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INTRODUCTION TO EPIDEMIOLOGY

Lecture one

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DEFINITION AND SCOPE

The term "epidemiology" springs directly from "epidemic," which originally referred to communicable disease outbreaks in humans. Epidemic is derived from the Greek roots ***epi*** (upon) and demos (people). The third component of epidemiology, the Greek root ***logos***, means study. ***Demos*** and another Greek root, ***graphein*** (to write, draw), combine to form the term demography, a kindred population-based science. Not only do epidemiology and demography share a linguistic heritage and other historical origins, they also overlap considerably in their data sources and research domains.

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 control of health problems. In other words, epidemiology is the study of our collective health. Epidemiology offers insight into why disease and injury afflict some people more than others, and why they occur more frequently in some locations and times than in others-knowledge necessary for finding the most effective ways to prevent and treat health problems.

This definition of epidemiology includes several terms which reflect some of the important principles of the discipline. It is highly important to signify the description of these terms:

Study. Epidemiology is a scientific discipline, sometimes called "the basic science of public health." It has, at its foundation, sound methods of scientific inquiry.

Distribution. Epidemiology is concerned with the frequency and pattern of health events in a population. Frequency includes not only the number of such events in a population, but also the rate or risk of disease in the population. The rate (number of events divided by size of the population) is critical to epidemiologists because it allows valid comparisons across different populations.

Determinants. Determinants are factors or events that are capable of bringing about a change in health. Some examples are specific biological agents that are associated with infectious diseases or chemical agents that may act as carcinogens. Other potential determinants may include less specific factors, such as stress or adverse lifestyle patterns (lack of exercise or a diet high in saturated fats).

Health-related states or events. Originally, epidemiology was concerned with epidemics of communicable diseases. Then epidemiology was extended to endemic communicable diseases and non-communicable infectious diseases. More recently, epidemiologic methods have been applied to chronic diseases, injuries, birth defects, maternal-child health, occupational health, and environmental health. Now, even behaviors related to health and well-being (amount of exercise, seat-belt use, etc.) are recognized as valid subjects for applying epidemiologic methods. Here the term "disease" is used to refer to the range of health-related states or events.

Specified populations. Although epidemiologists and physicians in clinical practice are both concerned with disease and the control of disease, they differ greatly in how they view "the patient." Clinicians are concerned with the health of an individual; epidemiologists are concerned with the collective health of the people in a community or other area. When faced with a patient with diarrheal disease, for example, the clinician and the epidemiologist have different responsibilities. Although both are interested in establishing the correct diagnosis, the clinician usually focuses on treating and caring for the individual. The epidemiologist focuses on the exposure (action or source that caused the illness), the number of other persons who may have been similarly exposed, the potential for further spread in the community, and interventions to prevent additional cases or recurrences.

Epidemiology has a **descriptive** dimension that involves the identification and documentation of patterns, trends, and differentials in disease, injury, and other health-related phenomena. Descriptive epidemiology provides the What, Who, When, and Where of health-related events. This science also has an **analytic** dimension, in which the etiology, or causes, of these phenomena are investigated. Epidemiology also helps investigate how well specific therapies or other health interventions prevent or control health problems.

OBJECTIVES OF EPIDEMIOLOGY

- Investigate the etiology of disease and modes of transmission.
- Determine the extent of disease problems in the community.
- Study the natural history and prognosis of disease.
- Evaluate both existing and new preventive and therapeutic measures and modes of health care delivery.
- Provide a foundation for developing public policy and regulatory decisions.

TYPES OF EPIDEMIOLOGY

Epidemiological researchers are increasingly realizing that the causes of ill health may operate at a number of different levels: internally, within the body; behaviourally, at the level of an individual; and contextually and structurally. These levels are related. Heart disease may reflect cholesterol levels (internal), dietary decisions (behavioural), or poverty (structural). A useful analogy that makes this point is that of ‘focusing upstream’. While the immediate causes of disease may indeed be internal to the body, these internal causes may reflect behavioural factors, themselves constrained by structure. It is now common to recognize different types of epidemiology which differ in the stress they place on these understandings of disease causation.

1- Clinical epidemiology

It studies the individual patients; aetiological studies focus on the internal mechanics of the body. Studies will normally involve clinically based measurements of the biochemical or physical functioning of samples individuals.

2- Social epidemiology

This type of epidemiology considers determinants of health and illness that are rooted in the divisions of contemporary society. The determinants are not single agents such as specific bacteria or other biological determinants of disease. Nor are they necessarily merely demographic variables, such as age or sex. Rather, they are concerned with the influence of a person's position in the social structure upon the development of disease (class, location, employment status and so on) and with the impact of behavioural factors.

3- Critical epidemiology

Critical epidemiology places an emphasis on the social and power relations that shape disease definition and disease causation. This approach uses qualitative as well as quantitative methodologies. There is a concern for causation and prevention but action is seen to be required at the population level.

4- Environmental epidemiology

More generally, epidemiology can also be distinguished by the type of disease it is studying, the ‘environment’ in which it is practiced, and the knowledge that it regards as legitimate.

5- Community epidemiology

The environment in which epidemiology is practiced is a distinguishing factor for community epidemiology in which a stress is placed on disease surveillance and occurrence in real-world settings, screening and the implementation of community-based interventions.

6- Occupational epidemiology

Occupational epidemiology focuses on the workplace, monitors the levels of disease in the workforce, and looks for causal relations between occupational exposures and subsequent disease.

7- Quantitative epidemiology

The legitimacy of a knowledge base underpins the realization that quantitative epidemiology is the underlying approach of evidence-based medicine in which interventions are subject to extensive critical assessment and review so that only the most effective procedures are used in disease management.

8- Popular or lay epidemiology

In contrast to quantitative epidemiology, popular or lay epidemiology sees experts like doctors, or even epidemiologists, removed from the frame of analysis and attention focused on accounts of disease causation which emphasize the qualitative views, opinions and knowledge of ‘ordinary’ people. For critics this can be anecdotal, uninformed or even dangerous. On a more positive note, and recognizing that most disease is self-treated, ignored or undiagnosed (the so-called clinical iceberg), popular epidemiology offers insight into the way in which most disease is most commonly understood and treated.

Introduction

Human health and disease are unequally distributed throughout populations. This generalization applies to differences among population groups subdivided according to age and other demographic characteristics, among different countries, within a single country, and over time. When specific diseases, adverse health outcomes, or other health characteristics are more prevalent among one group than among another, or more prevalent in one country than in another, the logical question that follows is “Why?” To answer the question “Why,” one must consider “three Ws”-**W**ho was affected? **W**here did the event occur? **Wh**en did the event occur?

The field of descriptive epidemiology classifies the occurrence of disease according to the variables of **person** (who is affected), **place** (where the condition occurs), and **time** (when and over what time period the condition has occurred). A descriptive epidemiologic study is one that is “. . . concerned with characterizing the amount and distribution of health and disease within a population.”

Hypotheses about the determinants of disease arise from considering the characteristics of person, place, and time and looking for **differences, similarities**, and **correlations.** Consider the following examples:

- **Differences**: if the frequency of disease differs in two circumstances, it may be caused by a factor that differs between the two circumstances. For example, there was a substantial difference in the incidence of food poisoning in Japan and Iraq. There are also substantial differences in genetics and diet. Perhaps these factors are related to food poisoning.
- **Similarities**: if a high frequency of disease is found in several different circumstances and one can identify a common factor, then the common

factor may be responsible. Example: AIDS in IV drug users, recipients of transfusions, and hemophiliacs suggests the possibility that HIV can be transmitted via blood or blood products.

- **Correlations**: If the frequency of disease varies in relation to some factor, then that factor may be a cause of the disease. Example: differences in coronary heart disease (CHD) vary with cigarettes consumption.

Uses of Descriptive Epidemiologic Studies

Descriptive epidemiologic studies aid in the realization of the following general aims:

1. Permit evaluation of trends in health and disease. This objective includes monitoring of known diseases as well as the identification of emerging problems. Comparisons are made among population groups, geographical areas, and time periods.
2. Provide a basis for planning, provision, and evaluation of health service. Data needed for efficient allocation of resources often come from descriptive epidemiologic studies.
3. Identify problems to be studied by analytic methods and suggest areas that may be fruitful for investigation.

Types of Descriptive Epidemiologic Studies

Three of the types of descriptive epidemiologic studies are **individual case reports**, **case series**, and **cross-sectional studies**

1- Case reports

The case report is a specific type of research design that reports on an aspect of the management of one or two patients. It is the first piece of research writing in the health field and represents the most basic type of study design. Not all case reports deal with serious health threats; however, they make a contribution to health knowledge and have educational value or highlight the need for a change in clinical practice or diagnostic/prognostic approaches.

Case reports cover the following: 1) Unusual observations; 2) an unexpected association between diseases or symptoms; 3) an unexpected event in the course observing or treating a patient; 4) findings that shed new light on the possible pathogenesis of a disease or an adverse effect; 5) unique or rare features of a disease; 6) an unusual combination of conditions leading to confusion; 7) unique therapeutic approaches; 8) variations of anatomical structures; 9) a new theory; 10) a question regarding a current theory; and 11) personal impact.

Types of case reports

Researchers must be familiar with the different types of case report because each type requires slightly different styles of writing and highlighting key points

[1] Diagnosis-related: describes new, rare, or unusual disease; unusual presentation or etiology of a known disease; unexpected association with diseases; new test or diagnostic method; and diagnostic dilemma or challenge.

[2] Management related: describes a new or improved treatment or surgical procedure; a new or rare side effect or complication of treatment; and therapeutic dilemma or challenge.

[3] Other issues: such as positional or quantitative abnormalities of an anatomical structure; two or more unexpected diseases or disorders in the

same patient; new possible mechanism of injury; and an unusual injury pattern.

Design of case report

A case report is an observational, descriptive research design that carefully recorded unbiased observations. The case should be described in details so that others can identify similar cases. The case report should provide information on the patient's socio-demographics (e.g. age, sex, ethnicity, race, employment status, social situation), medical history, diagnosis, prognosis, previous treatments, past and current diagnostic test results, medications, psychological tests, clinical and functional assessments, and current intervention. Authors explore and infer, not confirm, deduce, or prove. They cannot demonstrate causality or argue for the adoption of a new treatment approach.

Advantages of case report

1) Well documented case reports provide a direction to future clinical studies to augment evidence-based medicine.
2) Provide important patient-centered clinical insight that may inform the individualized nature of contemporary patient care.
3) Generate hypotheses for future clinical studies.
4) Guide the personalization of treatments in clinical practice.
5) Useful in integrative medicine and help to evaluate systems-oriented approaches to healthcare.
6) Identify rare manifestations of a disease.
7) Used for teaching and review purposes, they can also have a role in research.

Limitations of case report

1) Regarded as low-level evidence as the observations may be subject to bias
2) Lacks generalizability.
3) Lacks denominator data that are necessary to calculate the rate of disease.
4) Lacks a comparison or control group to compare outcomes and have little statistical validity.
5) Often describe highly select individuals who may not represent the general population. Since the care rendered to one patient may not produce a similar change in another patient, case reports should not be generalized but for the patient reported.
6) Infrequently cited, and therefore, publishing case reports are likely to decrease the journal's impact factor. This has led many editors to remove case report sections from their journals.

2- Case Series

A case series is a descriptive study that follows a group of patients who have a similar diagnosis or who are undergoing the same procedure over a certain period of time.

The primary purpose of a case series should be the generation of hypotheses that subsequently can be tested in studies of greater methodological rigor (i.e. analytic epidemiological studies). Briefly, a case series can be seen as a screening tool for sensible hypotheses that are worthy of further examination. Treatment safety and diagnostic accuracy are the principal outcomes that can be assessed fairly and reliably in a case series. In the assessment of either outcome, no control group is necessary and long-term follow-up can be obtained readily, especially in a retrospective design.

Strengths

1. High external validity (means that the results can be better applied to clinical practice in other centers).
2. No interference in treatment decision process.
3. Wide range of patients.
4. Inexpensive.
5. Study conduct takes little time.

Limitations

1. Lack of comparison group. It is impossible to determine whether the outcomes are attributable to the treatment effect or to other patient characteristics. As a result, hypotheses can only be made about apparent relationships.
2. Data collection often incomplete.
3. Susceptible to bias:

   Selection bias occurs when follow-up data are less likely to be collected from patients with a better or worse outcome. Moreover, measurement bias can arise when different methods of outcome measurement are used in a study

3- Cross-Sectional Studies

Epidemiologic Inferences from Descriptive Data

Descriptive epidemiology and descriptive studies provide a basis for generating hypotheses; thus studies of this type connect intimately with the process of epidemiologic inference. The process of inference in descriptive epidemiology refers to drawing conclusions about the nature of exposures and health outcomes and formulating hypotheses to be tested in analytic research.

PERSON VARIABLES

Person variables include age, sex, race, and socioeconomic status, marital status, nativity (place of origin), migration, and religion.

- **Age**; is perhaps the most important factor to consider when one is describing the occurrence of virtually any disease or illness because age-specific disease rates usually show greater variation than rates defined by almost any other personal attribute. For this reason, public health professionals often use age-specific rates when comparing the disease burden among populations. As age increases, overall mortality increases as do the incidence of and mortality from many chronic diseases.

- **Sex**; Numerous epidemiologic studies have shown sex differences in a wide scope of health phenomena, including mortality and morbidity. Males generally have higher all-cause age-specific mortality rates than females from birth to age 85 and older.

- **Race/Ethnicity**; Race and ethnicity are, to some extent, ambiguous characteristics that tend to overlap with nativity and religion. Nativity refers to the place of origin of the individual or his or her relatives. A common subdivision used in epidemiology is **foreign-born or native-born**. To a degree, race tends to be synonymous with ethnicity because people who come from a particular racial stock also may have a common ethnic and cultural identification. Also, assignment of some individuals to a particular racial classification on the basis of observed characteristics may be difficult. Often, one must ask the respondent to elect the racial group with which he or she identifies. The responses one elicits from such a question may not be consistent: Individuals may change ethnic or racial self-identity or respond differently on different occasions, depending on their perception of the intent of the race question. Classification of persons of mixed racial parentage also may be problematic.

- **Socioeconomic Status;** Socioeconomic status (SES) is defined as a "descriptive term for a person's position in society". SES is often formulated as a composite measure of three interrelated dimensions: a person's income level, education level, and type of occupation. In some instances, income level alone is used as an indicator of SES; in other cases, two or more of the foregoing dimensions are combined into composite variables. A three-factor measure would classify persons with high SES as those at the upper levels of income, education, and employment status (e.g., the learned professions). The social class gradient (variability in SES from high to low and vice versa) is strongly and inversely associated with levels of morbidity and mortality. Those who occupy the lowest SES positions are confronted with excesses of morbidity and mortality from numerous causes (from mental disorders to chronic and infectious diseases to the consequences of adverse lifestyle).

V. PLACE VARIABLES

Morbidity and mortality vary greatly with respect to place (geographic regions that are being compared). Examples of comparisons according to place are international, national (within-country variations such as regional and urban-rural comparisons), and localized occurrences of disease.

- **International:** The World Health Organization (WHO), which sponsors and conducts ongoing surveillance research, is a major source of information about international variations in rates of disease. WHO statistical studies portray international variations in infectious and communicable diseases, malnutrition, infant mortality, suicide, and other conditions. As might be expected, both infectious and chronic diseases show great variation from one country to another. Some of these differences may be attributed to climate, cultural factors, national dietary habits, and access to health care. Such variations are reflected in great international differences in life expectancy.

- **National (Within Country):** Many countries, especially large ones, demonstrate within-country variations in disease frequency. Regional differences in factors such as climate, latitude, and environmental pollution affect the prevalence and incidence of diseases.
- **Urban-Rural Differences:** Urban and rural sections of a country show variations in morbidity and mortality related to environmental and lifestyle issues. Urban diseases and causes of mortality are more likely to be those spread by person-to-person contact, crowding, and inner-city poverty or associated with urban pollution. Children’s lead poisoning is an example of a health issue that occurs among urban residents who may be exposed to lead-based paint from decaying older buildings. Agriculture is a major category of employment for the residents of rural areas. Farm workers often are exposed to hazards such as toxic pesticides and unintentional injuries caused by farm equipment. One group of employees who are at risk of health hazards associated with farming is migrant workers. Often they reside in crowded, substandard housing that exposes them to infectious agents found in unsanitary milieus. Many of these workers labor under extremely difficult conditions and lack adequate rest breaks, drinking water, and toilet facilities.

- **Localized Patterns of Disease:** Localized patterns of disease are those associated with specific environmental conditions that may exist in a particular geographic area. Illustrations include cancer associated with radon gas found in some geographic areas and arsenic poisoning linked to high levels of naturally occurring arsenic in the water. Local environmental conditions also may support disease vectors that may not survive in other areas. An example of a localized pattern of disease is provided by dengue fever, a viral disease transmitted by a species of mosquito (a vector) that is present along the border that separates Texas from Mexico near the Gulf of Mexico. Localized populations of the mosquitoes are thought to have contributed to an outbreak of dengue fever in 2005.

VI. TIME VARIABLES

Examples of disease occurrence according to time are secular trends, cyclic fluctuation (seasonality), point epidemics, and clustering.

- **Secular (long term) Trends**; refer to gradual changes in the frequency of diseases over long time periods (years).
- **Cyclic (Seasonal) Trends** are increases and decreases in the frequency of a disease or other phenomenon over a period of several years or within a year. Mortality from pneumonia and influenza peaks during February, decreases during March and April, and reaches its lowest level during the early summer. Detections of enterovirus infections have increased in frequency during the summer months within the past two decades.
- **Point Epidemics;** A point epidemic may indicate the response of a people group restricted in place to a common source of infection,

contamination, or other etiologic factor to which they were exposed almost simultaneously in a point of time. An example was demonstrated by an outbreak of *Vibrio* infections that followed Hurricane Katrina in 2005.

- **Clustering;** An example of a pattern derived from descriptive studies is disease clustering, which refers to "a closely grouped series of events or cases of a disease or other health-related phenomena with well-defined distribution patterns in relation to time or place or both. The term is normally used to describe aggregation of relatively uncommon events or diseases (e.g., leukemia, multiple sclerosis)."

  Clustering may suggest common exposure of the population to an environmental hazard; it also maybe purely spurious—due to the operation of chance. Clustering can refer to spatial clustering and temporal clustering.

ANALYTIC STUDIES

Lecture three

ANALYTIC EPIDEMIOLOGY

As you have seen, with descriptive epidemiology investigators can identify several characteristics of persons with disease, and they may question whether these features are really unusual, but descriptive epidemiology does not answer that question. Analytic epidemiology provides a way to find the answer: the comparison group. Comparison groups, which provide baseline data, are a key feature of analytic epidemiology.

When epidemiologists find that persons with a particular characteristic (exposure) are more likely than those without the characteristic to develop a certain disease, then the characteristic is said to be **associated with** the disease (outcome). The characteristic may be a demographic factor such as age, race, or sex; a constitutional factor such as blood group or immune status; a behavior or act such as smoking or having eaten a specific food; or a circumstance such as living near a toxic waste site. Identifying factors that are associated with disease helps in identifying populations at increased risk of disease; epidemiologists can then target public health prevention and control activities. Identifying risk factors also provides clues to direct research activities into the causes of a disease.

For instance, researchers may be interested in obtaining answers to the following questions:

* *Does a high level of anticardiolipin Ab increases the risk of abortion?*

Anticardiolipin Ab (exposure) → Abortion (outcome)

* *Does hepatitis B virus infection increases the risk of liver cancer?*

Hepatitis B infection (exposure) → Liver cancer (outcome)

Analytic epidemiological studies fall into two categories: **experimental (or intervention)** and **observational**.

Experimental studies

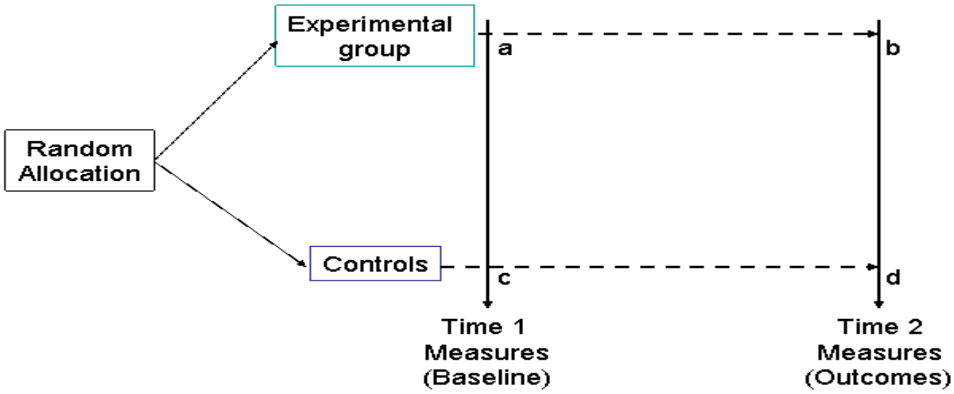
In an experimental study, investigators study the impact of some factors which they can control in laboratory-based research. For example, the investigators may take a litter of rats, and randomly select half of them to be exposed to a supposedly pyrogenic agent, then record the frequency with which fever develops in each group. For ethical reasons, it would be impossible to conduct such a study in human subjects. Thus, experimental studies in epidemiology are limited to interventions that are believed to be of potential benefit.

Experimental trials consist of trials to prevent disease (**field trials**) or trials to treat established disease processes (**clinical trials**).

1) Clinical trials

The objective of a clinical trial (or randomized controlled trials) is to evaluate one or more new treatments for a disease or condition. For instance, a clinical trial may be designed to assess whether a chemotherapeutic agent can prevent recurrence of an infection, increase survival or improve quality of life. Since clinical trials involve diseased people, they are often carried out in hospitals or other clinical settings where the subjects are treated and followed up for their condition.

A sample of patients with the condition, and who meet other selection criteria, are randomly allocated to receive either the experimental treatment, or the control treatment (commonly the standard treatment for the condition). Occasionally, a placebo or sham treatment will be used in the control group, but where there is already an accepted treatment, it is unlikely to be ethical to use a placebo. The experimental and control groups are then followed for a set time, and relevant measurements are taken to indicate the results (or 'outcomes') in each group (figure 1).



Effect measurement: (b - a) – (d - c)
Note:
random allocation should make a = c, but these are included in analysis to correct for any minor differences.

2) Field trials

In contrast, field trials deal with subjects who are disease-free. A field trial involves evaluation of whether an agent or procedure reduces the risk of developing disease among those free from that condition at enrolment.

Because these trials involve healthy rather than diseased people, they tend to be logistically more difficult to carry out than clinical trials. They generally have to be conducted in the field rather than in a hospital or clinics. Field trials usually require a greater number of subjects followed up for longer periods than clinical trials.

Main advantages of experimental studies are:

a) Controls all main forms of bias.
b) Good for both etiological and evaluative research.

Main disadvantages of experimental studies are:

a) Ethical concern in etiological applications.
b) Often uses selected population: issue of generalization.

Observational studies

Three main types of observational studies are the **cohort (follow up) study**, the **case-control study**, and **cross sectional survey (prevalence)**.

1) Cohort study

A cohort is a group of people who share a common characteristic or experience within a defined period (e.g., are born, are exposed to a drug or vaccine or pollutant, or undergo a certain medical procedure). Thus a group of people who were born on a day or in a particular period, say 1994, form a birth cohort. The comparison group may be the general population from which the cohort is drawn, or it may be another cohort of persons thought to have had little or no exposure to the substance under investigation, but otherwise similar. Alternatively, subgroups within the cohort may be compared with each other.

A cohort study is similar in concept to the experimental study. Investigators categorize subjects on the basis of their exposure and then observe them to see if they develop the health conditions under investigation. This differs from an experimental study in that, in a cohort study, epidemiologists observe the exposure status rather than determine it. After a period of time, epidemiologists compare the disease rate in the exposed group with the disease rate in the unexposed group. The length of follow-up varies, ranging from a few days for acute diseases to several decades for chronic diseases.

The main advantages of cohort study are:

a) Exposure is measured before disease onset and is therefore likely to be unbiased in terms of disease development.
b) Rare exposures can be examined by appropriate selection of study cohorts.
c) Multiple outcomes (diseases) can be studied for any one exposure.
d) Incidence of disease can be measured in the exposed and unexposed groups.

The main disadvantages of cohort study are:

a) They can be very expensive and time-consuming, particularly if conducted prospectively.
b) Changes in exposure status and in diagnostic criteria over time can affect the classification of individuals according to exposure and disease status.
c) Ascertainment of outcome may be influenced by knowledge of the subject’s exposure status (information bias).
d) Losses to follow-up may introduce selection bias.

2) Case-control study

The case-control study is more common than the cohort study. In a case-control study, epidemiologists enroll a group of people with disease ("cases") and a group without disease ("controls"). The prevalence (or level) of exposure to a factor is then measured in each group. If the prevalence of exposure among cases and controls is different, it is possible to infer that the exposure may be associated with an increased or decreased occurrence of the outcome of interest. The key in a case-control study is to identify an appropriate control, or comparison, group, because it provides a measure of the expected amount of exposure.

The main advantages of case-control studies are:

a. They are efficient in time and cost (at least compared with prospective cohort studies)
b. They provide the possibility to investigate a wide range of possible risk factors.
c. They are particularly suitable to investigate rare diseases or diseases with a long induction period.

The main disadvantages of case-control studies are:

a. It may be difficult to select an appropriate control group (selection bias).
b. It is difficult to obtain accurate unbiased measures of past exposures (information bias).
c. The temporal sequence between exposure and disease may be difficult to establish (reverse causality).
d. They are not suitable for investigating rare exposures (unless the exposure is responsible for a large proportion of cases, i.e., the population excess fraction is high).
e. It is not possible to obtain estimates of disease incidence among those exposed and those unexposed to a putative risk factor (except if the study is population-based).

3) Cross-sectional survey

Cross-sectional surveys are studies aimed at determining the frequency (or level) of a particular attribute, such as a specific exposure, disease or any other health-related event, in a defined population at a particular point in time. For instance, epidemiologists can carry out a cross-sectional survey to estimate the prevalence of cholera in a given population at the time of the survey.

In this type of study, subjects are contacted at a fixed point in time and relevant information is obtained from them. On the basis of this information, they are then classified as having or not having the attribute of interest.

In some instances, cross-sectional surveys attempt to go further than just providing information on the frequency (or level) of the attribute of interest in the study population by collecting information on both the attribute of interest and potential risk factors. For instance, in a cross-sectional survey conducted to estimate the prevalence of hepatitis B in a given population, it is also possible to collect data on potential risk factors for this condition such as socioeconomic status, intravenous drug use, sexual behaviour, etc.

Target population and study sample

As for the other types of epidemiological design, the aims of the study must be clearly established before its start. This process requires a precise definition of the attribute of interest (whether disease, exposure or any other health-related event) and of potential risk factors, and a clear consideration of the ***target population***, i.e., the population to which the main results of the study will be extrapolated.

Next, a suitable ***source population*** needs to be identified practical and logistic reasons, the source population is generally more limited than the target population. The choice of the source population should be determined by the definition of the target population and by logistic constraints. If this source population is small enough to be studied using the human and financial resources available, the entire population can be included. If the source population is still too large, a ***representative sample*** has to be selected.

How to select a sample?

In order to select a sample from the source population, epidemiologists need to decide on the *sample design*, i.e., on the method to be used for selecting the sampling units from the population. Samples are sometimes chosen by *judgement* (i.e., what the investigator judges to be a ‘balanced’ or ‘representative’ sample) or by *convenience* (i.e., the most easily obtained subjects such as volunteers or people who attend a clinic).

None of these methods provides any guarantee against the possibility that (conscious or unconscious) selection bias may be introduced. Some people may be more likely than others to get into the sample, and the sample will become unrepresentative. For example, clinic attenders may be different from non-attenders.

The best approach is to use random sampling. In this method, chance alone determines who will be included in the sample, removing any possibility of selection bias.

The main advantages of cross-sectional surveys are:

a) They are easier to conduct than other individual-based studies because no follow-up is required.
b) They provide a good picture of the health care needs of the population at a particular point in time.
c) They can be used to investigate multiple exposures and multiple outcomes.

The main disadvantages of cross-sectional surveys are:

a) Being based on prevalent (existing) rather than incident (new) cases, they are of limited value to investigate etiological relationships.
b) They are not useful to investigate rare diseases or diseases of short duration.
c) They are not suitable to investigate rare exposures.
d) It is difficult to establish the time sequence of events.

Problems in Conducting Epidemiological Studies

1) Selection Bias

Bias is a technical term for playing favorites in choosing study subjects or in assessing their exposure or disease status.

To avoid selection bias epidemiologists must select comparison populations that are similar except for the specific factors under study, and that's often difficult to do.

2) Misclassification

Misclassification is a technical term for mislabeling or mischaracterizing a study subject, and may occur with disease or exposure.

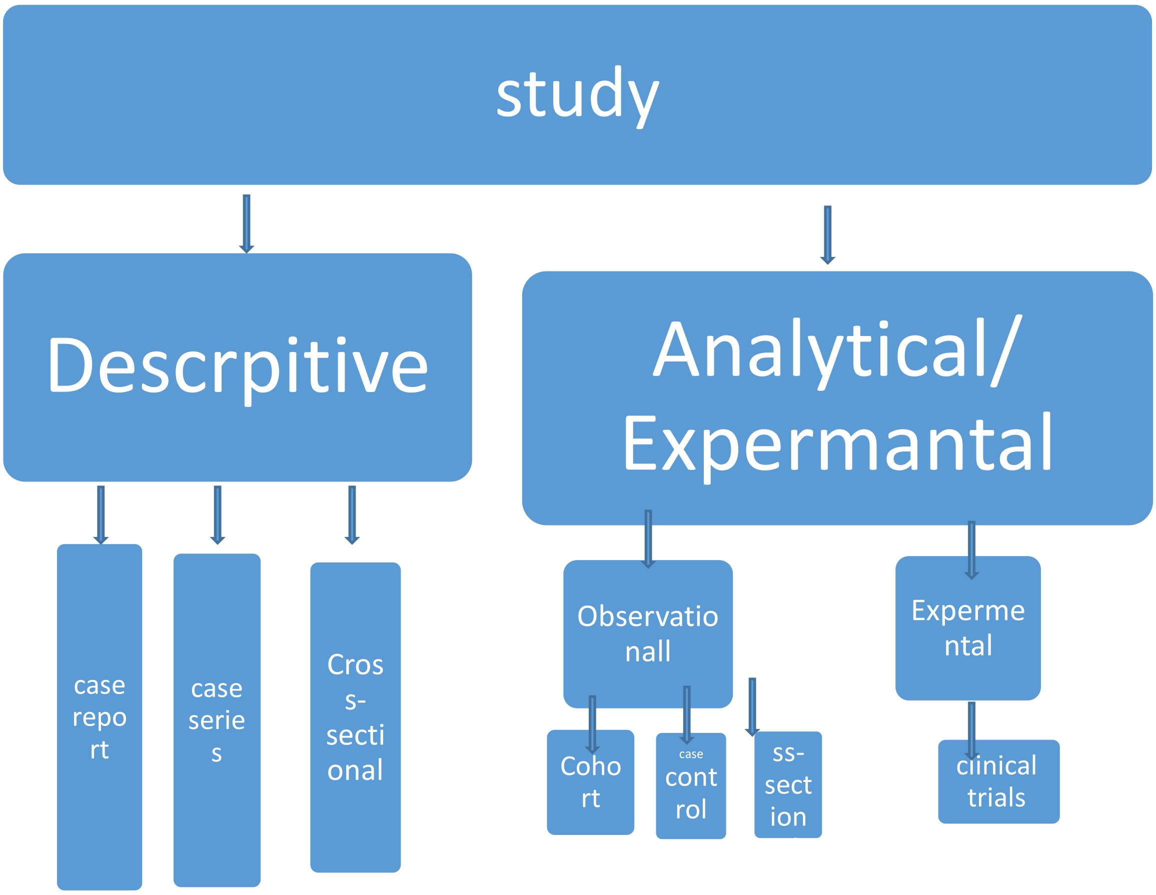
3) Confounding

Confounding is the technical term for finding an association for the wrong reason. It is associated with both the risk factor and the disease being studied, but need not be a risk factor for the disease under study. The confounding variable can either inflate or deflate the true relative risk.

To resolve this confusion, investigators looked at both factors simultaneously.

4) Statistical Variation

Statistical variation is the technical term for chance fluctuations. It is can be corrected by increasing the sample size.



Epidemics and Pandemic, their causes

Lecture 4

Epidemics and Pandamic, their causes

In epidemiology, an **epidemic** occurs when new cases of a certain disease, in a given human population, and during a given period, substantially exceed what is expected based on recent experience. Epidemiologists often consider the term outbreak to be synonymous to epidemic, but the general public typically perceives outbreaks to be more local and less serious than epidemics.

Epidemics of infectious disease are generally caused by a change in the ecology of the host population (e.g. increased stress or increase in the density of a vector species), a genetic change in the parasite population or the introduction of a new parasite to a host population (by movement of parasites or hosts). Generally, an epidemic occurs when host immunity to a parasite population is suddenly reduced below that found in the endemic equilibrium and the transmission threshold is exceeded.

The declaration of an epidemic usually requires a good understanding of a baseline rate of incidence; epidemics for certain diseases, such as influenza, are defined as reaching some defined increase in incidence above this baseline. A few cases of a very rare disease may be classified as an epidemic, while many cases of a common disease (such as the common cold) would not.

An epidemic may be restricted to one location; however, if it spreads to other countries or continents and affects a substantial number of people, it may be termed a **pandemic**.

Pandemic; A pandemic is an epidemic of infectious disease that has spread through human populations across a large region; for instance multiple continents, or even worldwide. A widespread endemic disease that is stable in terms of how many people are getting sick from it is not a pandemic. Further, flu pandemics generally exclude recurrences of seasonal flu. Throughout history there have been a number of pandemics, such as smallpox and tuberculosis. More recent pandemics include the HIV pandemic as well as the 1918 and 2009 H1N1 pandemics.

What is the difference between a pandemic and an epidemic?

A pandemic is different from an epidemic or seasonal outbreak.

1. Put simply, a pandemic covers a much wider geographical area, often worldwide. A pandemic also infects many more people than an epidemic.

An epidemic is specific to one city, region or country, while a pandemic goes much further than national borders.

2. An epidemic is when the number of people who become infected rises well beyond what is expected within a country or a part of a country. When the infection takes place in several countries at the same time it then starts turning into a pandemic.

3. A pandemic is usually caused by a new virus strain or subtype; humans either have no immunity against this virus, or very little immunity. If immunity is low or non-existent the virus is much more likely to spread around the world if it becomes easily human transmissible.

4. Pandemics generally cause much higher numbers of deaths than epidemics. The social disruption, economic loss, and general hardship caused by a pandemic are much higher than what an epidemic can cause.

In the case of influenza, seasonal outbreaks (epidemics) are generally caused by subtypes of a virus that is already circulating among people. Pandemics, on the other hand, are generally caused by novel subtypes - these subtypes have not circulated among people before. Pandemics can also be caused by viruses, in the case of influenza, that perhaps have not circulated among people for a very long time.

What are the main causes of Epidemic diseases?

The host and environment are in constant interaction and that a disease is caused by disturbance of equilibrium between agent, host and environment. The disease assumes epidemiological proportions when the environmental conditions are favorable for the disease agent and unfavorable conditions exist for man. Disasters like wars, famine, floods and earthquakes are following by epidemics of infectious disease.

Why does this happen? It happens because after the disaster, the favorable conditions for occurrence of an epidemic sets in there is no specific or a particular cause, which is responsible for occurrence of epidemic, but various factors complementing and supplementing each other are responsible for occurrence of epidemics.

The following factors favor occurrence of epidemics after disasters:

i) Temporary Population Settlements

Rehabilitation operations that follow a disaster are usually set up in crowded temporary camps or settlements. Provision of safe drinking water, sanitation and other basic services often lack at these places. This results in a rise in the incidence of infectious diseases like dysentery, measles, whooping cough, tuberculosis, scabies and other skin diseases.

ii) Pre-existent Diseases in the Population

The diseases already occurring in the area are most likely to emerge as epidemics when the area is struck by a disaster. An epidemic of non-existent disease in that area is unlike to be seen after such disasters.

iii) Ecological Changes

During natural disaster like floods and cyclones, ecological changes occur. It causes increase in the breeding sites for mosquitoes. This results in an increase in the cases of malaria. Open defecating and decay and decomposition of organic material increases insect breeding and thereby increases the transmission of disease like conjunctivitis, diarrhea, dysentery, enterovirus infections, and parasitic diseases.

iv) Resistance Potential of the Host

The nutritional and immunization status of the host population determines to a large extent its susceptibility to communicable disease. Children with poor nutrition are more likely to get infected with communicable disease and the incidence of measles, whooping cough, diphtheria and tuberculosis is likely to be higher if they are not immunized earlier.

v) Damage to Public Utility and Interruption of Public Health Services

Public utility services like water supply and sewage if damaged may cause large-scale contamination and subsequent introduction of diseases in the population. Interruption of ongoing health programmes in the area may also lead to resurgence of diseases.

Types of epidemic:

1. **Common source outbreak**

In a common source outbreak, the affected individuals had an exposure to a common agent. If the exposure is singular and all of the affected individuals develop the disease over a single exposure and incubation course, it can be termed a point source outbreak. If the exposure was continuous or variable, it can be termed a continuous outbreak or intermittent outbreak, respectively.

Common source outbreaks are, as the term implies, due to exposure to the virus, usually either in food, water, aerosol, or injected product. Common source outbreaks have the potential to be explosive because of the simultaneous exposure of many individuals; because the exposure is frequently limited in time, such outbreaks may be of relatively short duration. Finally, common source outbreaks challenge the epidemiologist because unraveling the source may lead to termination of an ongoing outbreak or prevention of future recurrences.

Two examples illustrate common source epidemics. At the beginning of World War II, the military decided to immunize a large number of troops against yellow fever because it was clear that there would be action in several tropical theaters where jungle yellow fever might be encountered. The attenuated 17D strain of yellow fever virus was a newly developed vaccine considered to be safe and effective immunogen. Because the vaccine efficacy depended on the infectivity of 17D virus, it was decided to enhance stability by including serum in the final formulation. Human serum was used to avoid serum sickness, and almost 1,000 donors were used, most of whom were medical students at Johns Hopkins University. Unfortunately, at least one individual was a carrier of hepatitis B virus. As a result, over 400,000 troops received contaminated vaccine causing a massive epidemic of hepatitis B (about 20,000 cases) in the spring of 1942. Although the onsets of cases were spread over time, when the common source was recognized and cases were plotted from the time of initial immunization with 17D vaccine, they formed a classical log-normal distribution. That provided a definitive estimate of the distribution of incubation periods for hepatitis B.

An outbreak of hepatitis A occurred in 1961 in Pascagoula, Mississippi, In some cases, detailed food histories were taken that showed, by comparison with controls, an association with raw oysters. Subsequent investigation disclosed that certain oyster beds in Pascagoula Bay were located near the discharge point for inadequately treated sewage from the city, and cases were associated with oysters supplied from these beds. This was one of the first instances of shellfish-associated hepatitis A and it was later demonstrated that oysters, through their siphoning system, are capable of concentrating virus up to 1,000 fold.

2. Propagated outbreak

In a propagated outbreak, the disease spreads person-to-person. Affected individuals may become independent reservoirs leading to further exposures.

Many epidemics will have characteristics of both common source and propagated outbreaks. For example, secondary person-to-person spread may occur after a common source exposure or an environmental vector may spread a zoonotic diseases agent.

Propagated epidemics, as the term implies, involve host to host spread of virus. The occurrence of an epidemic is therefore due to the action of the three parameters that determine disease incidence, namely, the proportion of the population susceptible, the proportion of susceptible infected, and the case: infection ratio. To produce the unusually high incidence that defines an epidemic, at least one of these parameters must be operating above its usual level. In some but not all outbreaks it is possible to implicate a specific parameter.

Measles incidence in Iceland over a 50- years period, there are intermittent epidemics alternating with periods of completes absence of measles. In this extreme situation, the virus invades the population, spreads widely and quickly, and fades out when the concentration of susceptible drops below the level needed to perpetuate the virus. The virus disappears entirely, allowing susceptible to accumulate as cohorts of infants are born. Once enough susceptible have accumulated, a single importation of measles can initiate a new epidemic. In this situation, the parameter required for epidemic initiation is the proportion of susceptible in the population.

By contrast, outbreaks of arbovirus disease are unrelated to the proportion of susceptible because infection is infrequent and a high proportion of the population is always susceptible. (Areas with hyperendemic yellow fever or dengue may represent a rare exception.) Epidemics are a reflection of the proportion of susceptible infection; because humans are deadend host who do not act as links in the infection chain, the key determinants are ecological factors that result in a high concentration of vectors and a high infection rate in the vector population. Epidemics are most commonly preceded by those climatic conditions (rainfall, temperature, and the like) that maximize the vector population.

In some instances, an outbreak is clearly associated with an increase in the ratio of cases to infections, often associated with a virus strain of high virulence. Such occurrences are probably frequent but are rarely well documented. One well-studied example is the pandemic of avian influenza that overwhelmed the poultry industry of the state of Pennsylvania in 1983. In this instance there was a sudden increase in the virulence of an influenza virus that was already enzootic in the poultry population, resulting in a pandemic that led to major commercial losses and which was only controlled by a widespread slaughter program. Unusually, isolates of the virus before and after the epidemic were available for analysis, and a classical series of studies showed that point mutation in the viral hemagglutinin enhanced the replication ability and virulence of the virus.

Epidemic Curves:

An epidemic curve gives a graphical display of the numbers of incident cases in an outbreak or epidemic, plotted over time. The form of the resulting distribution of cases can be used to propose hypotheses on the nature of the disease and its mode of transmission. The course of a population outbreak is most evident in infectious disease, but also occurs in situations such as a chemical spill leading to cases of respiratory disease.

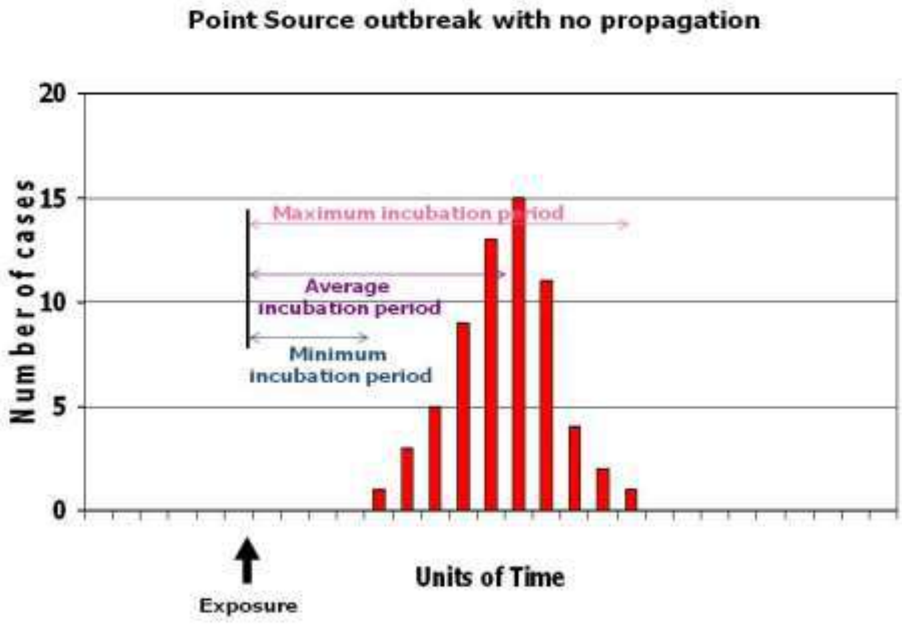
The major classes of epidemic curve.

A. Common Source Outbreaks:

Here the cases of disease arise from a single, shared or 'common' source, such as a batch of bad food, industrial pollution or a contaminated water supply. Controlling the source stops the outbreak, which include:

- **Point Source outbreak**

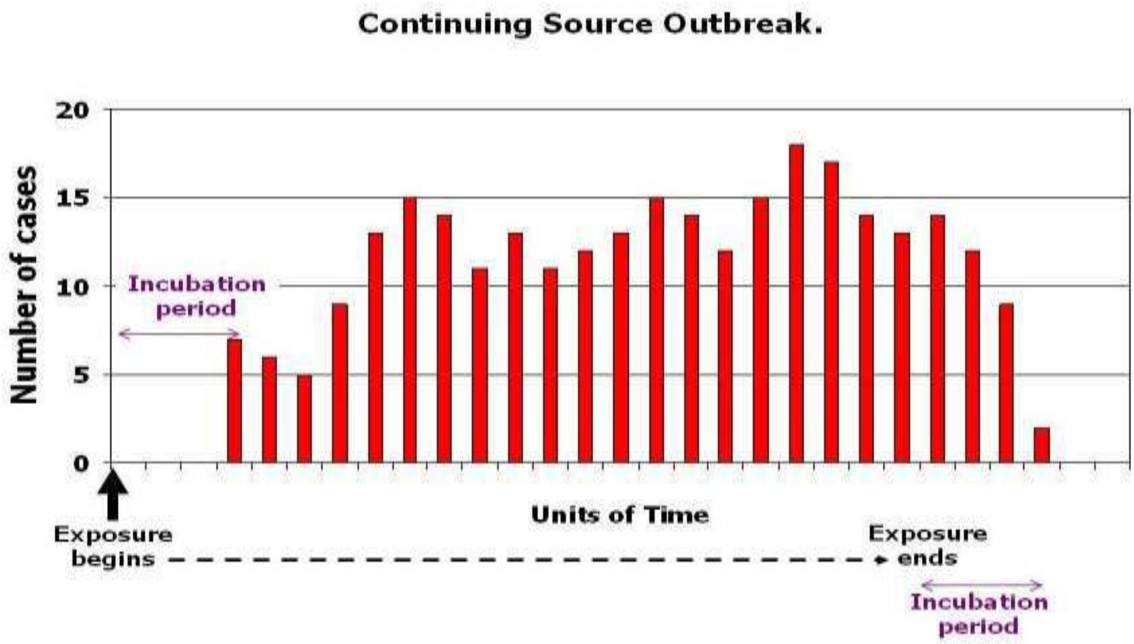
Here, all cases appear to occur within one incubation period, suggesting that cases did not arise from person-to-person spread. The fact that the outbreak was of short duration suggests that it was a single, brief (hence "point") exposure that did not persist over time. Examples include that embarrassing diarrhea saga following the neighbor's summer barbecue, or a respiratory illness in workers following a breakdown of a fume hood.



- **Continuing Source outbreak**

As with the point source outbreak, a group of people are exposed to a single noxious influence. But here the exposure continues over a longer time (e.g., a contaminated water supply that doesn't get fixed), so the outbreak persists for longer.

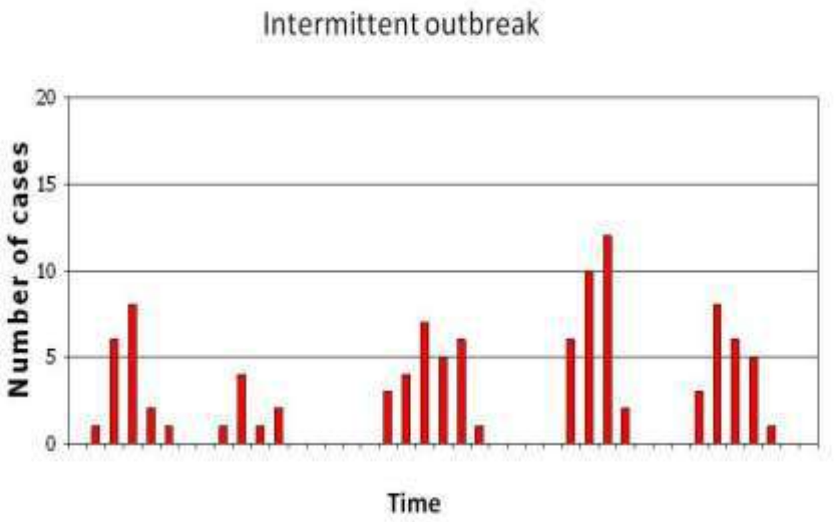
The relatively abrupt beginning of the outbreak suggests that many people were exposed simultaneously, rather than it spreading via transmission from one case to another. The fact that no cases arise beyond one incubation period following the termination of the exposure also supports this conclusion.



- **Intermittent outbreaks**

This pattern may occasionally see. This seems to be a common source that is not well controlled, so outbreaks recur. Depending on the time-frame, it could be seasonal or weather-related, or perhaps due to a common source such as an industrial contaminant being emitted at intervals.

The gaps between the outbreaks might initially suggest person-to-person transmission followed by an incubation period, but this is unlikely because in a transmissible disease the successive peaks would become larger and merge together, as in the next examples.



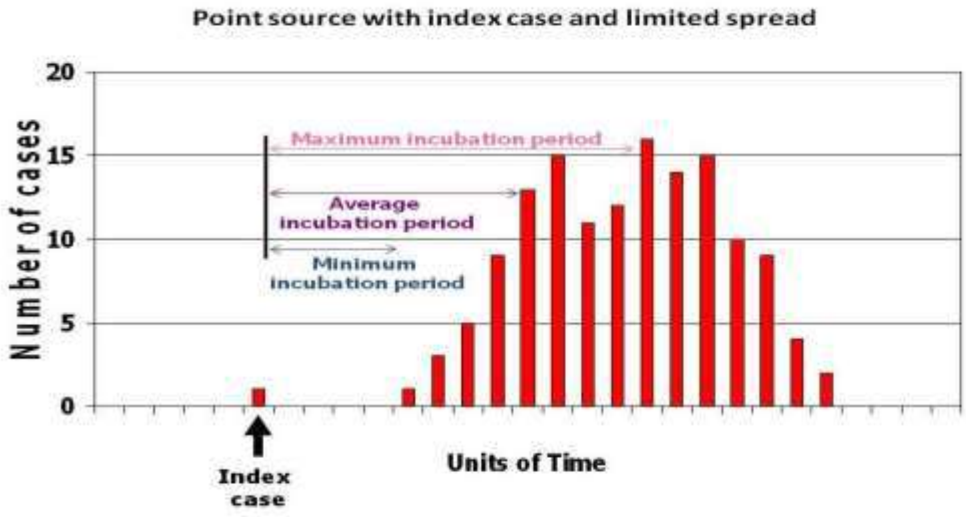
B. Person-to-Person Spread

Here the disease spreads via person-to-person contact – the classic infectious disease pattern. Controlling the source is no longer sufficient to control the outbreak.

- **Index case with limited spread**

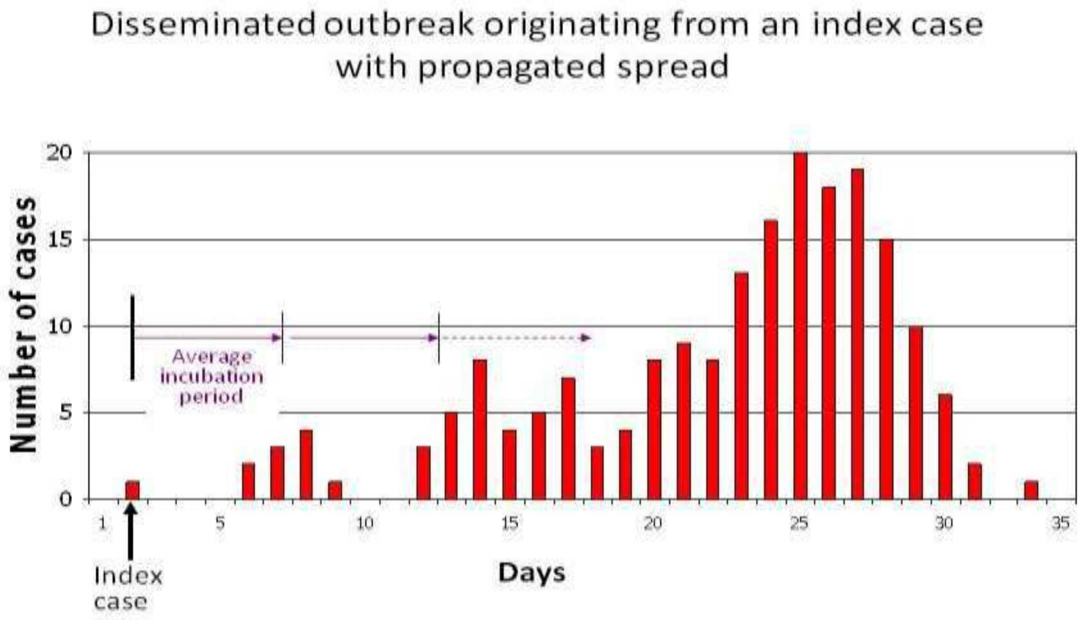
Here a single 'index' case (for example, a returning traveler) infects other people, and cases arise after an incubation period. (Perhaps, this called a point source with secondary transmission also).

The outbreak wanes when the infected people no longer transmit the infection to other susceptible people, perhaps because of successful control measures (isolation or quarantine). The graph suggests this was achieved quite quickly.



- **Propagated Spread**

This begins like an infection from an index case but then develops into a full-blown epidemic with secondary cases infecting new people who, in turn, serve as sources for yet other cases. This produces successively taller peaks, initially separated by one incubation period, but the peaks tend to merge into waves with increasing numbers of cases in each generation. The epidemic continues until the remaining numbers of susceptible individuals declines or until intervention measures take effect.



Transmission of epidemics:

- Airborne transmission: Airborne transmission is the spread of infection by droplet nuclei or dust in the air. Without the intervention of winds or drafts the distance over which airborne infection takes place is short, say 10 to 20 feet
- Arthropod transmission: Arthropod transmission takes place by an insect, either mechanically through a contaminated proboscis or feet, or biologically when there is growth or replication of an organism in the arthropod.
- Biological transmission: Involving a biological process, e.g. passing a stage of development of the infecting agent in an intermediate host. Opposite to mechanical transmission.
- Colostral transmission: A form of vertical transmission via successive generations.
- Contact transmission: The disease agent is transferred directly by biting, sucking, chewing or indirectly by inhalation of droplets, drinking of contaminated water, traveling in contaminated vehicles.
- Cyclopropagative transmission: The agent undergoes both development and multiplication in the transmitting vehicle.
- Developmental transmission: The agent undergoes some development in the transmission vehicle.

- Fecal-oral transmission: The infectious agent is shed by the infected host in feces and acquired by the susceptible host through ingestion of contaminated material.
- Horizontal transmission: Lateral spread to others in the same group and at the same time; spread to contemporaries.
- Mechanical transmission: The transmitter is not infected in that tissues are not invaded and the agent does not multiply.
- Propagative transmission: The agent multiplies in the transmission vehicle.
- Vertical transmission: From one generation to the next, perhaps transovarially or by intrauterine infection of the fetus. Some retroviruses are transmitted in the germ line, i.e. their genetic material is integrated into the DNA of either the ovum or sperm.

INVESTIGATING AN OUTBREAK

Lecture 5

UNCOVERING OUTBREAKS

One of the uses of surveillance (Public health surveillance is the ongoing systematic collection, analysis, interpretation, and dissemination of health data) is the detection of outbreaks. Outbreaks may be detected when routine, timely analysis of surveillance data reveals an increase in reported cases or an unusual clustering of cases.

WHY INVESTIGATE POSSIBLE OUTBREAKS

Health departments investigate suspected outbreaks for a variety of reasons. These include the need to institute control and prevention measures; the opportunity for research and training; program considerations; and public relations, political concerns, and legal obligations.

Control/prevention

The primary public health reason to investigate an outbreak is to control and prevent further disease. Before investigators can develop control strategies for an outbreak, however, they must identify where the outbreak is in its natural course: Are cases occurring in increasing numbers or is the outbreak just about over? The goal will be different depending on the answers to these questions.

If cases are continuing to occur in an outbreak, the goal may be to prevent additional cases. Therefore, the objective of the investigation would be to assess the extent of the outbreak and the size and characteristics of the population at risk in order to design and implement appropriate control measures.

On the other hand, if an outbreak appears to be almost over, the goal may be to prevent outbreaks in the future. In that case, the objective of an investigation is more likely to be to identify factors which contributed to the outbreak in order to design and implement measures that would prevent similar outbreaks in the future.

The decisions regarding whether and how extensively to investigate an outbreak are influenced by characteristics of the problem itself: the severity of the illness, the source or mode of transmission, and the availability of prevention and control measures. It is particularly urgent to investigate an outbreak when the disease is severe and has the potential to affect others unless prompt control measures are taken.

Research opportunities

Another important objective of outbreak investigations is, simply, to gain additional knowledge. Each outbreak may be viewed as an experiment of nature waiting to be analyzed and exploited. Each presents a unique opportunity to study the natural history of the disease in question. For a newly recognized disease, field investigation provides an opportunity to define the natural history--including agent, mode of transmission, and incubation period--and the clinical spectrum of disease. Investigators also attempt to characterize the populations at greatest risk and to identify specific risk factors.

Even for diseases that are well characterized, an outbreak may provide opportunities to gain additional knowledge by assessing the impact of control measures and the usefulness of new epidemiology and laboratory techniques.

Training

Investigating an outbreak requires a combination of diplomacy, logical thinking, problem-solving ability, quantitative skills, epidemiologic know-how, and judgment. These skills improve with practice and experience. Thus many investigative teams pair a seasoned epidemiologist with an epidemiologist-in-training. The latter gains valuable on-the-job training and experience while providing assistance in the investigation and control of the outbreak.

Public, political, or legal concerns

Public, political, or legal concerns sometimes override scientific concerns in the decision to conduct an investigation. Increasingly, the public has taken an interest in disease clusters and potential environmental exposures, and has called upon health departments to investigate. Such investigations almost never identify a causal link between exposure and disease.

Program considerations

Many health departments routinely offer a variety of programs to control and prevent illnesses such as tuberculosis, vaccine-preventable diseases, and sexually transmitted diseases. An outbreak of a disease targeted by a public health program may reveal a weakness in that program and an opportunity to change or strengthen the program's efforts.

STEPS IN AN EPIDEMIOLOGIC INVESTIGATION

The following steps need to be taken in all epidemiologic investigations.

1. Confirm the existence of an epidemic or an outbreak.
2. Confirm the diagnosis.
3. Determine the number of cases.
4. Orient the data in terms of time, person and place.
5. Develop a hypothesis.
6. Compare the hypothesis with the established facts.

7. Execute control and preventive measures.
8. Write a written report.

Step 1. Confirm the existence of an epidemic or an outbreak.

To determine if there is an outbreak, you can compare the current number of cases (incidence) with past levels of the same disease over a similar time period. If the number is unusually large or unexpected for the given place and time, you may have an outbreak.

When trying to confirm an outbreak, it is important to rule out other causes for increases in numbers of cases. For example, you might notice that several cases of *E. coli* O157:H7 have been reported to you over the past month. When you compare the numbers with cases recorded for the same month last year, you notice an increase. Then you remember that *E. coli* O157:H7 was recently made a reportable disease and this could be "surveillance artifact." That would be an artificial increase, and not necessarily a cause for alarm. Media attention to other outbreaks of the same disease tend to heighten public awareness and can lead to an increased number of cases being reported.

Step 2. Confirm the diagnosis.

This is done by obtaining appropriate specimens for laboratory study and obtaining clinical histories.

In some instances, there will be outbreaks of unknown etiology, and there will be no laboratory results to confirm the diagnosis. Cases or outbreaks of diseases of unknown etiology are just as valid as those with known etiologies.

Tests are used in medical diagnosis, screening, and research. How well is a subject classified into disease or non-disease group? Ideally, all subjects who have the disease should be classified as "having the disease" and vice versa. Practically, the ability to classify individuals into the correct disease status depends on the accuracy of the tests, among other things

A **diagnostic test** is used to determine the presence or absence of a disease when a subject shows signs or symptoms of the disease. A **screening test** identifies asymptomatic individuals who may have the disease. The diagnostic test is performed **after** a positive screening test to establish a definitive diagnosis**. Gold standard test** is the best test available. A **new test** is, for example, a new screening test or a less expensive diagnostic test. Use a 2 x 2 table to compare the performance of the new test to the gold standard test.

When evaluating a clinical test, the terms sensitivity and specificity are used. **Sensitivity** is the ability of the test to identify correctly those who have the disease. **Specificity is t**he ability of the test to identify correctly those who **do not have** the disease. Must know the correct disease status prior to calculation.

In accordance to the 2 × 2 table, sensitivity and specificity can be calculated using the following equations:

Sensitivity = a / (a+c)

Specificity = d / (b+d)

2 × 2 table

	Patient **with** disease	Patient **without** disease
Test is **positive**	**a** (true positive)	**b** (false positive)

Test is **negative**	**c** (false negative)	**d** (true negative)

An example:

Screening Results	True Characteristics in Population		Total
	Disease	No Disease	
Positive	80	100	180
Negative	20	800	820
Total	100	900	1,000

Sensitivity = 80/100 = 80% **Specificity** = 800/900 = 89%

Step 3. Determine the number of cases (ill people).

This helps to get an idea of the magnitude of the problem. Determination of case numbers is based on creating a **case definition**. A case definition is a set of criteria for deciding whether an individual should be classified as a case. The case definition places boundaries on who is considered a case, so the investigation does not include those with illnesses unrelated to the outbreak.

Step 4. Orient the data in terms of TIME, PLACE, and PERSON.

The purpose of data orientation or epidemiological characterizations is to arrange all incoming data so it means something. The investigator is searching for common associations based on TIME, PLACE, and PERSON to strengthen or amend current hypotheses. A common method of data orientation is plotting, on a graph, the cases by time of symptom onset to get an **epidemic curve**.

Step 5. Develop a hypothesis that explains the specific exposure(s) that may have caused the disease (and test this by appropriate statistical methods).

Using the information gathered from the previous steps, consider the possible source(s) from which the disease may have been contracted. One example of a simple hypothesis is: the cases became ill after sharing a common meal. To test or prove your hypothesis, epidemiologist would want to apply more analytical techniques, such as statistical testing.

Step 6. Compare the hypothesis with the established facts and draw conclusions.

For example, based on evidence gathered, you have a hypothesis that the salad was the vehicle of transmission in a salmonella outbreak. You then need to ask yourself how the salad became contaminated with salmonella and could this be verified with the results of the environmental investigation. In other words, are your epidemiologic results plausible and consistent with other investigational findings? Some of the questions that need to be addressed to make sure that your hypothesis is not only statistically sound, but makes sense in the real world are:

- Could your hypothesized events actually have happened?
- Is your hypothesis consistent with the environmental aspects of the investigation?
- Is it likely the vehicle of transmission identified became contaminated with the organism that has been isolated?

Step 7. Execute control and preventive measures.

Before initiating any control measures, think about the effectiveness, timeliness, costs, available resources, personnel requirements and possible consequences of proposed actions. Are the recommendations realistic for the establishment involved?

Step 8. Write a report.

After analysis of epidemiologic and environmental data, conclusions should be summarized in a report. It should identify a potential source(s) of the outbreak and suggests control measures to prevent future illness.

CUASTION

Lecture six

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Causation

Although investigators use analytic epidemiology to search for causes of disease, this is not a straightforward matter. First, not all associations between exposures and disease are causal relations. In addition, the accepted models of disease causation all require the precise interaction of factors and conditions before a disease will occur. Finally, the concept of cause itself continues to be debated as a philosophical matter in the scientific literature. Nonetheless, the following models and guidelines provide a framework for considering causation at a practical level.

For purposes of this course, we will define a **cause** of disease as a factor (characteristic, behavior, event, etc.) that influences the occurrence of disease. An increase in the factor leads to an increase in disease. Reduction in the factor leads to a reduction in disease. If disease does not develop without the factor being present, then we term the causative factor "**necessary**." If the disease always results from the factor, then we term the causative factor "**sufficient**." Exposure to *Mycobacterium tuberculosis* is necessary for tuberculosis to develop, but it is not sufficient, because not everyone infected develops disease. On the other hand, exposure to a large inoculum of rabies virus is a sufficient cause in a susceptible person, since clinical rabies and death will almost inevitably occur.

A variety of models of disease causation have been proposed. Models are purposely simplified representations. In this instance, the purpose of the model is to facilitate the understanding of nature, which is complex. Two of these models are discussed below.

Disease Models

How do diseases develop? Epidemiology helps researchers visualize disease and injury etiology through models.

The epidemiologic triad and the web of causation are among the best known of these models.

Epidemiologic Triad: Host, Agent, and Environment

The most familiar disease model, the epidemiologic triad, depicts a relationship among three key factors in the occurrence of disease or injury:

Host

The host is the actual or potential recipient or victim of disease or injury. Although the agent and environment combine to "cause" the illness or injury, host susceptibility is affected by personal characteristics such as age, occupation, income, education, personality, behavior, and gender and other genetic traits. Sometimes genes themselves are disease agents, as in hemophilia and sickle cell anemia.

Agent

An agent is a factor whose presence or absence, excess or deficit, is necessary for a particular disease or injury to occur. General classes of disease agents include chemicals such as benzene, oxygen, and asbestos; microorganisms such as bacteria, viruses, fungi, and protozoa; and physical energy sources such as electricity and radiation.

Many diseases and injuries have multiple agents. People who are not epidemiologists often confuse a disease or injury agent with its intermediary—its **vector** or **vehicle**. A vector is a living organism, whereas a vehicle is inanimate. The female of one species of mosquito carries the protozoa that are parasitic agents of malaria.

The mosquito is the vector or intermediate host of malaria, but not the agent. Similarly, an activated nuclear bomb functions as a vehicle for burns by conveying one of its agents, ionizing radiation.

Environment

The environment includes all external factors, other than the agent, that can influence health. These factors are further categorized according to whether they belong in the social, physical, or biological environments.

The social environment encompasses a broad range of factors, including laws about seat belt and helmet use; availability of medical care and health insurance; cultural "dos" and "don'ts" regarding diet; and many other factors pertaining to political, legal, economic, educational, communications, transportation, and health care systems. Physical environmental factors that influence health include climate, terrain, and pollution. Biological environmental influences include disease and injury vectors; soil, humans, and plants serving as reservoirs of infection; and plant and animal sources of drugs and antigens.

From the perspective of the epidemiologic triad, the host, agent, and environment can coexist fairly harmoniously. Disease and injury (or epidemics) occur only when there is interaction or altered equilibrium between them due to:

a) New agent.
b) Change in existing agent (infectivity, pathogenicity, virulence).
c) Change in number of susceptibles in the population.
d) Environmental changes that affect transmission of the agent of growth of the agent.

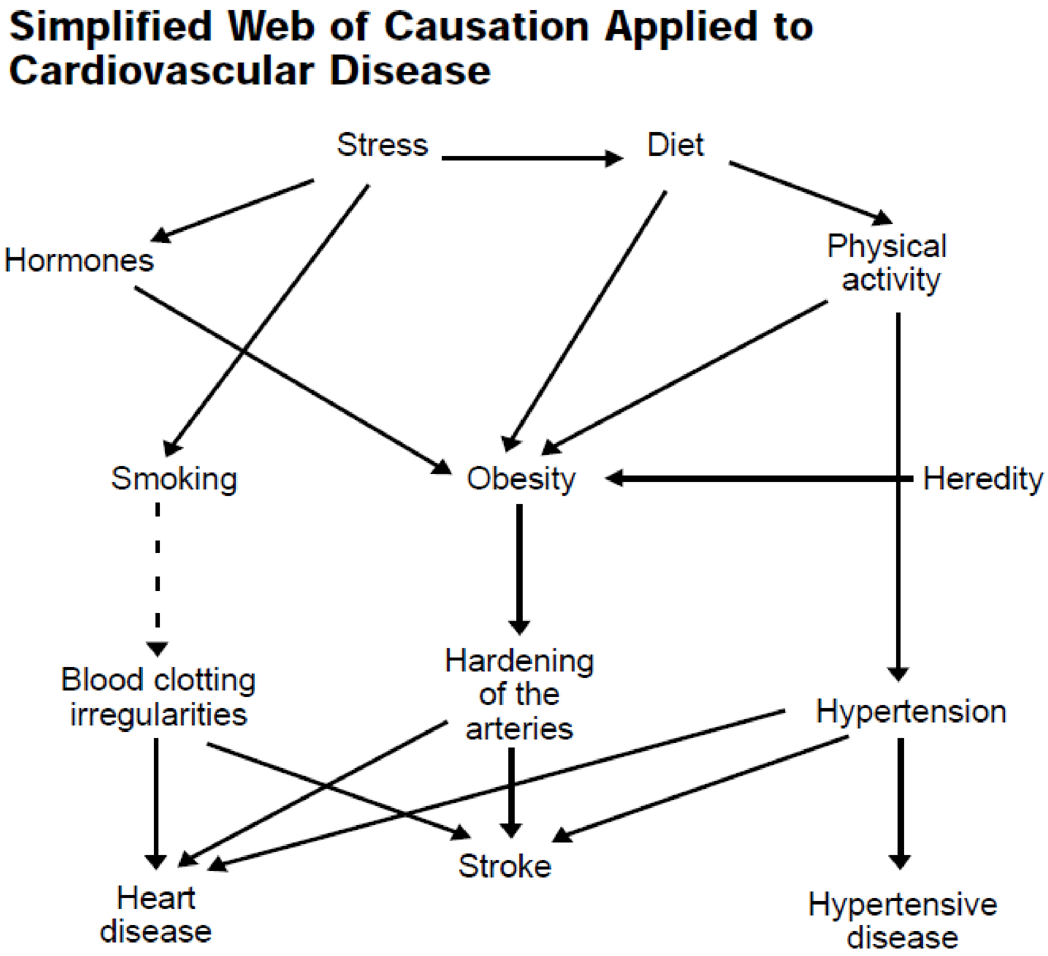
But if an agent, in combination with environmental factors, can act on a susceptible host to create disease, then disruption of any link among these three factors can also prevent disease.

Smallpox was eradicated globally through this kind of disruption. Smallpox is almost always spread by human face-to-face contact, but is less contagious than influenza, measles, chickenpox, and some other communicable diseases. Health personnel severed the link between disease agent and host by isolating each smallpox case upon diagnosis and then vaccinating everyone within a three-mile radius. This highly effective method, known as the **case-containment and ring-vaccination strategy**, proved to be a relatively low-cost way to eradicate smallpox.

Web of Causation

Although the epidemiologic triad has contributed to the understanding of disease etiology, the process that actually generates disease or leads to injury is much more complex. This complexity is better portrayed in a second model used by epidemiologists: the web of causation. The web of causation was developed especially to enhance understanding of chronic disease, such as cardiovascular disease. However, it can also be applied to the study of injury and communicable disease. The web of causation de-emphasizes the role of the agent and highlights other factors that encourage the onset of disease.

Using this model, scientists can diagram how factors such as stress, diet, heredity, and physical activity relate to the onset of the three major types of cardiovascular disease: coronary heart disease, cerebrovascular disease (stroke), and hypertensive disease (see Figure 1). In addition, the approach reveals that each of these diseases has a precursor, for example, hypertension, that can alert a diagnostician to the danger of a more serious underlying condition.



Compiling Epidemiologic Evidence

Models are useful in guiding epidemiologic research, but health scientists cannot answer the underlying questions about the causes of disease or injury without appropriate data.

Researchers need a myriad of data on the personal and medical backgrounds of individuals to determine, for example, whether physicians are more likely to have hypertension than construction workers—and whether one group is more likely than the other to develop a related disease.

Original data collected by or for an investigator are called **primary data.** Because primary data collection is expensive and time consuming, it usually is undertaken only when existing data sources—or **secondary data**—are deficient. Most descriptive epidemiologic studies use secondary data, often data collected for another purpose. Analytic epidemiologic studies usually require primary as well as secondary data

Application of epidemiology - 1

Lecture 7

Application of Epidemiology -1

As the basic method of public health, epidemiology touches many aspects of the health sciences. The late Jerry Morris, professor of community health at the London School of Hygiene and Tropical Medicine, articulated seven uses for epidemiology (Figure 1). These uses include one group related to health status and health services and another set related to disease etiology.

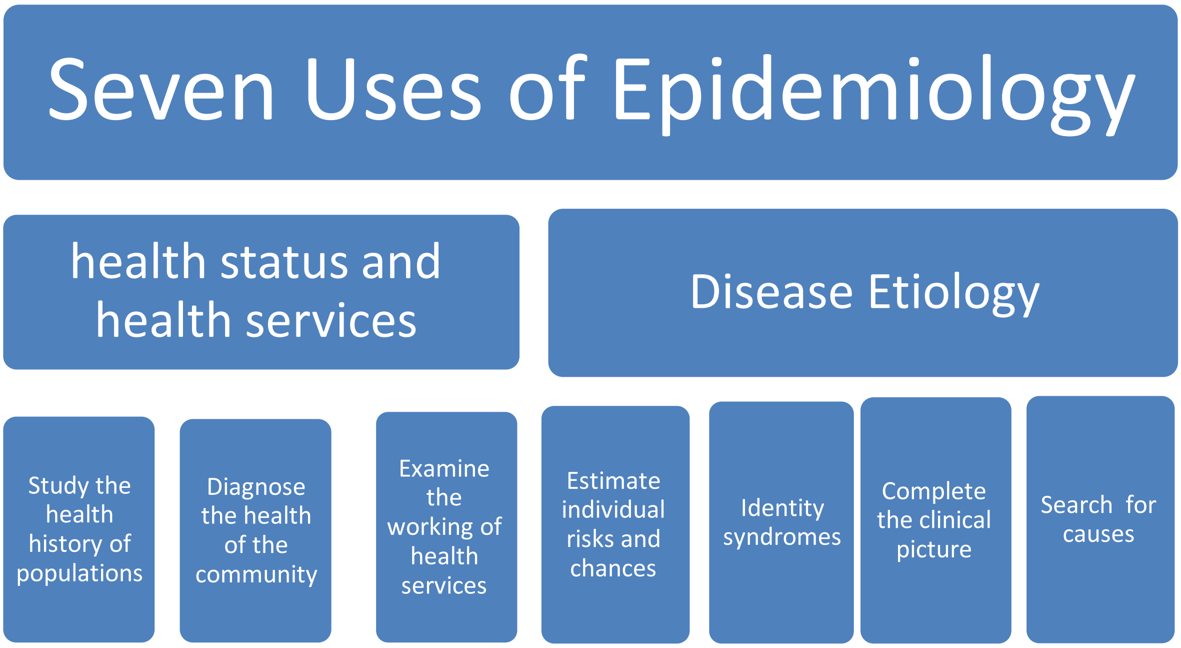


Figure 1: The seven uses of epidemiology.

1. To study the history of the populations health, the rise and fall of diseases and changes in their character. Useful projections into the future may be possible.

2.To diagnose the health of the community and the condition of the people, to measure the true dimensions and distribution of ill-health in terms of incidence, prevalence, disability, and mortality; to set health problems in perspective and define their relative importance; to identify groups needing special attention. Ways of life change, and with them the community's health; new measurements for monitoring them must therefore constantly be sought.

3. To study the working of health services with a view to their improvement. Operational research translates knowledge of (changing) community health and expectations in terms of needs for services and measure how these are met. The success of services delivered in reaching stated norms, and the effects on community health- and its needs- have to be

appraised, in relation to resources. Such knowledge may be applied in action research pioneering better services, and in drawing up plans for the future. Timely information on health and health services is itself a key service requiring much study and experiment. Today, information is required at many levels, from the local district to the international.

4. To estimate from the group experience what are the individual risks on average of disease, accident and defect, and the chances of avoiding them.

5. To identify syndromes by describing the distribution and association of clinical phenomena in the population.

6. To complete the clinical picture of chronic diseases and describe their natural history: by including in due proportion all kinds of patients, wherever they present, together with the undemanding and the symptomless cases who do not present and whose needs may be as great; by following the course of remission and relapse, adjustment and disability in defined populations. Follow-up of cohorts is necessary to detect early subclinical and perhaps reversible disease and to discover precursor abnormalities during the pathogenesis, which may offer opportunities for prevention.

7. To search for causes of health and disease by computing the experience of groups defined by their composition, inheritance and experience, their behavior and environments. To confirm particular causes of the chronic diseases and the patterns of multiple causes, describing their mode of operation singly and together, and to assess their importance in terms of the relative risks of those exposed. Postulated causes will often be tested in naturally occurring experiments of opportunity and sometimes by planned experiments.

Applications for the Assessment of the Health Status of Populations and Delivery of Health Services:

- ❖ **Historical Use of Epidemiology** (Study of Past and Future Trends in Health and Illness):

An example of the historical use of epidemiology is the study of changes in disease frequency over time. (These changes are known as secular trends). Illnesses and causes of mortality that afflict humanity, with certain exceptions, have shown dramatic changes in industrialized nations from the beginning of modern medicine to the present day. In general, chronic conditions have replaced acute infectious diseases as the major causes of morbidity and mortality in contemporary industrialized societies. Mortality data shed light on the overall health status of populations, suggest long-term trends in health, and help to identify subgroups of the population that are at greater risk of mortality than other subgroups.

Figure -2 identifies the top 10 causes of death for two contrasting years: 1900 and 2009, a period of more than one century. The data show that influenza and pneumonia dropped from the top position in 1900 to eight in 2009. In 2009 diseases of the heart were the leading cause of death, followed in second place by cancer. The overall crude death rate from all causes declined greatly during this period of about one century—from 1719.1 to 793.7 per 100,000 population.

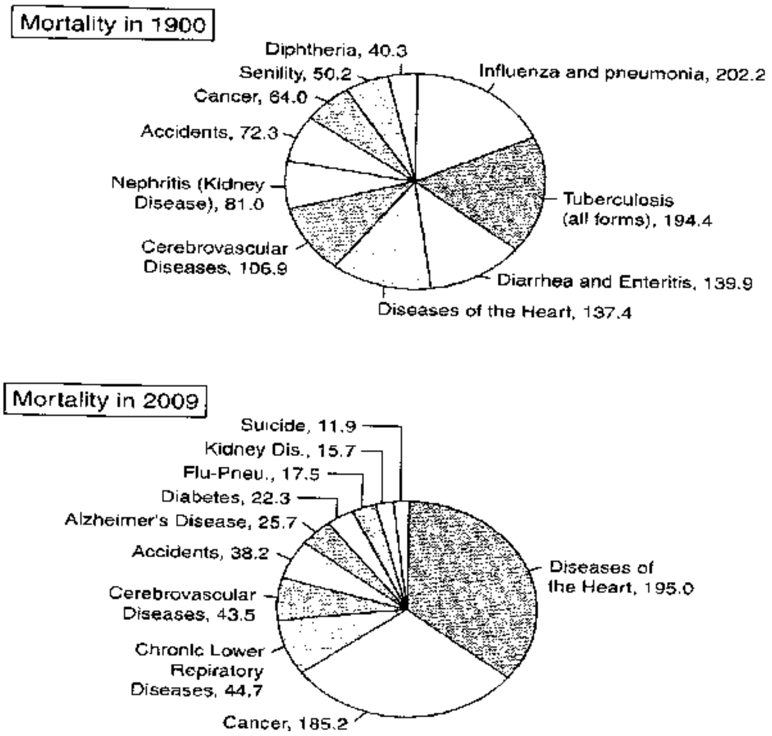
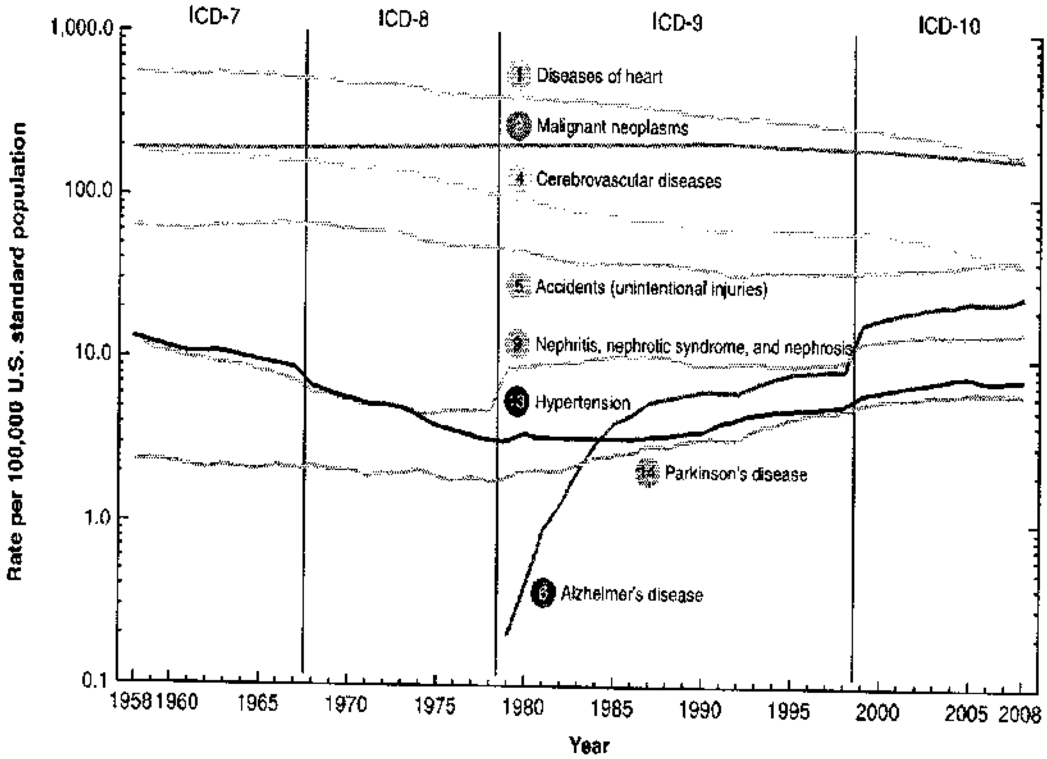


FIGURE 2–2 The ten leading causes of mortality, 1900 and 2009, rank, cause, and crude death rate per 100,000 (not age-adjusted). Data for 1900 exclude infant mortality. *Sources:* Data from U.S. Bureau of the Census, Statistical Abstract of the United States: 1957. p. 69 : United States Public Health Service, Vital Statistics Rates in the United States 1900–1940, Washington, DC: United States Government Printing Office, 1947; and from Kochanek KD, Xu JQ, Murphy SL, at al. Deaths: Preliminary Data for 2009, National Vital Statistics Reports. Vol 59, No 4, p. 5. Hyattsville, MD: National Center for Health Statistics, 2011.

Since the early 1960s, the leading causes of death over decades of time have shown marked changes (Figure 3). For example, death rates for heart disease, cancer, and stroke have shown long-term declining trends. Increases have been reported for Alzheimer's disease, kidney disease, and hypertension.



Notes: ICD is the International Classification of Diseases. Circled numbers indicate ranking of conditions as leading causes of death in 2008. Age-adjusted death rates per 100,000 U.S. standard population; see "Technical Notes."

FIGURE 2–3 Age-adjusted death rates for selected leading causes of death: United States, from 1958 to 2008. *Source:* Reproduced from Miniño AM, Murphy SL, Xu JQ, Kochanek KD. Deaths: Final Data for 2008. National Vital Statistics Reports; Vol. 59, No. 10. Hyattsville, MD: National Center for Health Statistics. 2011.

In determining the reasons for these trends, one must take into account certain conditions that may affect the reliability of observed changes; these are "variation in diagnosis, reporting, case fatality, or some other circumstance other than a true change of incidence."

Despite the factors that reduce the reliability of observed changes in morbidity and mortality, Changes in the occurrence and patterns of morbidity and mortality are the results of a range of factors including improvements in medical care (e.g., development of new immunizations and medicines), alterations in environmental conditions (e.g., increased levels of pollution in the presence of toxic chemicals in our food), and appearance of new or more virulent forms of microbial disease agents.

Predictions about the Future

The study of population dynamics in relation to sources of morbidity and mortality reveals much about possible future trends in a population's health. A population pyramid represents the age and sex composition of the population of an area or country at a point in time. By examining the distribution of a population by age and sex, one may view the impacts of mortality from acute and chronic conditions as well as the quality of medical care available to a population.

Figure 4 shows the age and sex distribution of the population of developed and developing countries for three time periods: 1950, 1990, and 2030. The left and right sides of each chart compare males and females, respectively. The x-axis (bottom of each chart) gives the number of the population in millions. The y-axis (left side of each chart) presents ages grouped into 5-year intervals. The following trends in the age and sex distributions are evident:

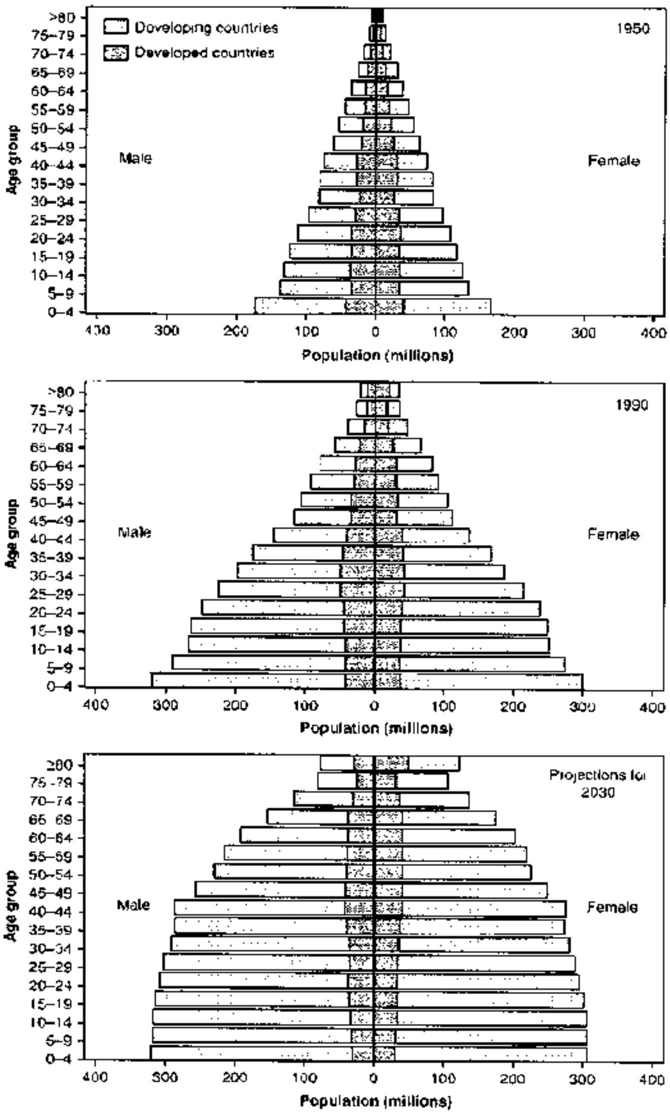


FIGURE 2–5 Population age distribution for developing and developed countries, by age group and sex–worldwide, 1950, 1990, and 2030.
Source: Adapted and reprinted from Centers for Disease Control and Prevention. MMWR 2003;52(6):103. The United Nations and the U.S. Bureau of the Census are the authors of the original material.

● Developing countries; In 1950 and 1990, less developed countries had a triangular population distribution. A triangular distribution is associated with high death rates from infections, high birth rates, and other conditions that take a heavy toll during the childhood years. These deaths result from a constellation of factors associated with poverty and deprivation: poor nutrition, lack of potable water, and unavailability of basic immunizations, antibiotics, and sewage treatment. Consequently, fewer children survive into old age, causing smaller numbers of the population in the older groups. By 2030, improvements in health in developing countries are likely to result in greater survival of younger persons, causing a projected change in the shape of the population distribution.

● Developed countries (industrialized societies); These countries manifest a rectangular population distribution. This rectangular shape was consistent for 1950 and 1990 and, with some exceptions, is projected also for 2030. Characteristically, infections take a smaller toll than in developing countries, causing a greater proportion of children to survive into old age; approximately equal numbers of individuals are present in each age group except among the very oldest age groups, with larger numbers of older women than men who survive. Because of reduced mortality due to infectious diseases and improved medical care in comparison with less developed regions, residents of developed countries enjoy greater life expectancy.

With continuing advances in medical care, the population of developed countries will grow increasingly older. The U.S. Bureau of the Census estimates that about one-fifth of the U.S. population in 2030 will be 65 years of age and older. There will be a need for health services that affect aging and all of its associated dimensions. One illustration is increasing the availability of programs for the major chronic diseases, both with respect to preventive care in the early years and direct care in the older years.

Population Dynamics and Epidemiology

Population dynamics denote changes in the demographic structure of populations associated with such factors as births and deaths and immigration and emigration. A population may be either fixed or dynamic. A fixed population is one distinguished by a specific happening and consequently adds no new members; therefore, the population decreases in size as a result of deaths only. Three major factors affect the sizes of populations: births, deaths, and migration.

The latter term includes immigration and emigration—permanent movement into and out of a country, respectively. As the population pyramid portends, population characteristics are related to health patterns found in the community. The term demographic transition refers to the historical shift from high birth and death rates found in agrarian societies to much lower birth and death rates found in developed countries. A decline in the death rate has been attributed in part to improvement in general hygienic and social conditions. Industrialization and urbanization contribute to a decline in the birth rate. The term epidemiologic transition is used to describe a shift in the pattern of morbidity and mortality from causes related primarily to infectious and communicable diseases to causes associated with chronic, degenerative diseases. The epidemiologic transition accompanies the demographic transition. The demographic transition, however, is not without its own set of consequences: Both industrialization and urbanization have led to environmental contamination, concentration of social and health problems in the urban core areas of the United States, and out-migration of inner city residents to the suburbs.

Health of the Community

One of the important applications in epidemiology is to provide methodologies used to describe the overall health of a particular community. The resulting description may then provide a key to the types of problems that require attention and also accentuate the need for specific health services. A complete epidemiologic description would include indices of health as well as indicators of the psychosocial milieu of the community. A representative list of variables that might be covered in a description of the health of the community is given as follows:

- Demographic and social variables:

  1. Age and sex distribution

  2. Socioeconomic status

  3. Family structure, including marital status and number of single- parent families

  4. Racial, ethnic, and religious composition

- Variables related to community infrastructure:

  1. Availability of social and health services including hospitals and emergency rooms

  2. Quality of housing stock including presence of lead-based paint and asbestos

  3. Social stability (residential mobility)

  4. Community policing

  5. Employment opportunities

- Health-related outcome variables:

  1. Homicide and suicide rates

  2. Infant mortality rate

  3. Mortality from selected conditions (cause specific)

  4. Scope of chronic and infectious diseases

  5. Alcoholism and substance abuse rates

  6. Teenage pregnancy rates

  7. Occurrence of sexually transmitted diseases

  8. Birth rate

- Environmental variables:
  1. Air pollution from stationary and mobile sources
  2. Access to parks/recreational facilities
  3. Availability of clean water

4. Availability of markets that supply healthful groceries
5. Number of liquor stores and fast-food outlets
6. Nutritional quality of foods and beverages vended to school

Working of Health Services: Operations Research and Program Evaluation

The term operations research (operational research) is defined as ‘‘the systematic study, by observations and experiment, of the working of a system (e.g., health services), with a view to improvement.” Epidemiology applied to operations research refers to the study of the placement of health services in a community and the optimum utilization of such services. “The usual epidemiologic approaches—descriptive, analytic, and experimental—are all used in health services research and, in addition, methods of evaluation have been expanded through their application to problems in health services.” A major contribution of epidemiology to operations research is the development of research designs, analytic techniques, and measurement procedures.

The perspective of operations research reveals the extent to which health services are harmonized. Coordination and integration of services helps to optimize use of available funds and services. Uncoordinated programs result in wasted resources, fragmentation, low efficiency, duplication, service gaps, lack of service continuity, and delays in securing services. Usually a single agency or program is unable to provide a full spectrum of needed health services, especially to individuals who are afflicted with severe health problems such as multiple sclerosis or mental disorders. One agency may specialize in diagnosis, evaluation, and treatment of the client’s physical problems, whereas another may emphasize mental health issues. Because the mental and physical dimensions of the person are intertwined, the holistic medical concept argues that there should be greater coordination among various healthcare agencies that specialize in a particular component of health services. Operations research facilitates such coordination.

Application of Epidemiology - 2

Lecture 8

Application of Epidemiology

Applications Relevant to Disease Etiology

The second group of applications encompasses uses of epidemiology that are connected with disease etiology (e.g., determining the causes of infectious and chronic diseases such as tuberculosis and cancer as well as preventing them).

To summarize, the doctrine of multiple causality or **multifactorial causality** (instead of single causal agents) is now accepted widely; current research indicates that a framework of multiple causes for chronic diseases such as heart disease, cancer, and diabetes mellitus is appropriate.

Risk Factors Defined

Because of the uncertainty of "causal" factors in epidemiologic research, it is customary to refer to an exposure that is associated with a disease as a risk factor.

There are three requisite criteria for risk factors:

1. The frequency of the disease varies by category or value of the factor. Consider cigarette smoking and lung cancer. Light smokers are more likely to develop lung cancer than nonsmokers, and heavy smokers are more likely still to develop the disease.

2. The risk factor must precede the onset of disease. This criterion, known as temporality, applies to the smoking–lung cancer example. We now know that smoking causes lung cancer. Nevertheless, hypothetically speaking, if individuals with lung cancer began to smoke after the onset of disease, smoking would not be a likely cause of their condition. The issue of the temporal relationship between exposure and disease is particularly relevant to chronic diseases such as cancer. Epidemiologists may not be able to determine when exposure occurred in relationship to onset of the disease.

3. The observed association must not be due to any source of error. In illustration, researchers could introduce methodological errors at any of several points during an epidemiologic investigation. These errors might occur in the selection of study groups, measurement of exposure and disease, and data analysis.

Modern Concepts of Causality

Epidemiologists identified nine issues that are relevant to causality and epidemiologic research;

1. Strength of association. example ; chimney sweeps in comparison to other workers had an enormous increase in scrotal cancer; the mortality was more than 200 times that of

workers not exposed to tar and mineral oils. A strong association is less likely to be the result of errors.

2. Consistency upon repetition. This term refers to whether the association between agent and putative health effects has been observed by different persons in different places, circumstances, and times. The Surgeon General's report of 1964 cited a total of 36 different studies that found an association between smoking and lung cancer.

3. Specificity. With respect to occupational exposures, if "the association is limited to specific workers and to particular sites and types of disease and there is no association between the work and other modes of dying, then clearly that is a strong argument in favor of causation."

4. Time sequence. For example, if one is trying to identify the role of diet in the pathogenesis of colon cancer, one has to be careful to sort out dietary preferences that lead to colon cancer versus dietary changes that result from early stages of the disease. There is some evidence that low intakes of calcium are associated with increased risk of colon cancer. If early stages of disease create problems with digestion of milk products (which are good sources of calcium), individuals may lower their intake of milk (and calcium) as a consequence of the disease. The shorter the duration between exposure to an agent and development of the disease (i.e., the latency period), the more certain one is regarding the hypothesized cause of the disease. For this reason, many of the acute infectious diseases or chemical poisonings are relatively easy to pinpoint as to cause. Diseases having longer latency periods (many forms of cancer, for example) are more difficult to relate to a causal agent; it is said that the onset of chronic diseases is insidious and that one is ignorant of the precise induction periods for chronic diseases. Many different causal factors could intervene during the latency period. This is why a great deal of detective work was needed to link early exposure to asbestos in shipyards to subsequent development of mesothelioma, a form of cancer of the lining of the abdominal cavity.

5. Biologic gradient. Evidence of a dose–response curve is another important criterion. the death rate from lung cancer increases linearly with the number of cigarettes smoked daily adds a great deal to the simpler evidence that cigarette smokers have a higher death rate than non-smokers."

6. Plausibility. If an association is biologically plausible, it is credible on the basis of existing biomedical knowledge. The weakness of this line of evidence is that it is necessarily dependent upon the biologic knowledge of the day.

7. Coherence of explanation. The association must not seriously conflict with what is already known about the natural history and biology of the disease. Data from laboratory experiments on animals may be most helpful.For example, the ability of tobacco extracts to cause skin cancer in mice is coherent with the theory that consumption of tobacco products in humans causes lung cancer.

8. Experiment. In some instances there may be "natural experiments" that shed important light on a topic. The observation that communities with naturally fluoridated water

had fewer dental caries among their citizens than communities without fluoridated water is one example.

9. Analogy. The examples thalidomide and rubella. Thalidomide, administered in the early 1960s as an antinausea drug for use during pregnancy, was associated subsequently with severe birth defects. Rubella (German measles), if contracted during pregnancy, has been linked to birth defects, stillbirths, and miscarriages. Given that such associations have already been demonstrated, “we would surely be ready to accept slighter but similar evidence with another drug or another viral disease in pregnancy.”

Study of Risks to Individuals

In many instances, epidemiologic research on disease etiology involves collection of data on a number of individual members of different study groups or study populations. Epidemiologists use two main types of observational studies for research on disease etiology: case-control and cohort studies. A case-control design compares a group of individuals who have a disease of interest (the cases) with a group who does not have the disease (the controls). The two groups are compared with respect to a variety of hypothesized exposures (e.g., diet, exercise habits, or use of sunscreens). Differences in exposure that are observed between the two groups may suggest why one group has the disease and the other does not. Another research method is the cohort study. In this approach, a study group free from disease is assembled and measured with respect to a variety of exposures that are hypothesized to increase (or decrease) the chance of getting the disease. One then follows the group over time for the development of disease, comparing the frequency with which disease develops in the group exposed to the factor and the group not exposed to the factor. Either type of study may demonstrate that a disease or other outcome is more likely to occur in those with a particular exposure.

Enlargement of the Clinical Picture of Disease

When a new disease first gains the attention of health authorities, usually the most dramatic cases are the ones observed initially. One may conclude incorrectly that the new disease is an extremely acute or fatal condition; later epidemiologic studies may reveal that the most common form of the new disease is a mild, subclinical illness that occurs widely in the population. To develop a full clinical picture of the disease, thorough studies are necessary to find out about the subacute cases; an adequate study may require a survey of a complete population.

One example of this use of epidemiology was the investigation of the 1976 Legionnaires’ disease outbreak, which at first seemed to be a highly virulent and new condition. The outbreak of a mysterious illness that ravaged participants at the American Legion’s July 1976 convention in Philadelphia riveted public attention. Concerned officials appealed to local and federal epidemiologists to investigate the outbreak. Disease detectives ascertained that Legionnaires’ disease was associated with a previously unidentified bacterium, Legionella pneumophila.

Although the Philadelphia outbreak suggested initially that Legionnaires' disease was highly fatal, subsequent research found a much lower case fatality rate; about 15% of the people who developed the disease died from it. The previously unrecognized disease had probably occurred sporadically in other areas of the countrybefore 1976.

Prevention of Disease

One of the potential applications of research on disease etiology is to identify where, in the disease's natural history, effective intervention might be implemented.

The natural history of disease refers to the course of disease from its beginning to its final clinical end points.

The period of prepathogenesis occurs before the precursors of disease (e.g., the bacterium that causes Legionnaires' disease) have interacted with the host (the person who gets the disease). The period of pathogenesis occurs after the precursors have interacted with the host, an event that is marked by initial appearance of disease (the presymptomatic stage) and is characterized by tissue and physiologic changes. Later stages of the natural history include development of active signs and symptoms, and eventually recovery, disability, or death (all examples of clinical end points).

Primary Prevention

Primary prevention occurs during the period of prepathogenesis. Primary prevention includes health promotion and specific protection against diseases. The former is analogous to a type of prevention known as primordial prevention. The term primordial prevention denotes ". . . conditions, actions and measures that minimize hazards to health and that hence inhibit the emergence and establishment of processes and factors (environmental, economic, social, behavioral, cultural) known to increase the risk of disease."

Primordial prevention is concerned with minimizing health hazards in general, whereas primary prevention seeks to lower the occurrence of disease. Primordial prevention is achieved in part through health promotion, which includes health education programs in general, marriage counseling, sex education, and provision of adequate housing.

Examples of primary prevention that involve specific protection against disease-causing hazards are wearing protective devices to prevent occupational injuries, utilization of specific dietary supplements to prevent nutritional deficiency diseases, immunizations against specific infectious diseases, and education about the hazards of starting smoking. Interventions to reduce the number of alcohol-related traffic accidents similarly may focus on education, media campaigns, and warning labels on alcohol-containing beverages.

Primary prevention may be either active or passive. Active prevention necessitates behavior change on the part of the subject. Wearing protective devices and obtaining vaccinations require involvement of the individual to receive the benefit. Passive interventions, on the other hand, do not require any behavior change. Fluoridation of public water supplies and vitamin fortification of milk and bread products achieve their desired effects without any voluntary effort of the recipients.

Secondary Prevention

Secondary prevention, which takes place during the pathogenesis phase of the natural history of disease, encompasses early diagnosis and prompt treatment as well as disability limitation. One example of secondary prevention is early diagnosis and prompt treatment linked to cancer screening programs, which are efforts to detect cancer in its early stages (when it is treated more successfully) among apparently healthy individuals. One should note that in the instance of a positive screening result confirmed by a diagnostic workup, cancer is already present; however, detection of the tumor before the onset of clinical symptoms reduces the likelihood of progression to death. Most cancer screening programs are forms of secondary prevention.

Later in the natural history of disease (when discernible lesions or advanced disease have appeared), there occurs a type of secondary prevention called disability limitation, which is designed to limit and shorten the period of disability and prevent death from a disease. Another goal of disability limitation is to prevent the side effects and complications that may be associated with a disease.

Tertiary Prevention

Tertiary prevention takes place during late pathogenesis (advanced disease and convalescence stages). Thus, disease already has occurred and has been treated clinically, but rehabilitation is needed to restore the patient to an optimal functional level. Examples include physical therapy for stroke victims, halfway houses for persons recovering from alcohol abuse, sheltered homes for the developmentally disabled, and fitness programs for heart attack patients. This category of prevention seeks to achieve maximum use of the capacities of persons who have disabilities and help them regain full employment.

Pandemic preparedness and management

Lecture 9

Pandemic preparedness and management

The COVID-19 pandemic has painfully confirmed what experts have warned against since the 2009 H1N1 and 2014-2016 Ebola pandemics: the world has been gravely under-prepared for large outbreaks of emerging infectious diseases.

The WHO had new initiatives on better preparedness for future health threats and formulated a range of recommendations, which are summarized below:

Prevent and pre-empt

- Support multifaceted efforts to investigate, map and reduce the risk of emerging infectious diseases globally, including the surveillance of pathogen reservoirs, mitigation, forecasting and early detection of potential outbreaks.

- Support a combination of complementary approaches for accelerating the research on and development of responses to pathogens with epidemic and pandemic potential .

- Strengthen multi- and cross-disciplinary research on pandemic prevention, preparedness, responses and impacts, analysing the multi-faceted societal aspects and consequences of health crises.

Enhance coordination across Member States and at international level

- Establish a standing EU advisory body for health threats and crises ,including epidemics and pandemics. This body should liaise with advisory bodies in the Member States as well as at EU and global level. It should have a multidisciplinary and inclusive membership so it can advise on biomedical, behavioural, social, economic, cultural, ethical, legal ,technological and international aspects .

- Ensure that monitoring efforts are comprehensive, evidence-based ,rapidly shared and well-coordinated across the EU, enabling strategic decisions in response to the situation at hand, insights through real-time comparisons, as well as collective action where appropriate .

- Establish a joint early-response mechanism to contain epidemics and pandemics, including a toolbox of strategies, such as testing, tracing, and isolating as well as containment measures. Any strategy needs to be based on scientific evidence, guided by the fundamental rights framework and applied in a situation-dependent manner. Herd immunity is a concepbest applied in the context of vaccine-acquired immunity. Achieving herd immunity through natural infection by a previously unknown pathogen involving risks to life and health conflicts with the WHO's ethical framework and its multi-principled approach, requiring that utility and equity considerations are balanced .

 Coordinate research and the development and implementation of medical countermeasures during a pandemic or other health threat. Crucial scientific questions should be clarified as quickly as possible after the onset of a health threat such as a pandemic to rapidly inform effective and safe public health measures .

 Coordinate research and the development and evaluation of social measures to mitigate harm and to increase resilience in case of pandemics or other public health crises. Social, economic, ethical, psychosocial and cultural challenges raised by a pandemic should be addressed as quickly as possible after its onset to inform a range of nuanced and locally appropriate measures .

Strengthen systems for preparedness and management

 Encourage Member States to provide healthcare for all, respecting the principles of justice and solidarity and adhering to the commitments established in the context of European fundamental rights instruments ,such as the European Pillar of Social Rights, and the Sustainable Development Goals .

 Ensure robust and equitable access to critical products and services for all EU citizens and demonstrate global solidarity. This involves pre-emptively providing criteria for the allocation, among and within Member States, of limited resources essential to manage a pandemic and mitigate harm, with due regard to the moral equality of all persons .

 Encourage Member States to strengthen public health infrastructure as an essential part of efficient and equitable health services, including interoperable and interconnected health information systems; develop rapid and reliable testing and tracing systems supported by laboratory networks and monitoring capabilities; build public health workforce capacity and strengthen community infrastructures of social care .

 Establish systems for effective risk communication and tackling disinformation and misinformation during crises and strengthen the ECDC's role also in this regard. Develop communication strategies for advice and policy that are evidence-based, fit for purpose, flexible and nuanced and that counter stigmatising and homogenising discourses that serve to exclude and marginalise .

 Together with EU Member States, develop strategies to sustain education in all sectors and in accordance with the Digital Education Plan 2021-2027.The closure of educational institutions touches on several key areas of society and has long-lasting social, economic, medical and psychosocial consequences. It should be carried out with utmost restraint .

 Encourage Member States to strengthen efforts in community involvement and organisation and support civil-society organisations .

 Foster appropriate engineering and other controls in public buildings to limit infection risk indoors for airborne diseases, such as sufficient and effective ventilation, possibly enhanced by particle filtration and air disinfection, avoiding air recirculation and overcrowding. Such measures can help to avoid the need for applying more invasive and restrictive measures such as the closure of educational institutions and work places .
Uphold fundamental rights and strengthen social justice

 Uphold highest standards in the protection of fundamental rights and civil liberties during pandemics. In the rare case of encroachments on rights and liberties to limit harm and risks during pandemics they should be considered only with utmost care, be explicitly limited in time ,continuously reviewed and justified with respect to their necessity and proportionality and lifted as soon as possible .

 Implement the European Pillar of Social Rights, for example by extending social security benefits to workers in non-standard and precarious employment and updating policies towards an appropriate acknowledgement of the value of care work .Find solidarity-based and sustainable ways of living

 Take action in a cross-cutting manner based on the increasing body of knowledge about unsustainable ways of living, which also contribute to the emergence of epidemics and pandemics. This includes addressing the links between health crises and environmental degradation from a‘ planetary health’ perspective, and related fields, such as environmental protection, food, transport and urban planning. It also includes addressing the links between health crises, poverty and structural inequalities.

Hospital infections and epidemics

Lecture 10

Hospital infections and epidemics

What are hospital infection outbreaks?

The definition of a healthcare-acquired-infection (HAI) is clinically-evident infection 48 hours after the admission to the healthcare facility. HAIs are the leading causes of illness and death amongst hospitalised patients. A growing number of patients admitted to acute care hospitals acquire one of more HAIs during their stay. Outbreaks of HAIs are possibly more frequent than are identified and/or reported. An outbreak may be defined as an increase in the occurrence of a disease by reference to a recorded baseline rate – although, in practice, timely notification of a possible outbreak often relies on the past experience of clinical and laboratory staff, and on them being alert to the condition of individual patients. Every hospital needs to establish its baseline HAI incidence so that it can identify unusual levels, action thresholds or outbreaks when they occur.

An outbreak may also be identified by cases of infection that are clearly associated by time, place and person. Person may be represented by the same ward type, attending clinical staff or patient demographic. Although outbreaks represent only a small percentage of cases of infection acquired in hospital, any major increase in cases is evidence that an infection has begun to spread and is beginning to pose a possible serious threat to other patients and staff.

Hospitals need to have plans to deal with outbreaks of HAIs. The infection control practitioners in the hospital should be closely involved in drawing up and approving these plans that should form part of the facility's comprehensive infection prevention and control (IPC) programme. The infection control team must have access to managers and medical and nursing staff who have the authority to take the actions necessary to contain the outbreak. Key elements in prevention of HAIs are implementation of bundles. Regular but ad hoc IPC audits utilizing the National

Department of Health’s tool developed from the National Infection Prevention and Control Policy & Strategy (2013).

infection prevention and control programmes

1-1 What is infection prevention and control?

Infection prevention and control (IPC) aims to prevent or control the spread of infections in healthcare facilities and the community. IPC is a universal discipline with relevance to all aspects of healthcare.

It is part of every healthcare workers’ duty of care to ensure that no harm is done to patients, visitors or staff. All healthcare workers require at least a basic understanding of IPC principles and practice.

Infection prevention and control is a discipline that aims to prevent or control the spread of infections in healthcare facilities and the community.

1-2 What is an infection prevention and control programme?

IPC programmes include activities, procedures and policies designed to reduce the spread of infections, usually within healthcare facilities. The primary goals of an IPC programme are:

- To prevent susceptible patients acquiring pathogenic (disease-causing) micro-organisms
- To limit the spread of antimicrobial resistant infections.

1-3 What is included in infection prevention and control programmes?

There are several components that are common to IPC programmes worldwide including:

- Skilled IPC practitioners (usually nurses, occasionally doctors) who co-ordinate the IPC programme activities and develop, revise, audit and implement policies
- Accountability for IPC and integration of IPC as an essential part of healthcare with direct links to clinical services and non-clinical services (e.g. healthcare facility management and support services).
- A mandate to implement best-practice standards and guidelines
- A strong education component, involving all categories of healthcare workers
- Surveillance for healthcare-associated infections and outbreaks.

Although the basic principles of IPC apply globally, each country and individual healthcare facility will need to adapt and add to the core elements based on their specific circumstances, e.g. differences in patient population, infectious disease profiles, and type of healthcare services delivered.

1-4 Why are infection prevention and control programmes needed?

Healthcare facilities are places where sick people congregate, creating many opportunities for micro-organisms to spread between patients, visitors and healthcare workers. Medical care is also increasingly complex, with multiple, invasive procedures increasing the risk of developing healthcare-associated infections (HAI). Many of these infections (up to 70%) are preventable. Research has proven that IPC programmes can make healthcare safer and more affordable by preventing the suffering, loss of life and cost caused by healthcare-associated infection.

IPC programmes can make healthcare safer and more affordable by preventing the suffering, loss of life and cost caused by healthcare-associated infection.

1-5 Why are infection prevention and control programmes especially important in low-resource settings?

Many low-resource settings have a high burden of infectious diseases, including HIV and tuberculosis. IPC has a critical role to play in these settings to enhance patient safety and to avoid the use of scarce resources for the treatment of healthcare-associated infection.

1-6What are the main activities of an infection prevention and control practitioner?

The main activities performed by the IPC practitioner include:

- Organising surveillance for healthcare-associated infections
- Providing advice and leadership in outbreak investigation
- Developing and delivering training on IPC to healthcare workers
- Developing and implementing IPC-related policies and procedures
- Auditing the quality and effectiveness of healthcare facility environmental cleaning
- Auditing the quality and effectiveness of disinfection and sterilisation practices
- Implementing local, national or international best-practice guidelines for prevention of infection transmission in clinical care.

In many countries, the IPC practitioner has other duties such as seeing to occupational health or quality management. The term ‘quality management’ refers to all activities related to quality planning, assurance, quality control and improvement. In some cases, this may hamper their ability to perform all the required IPC activities. Since the aim is to prevent harm to patients and staff, IPC programmes often form part of a healthcare facility’s quality management programme.

1-7What are the key indicators for infection prevention and control programmes?

There are three key indicators that can be used to report on the impact of an IPC programme.

Compliance indicators: these rate how well local or national Department of Health guidelines are being followed, e.g. the percentage of handwash basins in a facility with soap, water and towels available.

Process indicators: these rate how well individuals follow facility-based guidelines, but may also include how many individuals were trained on local IPC policy implementation, e.g. the percentage of hand hygiene compliance; the number attending training on tuberculosis (TB) infection control.

Outcome indicators: these measure the outcome that IPC programmes are trying to prevent, healthcare-associated infection, e.g. the facility's infection rate from surgical site infections, urinary tract infections in catheterised patients and rates of antibiotic-resistant infections.

The key indicators of IPC programmes address compliance, process and outcome.