have occurred, study proceeds backwards from the effect to the cause and it has a control group to support or refute an inference.[13]

The basic design of case-control study is demonstrated in Figure 1.

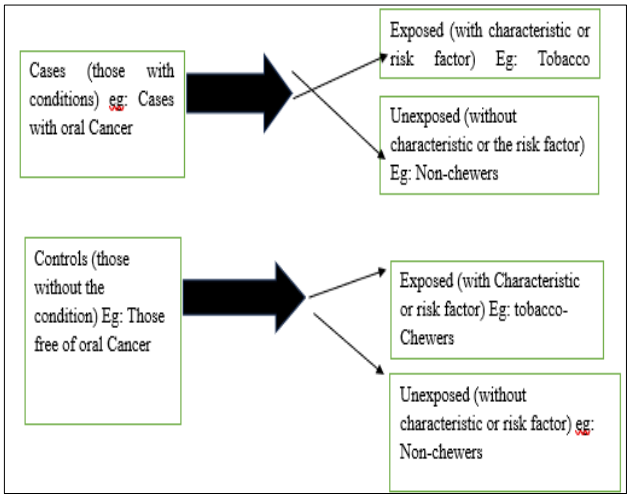

Figure 1: Case control basic design.[14]

Basic steps in case-control study

Selection of the cases and control

Cases - case definition - (diagnostic criteria and the eligibility criteria) and source of the cases: (hospital or general population).

Controls were free from the disease under study, similar to the cases in all aspects, sources- hospitals, neighbourhood, general population and matching- the process of selecting the controls, quite similar to cases in all variables. It is also essential for the comparability and for elimination of the confounding bias.

Procedure of matching involves group matching and pair matching

Confounding factor

It is a factor which is associated with both exposure and the disease and unequally distributed in the study and control groups. Eg: alcohol in case of oesophageal cancer.

Measurement of the exposure

Information should be obtained by- questionnaire, interviews, hospital records, employment records, analysis and interpretation, exposure rates: estimation of the rates of exposure of the suspected factor among the cases and controls, odds ratio: estimation of the disease risk; associated with the exposure and the controls; here the cases and the controls must be representative of the general population; with respect to exposure. cohort study: "cohort" is a group of people with similar characteristics. It is also called the follow-up or incidence ratio, usually begin with a control group, population free of any disease. Whole cohort is followed as to observe the effect of exposure.

Types

Prospective cohort studies, here, the outcome that is the disease has not yet occurred at the time; when the investigation begins. Retrospective cohort, here, in this case; the outcomes have all occurred before the onset of the investigation. Combination of prospective and retrospective cohort studies, in this case, both the retrospective and the prospective elements are combined; the cohort is identified from past records and is assessed of date for the necessary outcomes.[15]

Indications of cohort studies

When good evidence of an association exists in between the exposure and disease, as derived from clinical observations. When the exposure is rare; but the incidence of disease is high among the exposed. Example, exposure to X- rays. When the attrition of the study population can be minimized. Example, follow-up is easy; cohort is stable and easily accessible. When ample funds are available.[15]

Components of cohort study

Components of cohort study includes selection of the study, obtaining the data on exposure, selection of the comparison group, follow-up and analysis.

Advantages of cohort study

Incidence can be calculated, several possible outcomes; related to exposure can be studied simultaneously. These studies provide a direct estimate of relative risk; dose response ratios can also be calculated. Since the comparison groups are formed; before the disease develops, certain forms of bias can be minimized; like the classification of individuals into exposed and the unexposed groups.[15]

Disadvantages of cohort study

These studies involve a large number of populations. It takes a long time to complete the study and obtain the outcomes. Certain administrative problems; such as loss of experience stuff; loss of funding and extensive record keeping are inevitable. It is not unusual to lose a substantial portion of original cohort. Selection of the comparison groups, which are representative of the exposed and unexposed groups of the population is a limiting factor.

Comparison between case control and cohort studies is given in Figure 2.[16]

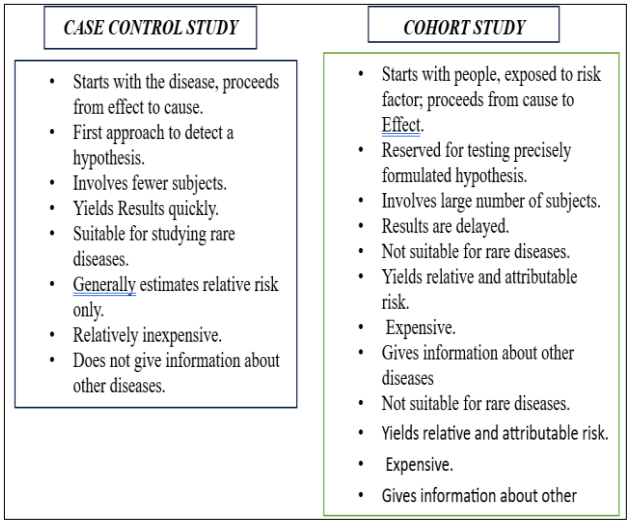

Figure 2: A basic comparison between case control and cohort.[16]

RELATIVE RISK (RISK RATIO)

Relative risk

It is the ratio of the incidence of the disease among the exposed and the unexposed. It is defined as the direct measure of the strength of the association between the suspected cause and the effect. It does not indicate the casual relationship.

Attributable risk

It is hence defined as the difference in the incidence rates of disease among the exposed and the non-exposed group.

$$AR = (IR.\,Among\ the\ non - exposed / incidence\ among\ the\ exposed) \times 100\%$$

It is the proportion of the disease, due to a particular risk factor exposure. This hence implies that the amount of disease is eliminated; if the suspected risk factor is removed.[17]

Experimental epidemiology

It is basically an involvement, attempting to change a variable in subjects under the study. This could mean the elimination of a dietary factor thought to cause allergy, or testing a new treatment on a selected group of patients. The effects of an intervention are measured by comparing the outcome in the experimental group with that in a control group.[17]

Objectives of experimental epidemiology are to provide a "scientific proof", to provide a method of measurement for effectiveness and efficiency of "therapeutic/ preventive measure for a disease" and method to measure for the purpose of efficiency "health services for prevention", control and treatment of disease.[18]

Types of experimental epidemiology

Randomised control trial is a planned experiment; designed to assess the efficacy of an intervention in human beings; by comparing the effect of intervention in study group to a control group. The allocation of subjects to study or control is determined purely by chance or randomization. For new programme or newer therapy, RCT is the best method of evaluation (Figure 3).[18]

Basic steps in RCT

Drawing up a protocol, selecting experimental and the reference population, randomization, manipulation or an intervention, follow-up and an assessment of outcome.

Drawing up a protocol

Study conducted under strict protocol

Protocol specifics, aim and objective, criteria for selection, control group, sample size, intervention applied and standardization schedule.[18]

Selecting reference and the experimental population

Reference population is the population, in which the results of the study are applicable. It may be human being, country, specific age, sex, and occupation. Experimental population is derived from the target population, must be a representative of reference population, qualified for the study and ready to give informed consents. Randomization is a statistical procedure as to allocate the participants in group- 'study group' and the 'control group'. It is an attempt to eliminate "bias" and thereby allow "comparability". It eliminates "selection bias". Matching is for only those 'variables'; which are known.[18] Manipulation or intervention is done by application of therapy or the reduction or withdrawal of the suspected causal factor in the study and the control group. This manipulation creates independent variables, whose effect is measured in the final outcome.

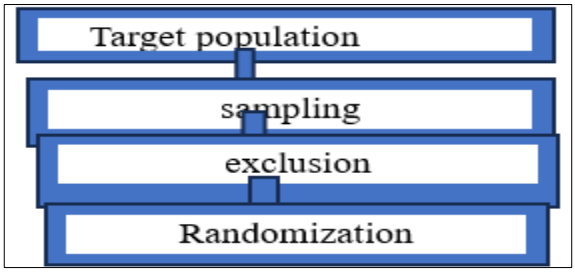

Figure 3: Design of randomised control trial (RCT).

Follow-up for both the groups should be conducted in a standard manner in a definite time period. Duration of trial depends on the changes; expected in that duration since the study started. Some loss of subjects due to migration, death is known as the attrition.[19] Assessment is the final step. It is an assessment of the outcome in terms of positive and negative results. The incidence of positive and negative results was compared in both the groups- study group and the control group. Results are tested for statistical significance. Blinding is the procedure to eliminate the bias. It is of three types: single blind trial, double blind trial, triple blind trial.[19]

Some other study designs

Concurrent parallel study design

In this situation, comparisons are made between two randomly assigned groups, one group exposed to specific treatment and the other group unexposed.

Cross over type of study design

With this study design; each patient serves as his own control, as before the patients are randomly assigned to a study group and control group.[19]

Ethical issues in epidemiological studies

It includes informed consent, confidentiality, respect for human rights and scientific integrity.

Association and causation

Types of association- causal association and non-causal, spurious population. Defining the variables in an association - independent and dependent variables,

confounding variables, control variables, intermediate or intervening variables and effect modification.

Problems in establishing the causality

The existence of a correlation or association does not necessarily imply causation. The concept of a single cause (the agent), once held in relation to communicable disease, has been replaced by the concept of multiple causation of the diseases such as cancer and heart disease. The criteria used in establishing causality in infectious disease, namely the Koch's postulates are not applicable to non-infectious diseases. No statistical method can differentiate between causal and non-causal associations. The period between the exposure to a factor or cause and the appearance of clinical disease is relatively long in non-infectious articles. Specificity easily established in the infectious diseases does not apply to most other diseases. Certain confounders; that are associated with the cause of a disease tend to distort or confound the relationship with the suspected factors. Several systematic errors or bias in the research design or data collection can produce false or spurious associations.[20]

CONCLUSION

The most outstanding contribution of epidemiology is the study of association and the causation in health and disease. The reasons for interest in establishing or excluding causality are as follows- to understand the determinants of disease, occurrence, distribution and the outcome; to identify the links in the chain of causality that are amenable to the intervention through general or specific intervention programs; and to relate the output and impact of intervention programs to their input, i.e. a causal evaluation.

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