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Production of Courseware

e-Content for Post Graduate Courses

Paper No. : 06 Human Growth Development and Nutrition

Module : 29 General Concepts of Epidemiology I

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Description of Module	
Subject Name	Anthropology
Paper Name	06 Human Growth Development and Nutrition
Module Name/Title	General Concepts of Epidemiology I
Module Id	29
Pre-requisites	
Objectives	
Keywords	

Introduction to epidemiology

- Define epidemiology
- Population perspective of epidemiology
- History of epidemiology
- Sub field of epidemiology
- Descriptive and Analytical epidemiology

Understanding Measures of Disease Frequency

- Introduction to Disease Frequency

Learning objectives

- Understand basic concepts in epidemiology
- Discuss example of epidemiology applied to different areas of public health/Sub field of epidemiology
- Define descriptive and analytical epidemiology
- Characterize the population perspective
- Apply the population perspective to an understanding of the global burden of health outcomes and diseases
- Differentiating the following measures: prevalence, risk, rate, and odds
- Calculate the following measures: prevalence, risk, rate, and odds
- Define the concept of person-time and be able to apply this to calculations of rates
- Choose the measure of frequency appropriate for a given situation
- Interpret prevalence, risk, rate, and odds within the context of epidemiology

With the shift in disease prevalence from infectious to chronic diseases (like heart diseases, cancer, diabetes etc) and the development of complex models to explain this shift, the single agent model of epidemiology failed to explain the ñcomplex webò of biological, behavioral, environmental factors which led to the development of these chronic diseases. This led to the importance of introducing anthropological approach in understanding the subjective reasons for the failure of a particular health initiative.

The demand for anthropological input in public health emerged less from academic epidemiology and more from the limitations that professionals in leading organizations, such as the World Heath Organization and bilateral donor agencies, experienced when relying solely on epidemiology for improving program development, evaluation and implementation (*Zoysa et al, 1998)*. As a result, a certain template for expected ways of collaboration developed. Most commonly, applied epidemiological projects now generally incorporate sub-studies based on use of ñqualitative methods,ò usually in a so-called ñformative phase,ò to be carried out by anthropologists. In this template, the anthropologistôs role has consisted largely of helping epidemiologists adapt standardized measurement tools to specific contexts, providing a descriptive narrative of patientsô subjective experiences, or explaining the reasons for the failure of a particular programmatic initiative. Therefore, it is necessary for anthropologists also to understand the concepts of epidemiology in order to make better collaboration between the two disciplines. This module would help us in understanding basic concepts of epidemiology, followed by calculation of various risk estimates. The following modules will focus on type of study designs used for conducting various epidemiological studies.

1. Introduction

The word epidemiology comes from the Greek words epi, meaning "on or upon," demos, meaning "people," and logos, meaning "the study of." Epidemiology is the study of how often diseases occur in different groups of people and why. Epidemiological information is used to plan and evaluate strategies to prevent illness and as a guide to the management of patients in whom disease has already developed. Many definitions have been proposed to define scope of epidemiology; here are two that capture the underlying principles and spirit of epidemiology:

ñEpidemiology 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.ò (Last JM, 1995).

ñEpidemiology is the study of the distribution and determinants of disease frequency in man.ò (MacMahon and Pugh, 1970).

These definitions of epidemiology include several terms which reflect some of the important principles of the discipline:

Study - Epidemiology is a scientific discipline and has at its foundation, sound methods of scientific inquiry.

Distribution - Epidemiology is concerned with the frequency and pattern of health events in a population. Epidemiology focus at population level rather than individual level. Frequency includes not only the number of such events in a population, but also the rate or risk of disease in the population. Pattern refers to the occurrence of health-related events by time, place, and personal characteristics.

Epidemiology is: a) a quantitative discipline built on a working knowledge of probability, statistics, and sound research methods; b) a method of causal reasoning based on developing and testing hypotheses pertaining to occurrence and prevention of morbidity and mortality; and c) a tool for public health action to promote and protect the public's health based on science, causal reasoning, and a dose of practical common sense (Cates WJ, 1982).

2. Population Perspective of Epidemiology

Epidemiology focuses on population perspective rather than individual or biomedical perspective. It main focus is on social, psychological, and environmental factors that are associated with health outcome. The occurrence of health outcomes or disease in population is impacted by immediate causal agents as well as other factors. For example, housing condition in which people live can influence their health. Population perspective help researcher to understand what specific factors affects the health of the population. Population perspective look at *proximal* (downstream) or *distal* (upstream) factors in order to understand the exact causes of diseases.

Proximal or micro level factors and includes physiological and biological factors such as genetic makeup, age, ethnicity, gender, and immune status. Downstream determinants typically are related to diseases and illnesses. Risk factors that cannot be changed can be used to identify groups of people at increased risk and to develop targeted interventions.

Distal or upstream factors are macro level factors such as global forces and government policies. Upstream approaches try to prevent health problems at the source so they donൻt need to be fixed down the stream. Factors such as community design, education, employment, living and working conditions, and poverty are major determinants of health that can be addressed at upstream level.

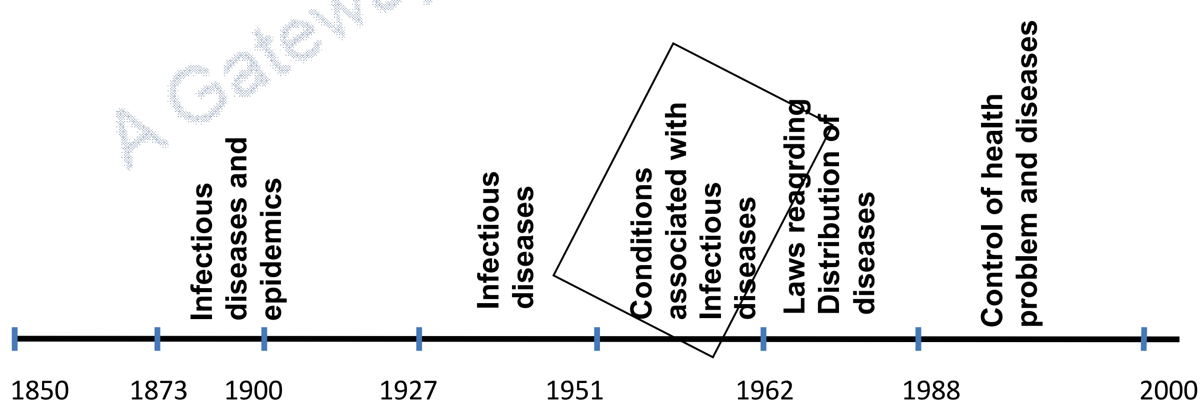
Population perspective refers to a web of causation where many factors play a role in the disease development. Factors including family support, social network, global climate, labor conditions and advertisement, all play part in disease occurrence and therefore should be considered when deciding a public health intervention. All epidemiological research involve some sort of population and every population has its own history, culture, economic and social context which could explain how and why people are exposed to risk factors and how people are affected by their exposure. Population research begins by considering the distribution and determinants of health outcomes at the population level but population research may also include individual and micro level analysis. And understanding of this historical and social context health outcome helps in conducting effective research and in designing effective interventions.

3. History Of Epidemiology

In order to understand the field of epidemiology, it is first helpful to review some of the basic history of the field. People have long viewed epidemics of disease and plagues as terrifying occurrences. There has been continued desired to have a more rational and complete way to understand diseases and health outcomes rather than just believing that diseases were simply caused by spirits or God. This empirical observations of epidemics and other causes of mortality were the beginning of the field of epidemiology.

The history of epidemiology has involved many key players who advanced the study of disease from a supernatural point of view to a viewpoint based on scientific evidence. The Greek physician Hippocrates (460-377 BC) also known as the father of medicine, and was the first epidemiologist. He was the first person known to have examined the relationships between the occurrence of disease and environmental influences. However, the epidemiologic knowledge advanced slowly during next 2000 years. Dr. John Snow who investigated into the causes of the 19th century cholera epidemics, is known as the father of (modern) epidemiology. His identification of the contaminated water as the cause of the Soho epidemic is considered the classic example of epidemiology. He used chlorine in an attempt to clean the water, thus ending the outbreak. This has been perceived as a major event in the history of public health and regarded as the founding event of the science of epidemiology, having helped shape public health policies around the world.

Epidemiologyôs focus was initially on infectious diseases, until early in the 20th century. Its focus was just on infectious diseases and epidemic in mid 1800s. Epidemiology began to focus on infectious diseases overall in the mid 1900s. By the mid 1950ôs epidemiology focus then included not just infectious disease but specific conditions associated with them. In the 1960ôs epidemiology began to focus on laws regarding distribution of disease at a community level. Towards the end of 20th century, computers, increasing information technology, and the new methodological approaches altered the field of epidemiology. Epidemiology has become standard area of clinical science and is the most fundamental basic science of public health. In late 1980ôs epidemiology focused on how to control or minimize health problems and diseases.



4. **Sub-Field Of Epidemiology**

Epidemiology has numerous subfields, concentrating on specific approaches or types of disease. Many epidemiologists focus on specific areas of study, such as:

- Infectious epidemiology
- Chronic diseases epidemiology (ex. Cancer, cardiovascular)
- Maternal and child health epidemiology
- Injury and accident epidemiology
- Environmental epidemiology
- Nutritional epidemiology
- Health policy epidemiology
- Health behaviour epidemiology
- Molecular epidemiology
- Clinical epidemiology
- Occupational epidemiology
- Social epidemiology

4.1 Infectious Epidemiology is the epidemiological study of infectious or communicable diseases. Through the beginning of 20^{th} century, infectious diseases were considered to be the most important global health problem. Infectious diseases are caused by an infectious agent or by the product of infectious agent. Such an infection is due to transmission of the agent from an infected individual, animal or reservoir to a susceptible host. Transmission may be direct or indirect via plant or animal host, vector or object. One example might be the occurrence of the Ebola virus that happened in Africa some time ago. Epidemiologists were heavily involved in trying to identify the agent responsible for the outbreak and the means of the agent's transmission.

4.2 Chronic Diseases Epidemiology is the study of diseases or conditions that have a prolong duration such as heart diseases, epilepsy, diabetes, cancer, stroke, arthritis, glaucoma etc. Over time, there has been a change in epidemiology to also focus on study of chronic diseases. This change came about in part due to the availability of antibiotics and vaccines that have reduced the incidence of some infectious diseases, cured some cases or even prevented some cases of infectious diseases. The change to focus on chronic diseases started in the 1940s and 1950s.

4.3 Maternal and Child Health Epidemiology focuses on improving the health and well being of women, children and families and investigating risk factors for health outcomes that especially affects women and children.

4.4 Injury and Accident Epidemiology is a very important issue in public health, however, epidemiologic and scientific method for the study of injuries and injury control were only really developed beginning in the late 1960s. Urbanization and work in factories increased during industrial revolution and led to increase in work-related accidents and injuries. In the past, such accidents and injuries were considered part of normal working life. However, now it has been known that injuries and accidents occur under patterns and conditions. Many injuries and accidents are predictable and are more likely to occur in certain risk groups, so we can work to reduce or prevent them.

4.5 Environmental Epidemiology focuses environmental exposures or factors that affects health outcomes. Examples of environmental factors or exposures includes chemical or physical agents, microbiological pathogens, social conditions that can affect environmental exposure and climate change.

4.6 Nutrition Epidemiology examines associations between nutrition and health outcomes. Research studies may focus on diet and physical activity. For example recent studies has shown that food allergies are increasing. The number of children with food allergies has increased by 18% from 1997 to 2007 according to US center for disease control and prevention (CDC).

4.7 Health Policy Epidemiology, knowledge gain from epidemiologic studies can be used when planning for health outcomes and diseases control programs, and for policies at both individual and population levels. Public health policy decision should be evidence based, and epidemiologic studies can provide this needed evidence. Example of area of health policy includes medical research policy, pharmaceutical policies, vaccine policy, tobacco control policy, breastfeeding promotion policy.

4.8 Health Behavior Epidemiology focuses on research of distribution and determinants of health behaviours and evaluates interventions and services for behaviours such as substance abuse or psychiatric disorders and also how health behaviours and policies are associate with communicable diseases such as tuberculosis, HIV, and other sexually transmitted infections. An understanding of how behaviour affects health promotion and diseases prevention is important.

4.9 Molecular Epidemiology refers to the applications of molecular techniques and genetic techniques to the study of the occurrence of disease and the mechanisms of disease in the population. For example, some important work has been done on genetic factors in cancer and how those relate to the occurrence of disease in the population.

4.10 Clinical Epidemiology refers to the application of epidemiology to specific clinical problems. An example would be, "If an individual is administered a specific treatment, what is the likelihood that that individual will survive?" Another aspect of clinical epidemiology is the use of screening tests to refer individuals for diagnostic work-up.

4.11 Social Epidemiology often draws upon the tools of sociology and social sciences in order to explain the occurrence of diseases in populations. Examples of issues relevant to social epidemiology include how diseases vary according to social class and status hierarchy.

5. Descriptive and Analytic Epidemiology

5.1 Descriptive Epidemiology

It describes the distribution of disease through describing a condition by various characteristics of person, place, and time.

- Personal characteristics include demographic factors such as age, race, sex, marital status, and socioeconomic status, as well as behaviors (such as occupation or risk-taking activity) resulting in environmental exposures.

- Place characteristics include geographic variation, urban-rural differences, and location of work sites or schools.
- Time characteristics include annual occurrence, seasonal occurrence, and daily or even hourly occurrence.

It is the first stage in an epidemiologic study, in which a disease that has occurred is examined. When we ask what is the distribution or pattern of diseases or health outcome in a population we are talking about descriptive epidemiology. Descriptive epidemiology deals with the frequency and distribution of disease or risk factors in the population. Descriptive epidemiology can be used for hypothesis generation, but usually cannot be used to test hypothesis.

Descriptive epidemiology can be used to evaluate:

- trends in disease, health and risk factors such as smoking or
- determine if a health status is improving or getting worse
- to determine if new diseases are occurring, and
- provides factual basis for evaluating public health programs and services
- to identify the problems to be studied by analytic epidemiology

5.2 Analytic Epidemiology

It aims to research and study risk factors and preventive risk factors for diseases. It is applied to understand the underlying causes of the pattern of diseases or health outcome and investigate the causes. Use of comparison group is the key of analytic epidemiology. For example, study on the causes of obesity would study dietary differences between two or more comparison groups.

6. Understanding Measures of Disease Frequency

6.1 Introduction to Disease Frequency

The essence of epidemiology is to measure the distribution and determinants of disease (outcomes) frequency in human populations in order to control health problems. Thus, the objectives of epidemiology are to determine the extent of disease in a population, identify patterns and trends in disease occurrence, identify the causes (exposures) of disease, and evaluate the effectiveness of prevention and treatment activities. Measuring how often a disease arises in a population is usually the first step in achieving these goals. These measures are called ñmeasures of disease frequencyò.

Because epidemiology is concerned with the occurrence of disease in groups of people rather than in individuals, populations are at the heart of epidemiologistsô measurements. A population can be defined as a group of people with a common characteristic such as place of residence, religion, gender, age, use of hospital services, or life event (such as giving birth).

Epidemiologists must always consider three factors when they measure how commonly a disease occurs in a group of people: (1) the number of people that are affected by the disease, (2) the size of the population from which the cases of disease arise, and (3) the length of time that the population is followed. Failure to consider all three components will give a false impression about the impact of the disease on a population.

6.2Measures of Disease Frequency

The two basic measures of disease frequency in epidemiology are incidence and prevalence. Incidence measures the occurrence of new disease, and prevalence measures the existence of current disease. Each measure describes an important part of the natural course of a disease. Incidence deals with the transition from health to disease, and prevalence focuses on the period of time that a person lives with a disease.

6.2.1 Incidence

Incidence is defined as the occurrence of new cases of disease that develop in a candidate population over a specified time period. There are three key ideas in this definition. First, incidence measures new disease events. For diseases that can occur more than once, it usually measures the first occurrence of the disease. Second, new cases of disease are measured in a candidate population, which is a population of people who are ñat riskò of getting the disease. Someone is at risk because he or she has the appropriate body organ, is not immune, and so forth. For example, a woman who still has an intact uterus (that is, she has not undergone a hysterectomy) is a candidate for getting uterine cancer, and a child who has not been fully immunized against the polio virus is a candidate for contracting poliomyelitis. Third, incidence takes into account the specific amount of time that the members of the population are followed until they develop the disease. Because incidence measures a personõs transition from a healthy to a disease state, time must pass for this change to occur and be observed.

$$\text{Incidence} = \frac{\text{Number of new cases during a period of time}}{\text{Number of candidate population during a specified period of time}}$$

6.2.2 **Prevalence**

Prevalence is one of the most common epidemiologic measures you see in our daily news. For example, you may see a news headline based on prevalence measure, such as óthe proportion of people that are overweight.

News paper headline*: "Approximately 12% of world population is obese."*

"Malaria infects 10% of world population."

While incidence measures the frequency with which new disease develops, prevalence measures the frequency of existing disease. It is simply defined as the proportion of the total population that is diseased. There are two types of prevalence measuresð *point prevalence* and *period prevalence*ð that relate prevalence to different amounts of time. Point prevalence refers to the proportion of the population that is diseased at a single point in time and can be thought of as a single snapshot of the population. The point can be either a particular calendar date such as December 1, 2005 or a point in someoneôs life such as college graduation. Period prevalence refers to the proportion of the population that is diseased during a specified duration of time, such as during the year 2005. The period prevalence includes the number of cases that were present at the start of the period (for example, January 1, 2005) as well as the number that developed during the period (for example, January 2 through December 31, 2005). It may be helpful to think of period prevalence as derived from a series of snapshots. Mathematically, point prevalence and period prevalence are expressed as follows:

$$\text{Point Prevalence} = \frac{\text{Number of cases in a defined population at one point in time}}{\text{Number of persons in a defined population at the same point in time}}$$

$$\text{Period prevalence} = \frac{\text{Number of defined cases dring a period of time}}{\text{Number of persons in a defined population during a period of time}}$$

It is important to understand who should be in the denominator of the calculation. The denominator should represent the people who could have the disease or health outcome in the study population.

Example

Of 10,000 female residents in town A on 1st January 2015, 1,000 have hypertension. The point prevalence of hypertension among women in town A on this date is calculated as:

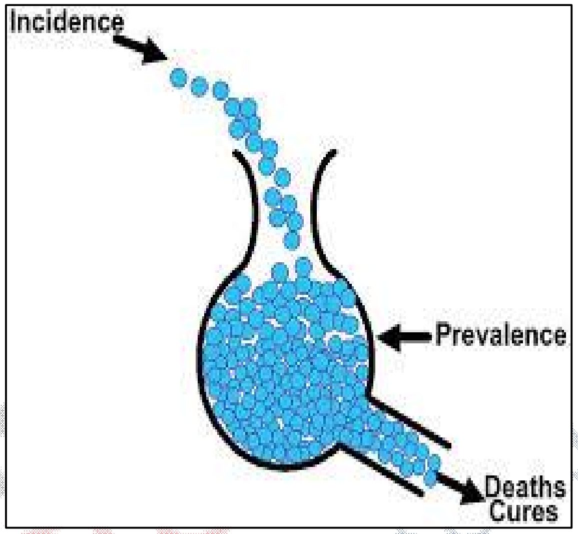
1,000/10,000 = 0.1 or 10%

Thus the prevalence of hypertension on January 1^{st}, 2015 was 10 percent.

- Prevalence is a useful measure for quantifying the burden of disease in a population at a given point in time
- Calculating prevalence of various conditions across different geographical areas or amongst different sub-groups of the population and then examining prevalence of other potential risk factors can be of particular use when planning health services

Prevalence is not a useful measure for establishing the determinants of disease in a population

- Prevalence can be viewed as describing a pool of disease in a population i.e. all the existing cases of diseases not just new cases of diseases.
- Incidence describes the input flow of new cases into the pool.
- Incident cases includes all individuals who change in status from not having a diseases to having a disease in a specific time period
- Incident cases are used to calculate risk, rates



(Figure 1)Gordis: Epidemiology, 4th Edition.

To understand incident cases versus prevalent cases, imagine a pot partially filled with water (fig 1). Each drop of water in pot represents an existing case of the health outcome or disease. These are prevalent cases. The total capacity of the pot represents total population at risk of disease. If we add more water to bucket, then the new drops are incident cases. Any water that drains out or leaves the pot represents death or recovery. So to briefly summarize, the difference between prevalent cases and incident cases are that incident cases are new cases of diseases, and prevalent cases include existing and new cases of disease.

6.2.3 Risk

Rates are very flexible measures of health outcome or disease occurrence. They are more exact and they reflect more dynamic, changing study population. It is the probability of getting either a disease or health outcome and it is for a population and not an individual. For calculating risk:

Numerator: incident cases (i.e. new cases identified during study follow-up)
Denominator: study population at risk of getting disease at beginning of follow-up

So the formula for calculating risk is as follows:

$$\text{Risk} = \frac{\text{Number of new cases or incident cases}}{\text{Total number of at-risk individuals}} \text{ in specified time period}$$

- Risk measures the number of new cases of the health outcome or disease that develop among the people in the population at risk, over a specified time period.
- Risk refers to the probability that a disease will occur.
- Risk can be expressed as proportion and ranges from 0% to 100%.

Why to measure risk?

We use risk as measure for several reasons:

1. Itős fairly easy to calculate and interpret risk.
2. It has clear meaning to clinicians and lay-people.
3. And patients understand basic percentages.

Risk can be used to make various health decisions both at the population and at individual level. At an individual level risk can be used to help patients decide whether to accept a drug intervention. When calculating risk, we generally assume:

- A specified time period: that the entire population at risk at the beginning of the study period has been followed to determine who developed the disease of interest.
- A closed study population: means no new individuals are entering study once the study has started. So no individual can join halfway through the study. In a closed study population, people in the study do not leave or enter the population due to birth, death, migration, loss to follow up etc.

6.2.4 **Rates**

Rate measures occurrence of new cases of a disease in a population. It is not same as proportion because denominator is not fixed. Instead rate accounts for realistic situation in which population is changing over time. Population at risk change due to changes such as births, deaths, and migration. In a study population, a person can decide to longer participate in study population thus some people may be lost to follow up during the course of study. In order to take this change in account, rates take in account the sum of time called óperson timeô that each person remains at risk for that disease under study observation.

Advantage of using rate instead of prevalence, incidence or risk:

- Rates are more flexible, more exact, capture the reality of changing population
- Rates can also be used to study repeated events, where a person can develop the disease. They no longer have the disease or health outcome for a period of time, and then develop the same disease or health outcome again.

Disadvantage of using Rates:

The reason we don't use rates all the time because rate data can be more costly and difficult to collect.
How to calculate Rates:
1st step: Define study population: The first step to calculate rate is to define the study population.
2nd step: Determine new cases: Then to determine the number of new cases of disease.
3rd step: Determine the denominator: i.e. person time at risk.

$$\text{Rate} = \frac{\text{Number of new cases or incident cases}}{\text{Total person-time at risk}} \text{ in specified time period}$$

The incidence rate is the rate of contracting the disease among those still at risk. When a study subject develops the disease, dies or leaves the study they are no longer at risk and will no longer contribute person-time units at risk.

Calculation of person-time at risk

The denominator in an incidence rate is the sum of each individual's time at risk and is commonly expressed in person time at risk. Person time is the sum of time that each person remain at risk for the disease or health outcome under the study observation. Person time can be expressed in units of person-years, person-months, person-days or some other scales. A person in the study can stop contributing person-time for a variety of reasons, such as death, leaving the study, moving to different country or the person develops the disease or health outcome during study or the researcher is unable to follow-up with them.

The use of person time as oppose to just time enable one to handle situations in which people die or migrate out of the study population or where there are drop out in a study, and where you have not been able to follow your entire study population at risk to watch for the development of the disease under investigation. Thus, the follow up period does not need to be uniform for all participants. Person-time for a group is the sum of the times of follow up for each participant in that group.

For example: Person-time (years) at risk for 5 individuals in a hypothetical cohort study between 2000-2004.

Year → Persons ↓	**2005**	**2006**	**2007**	**2008**	**2009**	**Years at risk**
1	---					5.0
2	---X					4.5
3	---X					3.5
4	---------------------------------------X					1.5
5	---L					3.5
Total	4	5	4.5	3	1.5	**18**

--- = time at risk, X = disease, L = person lost to follow up

Figure illustrates the calculation of person-time units (years) at risk of a hypothetical population of 5 individuals in a 5 year cohort study. In the above example the incidence rate for disease (X) is calculated as:

$$\text{Rate} = \frac{\text{Number of new cases or incident cases}}{\text{Total person-time at risk}} \text{ in specified time period}$$

Rate = 3/18 = 0.167 per person year or 16.7 per 100 person years.

Note that for most rare diseases, risks and rates are numerically similar because the number at risk will approximately equal the total population at all times.

6.2.5 Odds

In statistics we refer odds as the ratio of the probability that an event, such as a disease, will occur, to the probability that the event, such as disease, will not occur. Odds are used in epidemiology because of their convenient mathematical properties.

If we use ‘*p*’ as the symbol for probability. Then the mathematical formula for calculating odds is ***p*/(1-*p*)**

Advantage of Odds

- Odds are easy to calculate and interpret.
- Odds tend to have more meaning to clinicians and lay-person compared to rates.
- Odds can be used to provide information to patients in clinical settings since it can be easily understood.

Example 1: the probability of occurrence of a event is 0.20, then the odds are:

***p*/(1-*p*)**= 0.20/(1-0.20)
= 0.20/0.80
= 0.25

Example 2, if the probability of diabetes in a patient is 5%, then the odds of diabetes are:

So probability is 0.05,

Odds = 0.05 / (1-0.05)
= 0.052632 or 1:19

Example 3: Out of 100 births, the probability of having a boy is 51% while the probability of having a girl of 49%. The odds of having a boy is:

Odds = 51/49
= 1.04