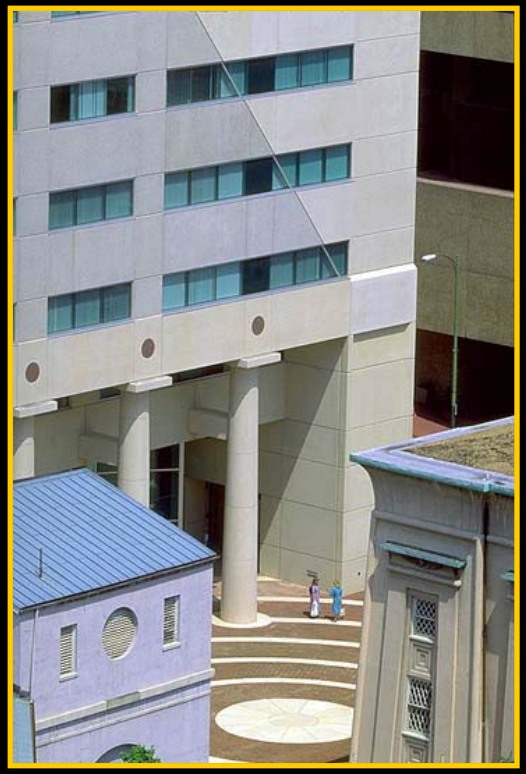
Measures of Disease Frequency



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Objectives

1. Differentiate rates, proportions and ratios
2. Compute prevalence and incidence rates
3. Define the different mortality rates and years of potential life lost
4. Compute and differentiate crude, specific and adjusted rates
5. Determine the uses for adjusted rates
6. Name the two methods of rate adjustment

Introduction

- The most common form of organizing epidemiologic information is through collecting information about cases and non-cases.
- The numbers are usually translated into rates.
  - Rates indicate the risk of disease for a population.
  - This helps to identify high-risk groups and causal factors.
- Data elements collected from cases and non-cases are called variables (age, sex, race, weight, height, temperature, blood pressure, disease, death etc)

Rates, Ratios and Proportions

- Variables or data elements are summarized to provide number of cases, proportions, rates and ratios = frequency
- In epidemiology many variables have only two possible categories
  - these are called dichotomous variables
    - (e.g. disease or no disease; alive or dead).
- The frequency measures we use with dichotomous variables are ratios, proportions and rates.

Rates, Ratios and Proportions

- **Ratio** = the values of x and y may be completely independent, or x may be included in y. For example, the sex of children attending well baby clinic (male to female).

- **Proportion** = x is included in y (female/all $*10^n$)
  i.e. Percent of females

Rates, Ratios and Proportions

- **Rate** = is a proportion with time dimension. It measures the occurrence of an event in a population over time.
  - *Rate= number of cases or events occurring during a given time period/ population at risk during the same time period*10^n*
  - Rate is the measure of risk for disease with a time components
  - The persons in the denominator must reflect the population from which the cases in the numerator arose

Rates, Ratios and Proportions

- The counts in the numerator and denominator should cover the same time period
- The person in the denominator must be at risk for the event
- Once numerator is divided by denominator – the quotient is multiplied by a factor to make it easier to understand

Incidence Rate

- Incidence rate is the most common way of measuring and comparing the frequency of disease in populations.

- Definition: incidence refers to the occurrence of new cases in a population over a period of time.

- It estimates the risk of developing a disease in a specified population during a specified period of time.

Cumulative Incidence

There are two types of Incidence rates:

1. **Cumulative Incidence (CI):** is the proportion of people who become diseased during a specified period of time.

$$CI = \frac{\text{Number of new cases of a disease during a specific period}}{\text{Total population at risk}} \times 10^n$$

- CI provides an estimate of the probability, or risk that an individual will develop a disease during a specified period of time.

- The time period must be clearly specified when reporting the CI.

Cumulative Incidence

- The CI assumes
  - That the entire population is at risk at the beginning of the study period
  - That the populations has been followed for the specified time interval

Cumulative Incidence

- In 2000:
  - 733,151 new cases of gonorrhea were reported among the United States civilian population.
  - The mid-year civilian population was estimated to be 246,552,000.

CI=[733,151/246,552,000] x 1,000= 2.97 per 1000 population.

Incidence Density

2. **Incidence density (ID)** = measure of risk in a changing population where people are free of disease at start and observed for onset of disease for different time periods

- Shows how rapidly cases develop

- In presenting an incidence density, it is essential to specify the relevant time units – i.e. number of cases per person-day, person-month, person-year, etc.

- Person-time is the number of persons at risk for disease multiplied by the length of time they are observed for onset of disease

Incidence Density

Person years = # of person * # of years followed up

Example: In a cohort study, 600 contraceptive users were followed over the course of three years as follows:

- 100 women for 1year
- 200 women for 2 years
- 300 women for 3 years

The number of person-years of observation in this study is:

- 100 women x 1 = 100 person-years
- 200 women x 2 = 400 person-years
- 300 women x 3 = 900 person-years

Total = 1400 person-years

Incidence Density

- Of these 600 people
  - 10 developed thromboembolism.

- The incidence rate of thromboembolism is calculated as:
  - 10/1400 = 7.1 per 1000 person years of follow up.

Prevalence Rate

- Is the proportion of persons in a population who have a particular disease or attribute at a specified point in time or over a specified period of time

- Gives an indication of the "burden" of disease in a population - numerator is existing cases

- Usually expressed as a percentage i.e., multiplier = 100 and if the disease is rare it is expressed as 10^n

Prevalence Rate

There are two types of prevalence:

1. **Point prevalence:** is the presence of a disease at a single point in time (snap shot).

$$= \frac{\text{Number of existing cases at a specific point of time}}{\text{Total mid-point population at risk}} \times 10n$$

2. **Period Prevalence:** the presence of a disease at a particular time interval.

$$= \frac{\text{No. of existing cases at a specific period of time}}{\text{Total mid-period population at risk}} \times 10n$$

- Prevalence usually refers to point prevalence

RELATIONSHIP BETWEEN PREVALENCE AND INCIDENCE

- Incidence – new cases
- Prevalence – all cases (existing and new)
- Prevalence and Incidence are related by average duration (D) of disease in a stable population

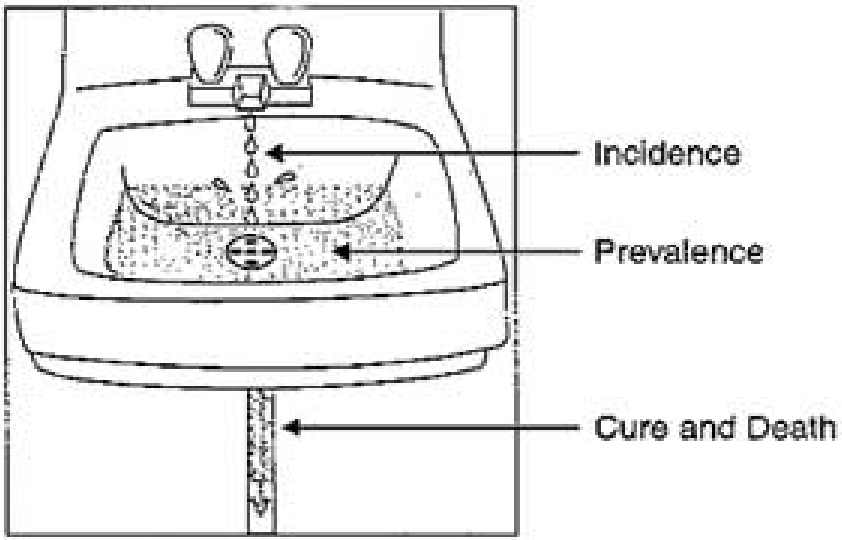


FIGURE 2-4. Relationship between Incidence, Prevalence, Mortality and Cure

PREVALENCE AND INCIDENCE

- If a disease lasts a long time, there will be higher prevalence in the population

- If incidence is low but those affected have the condition for long = the prevalence will be high relative to the incidence

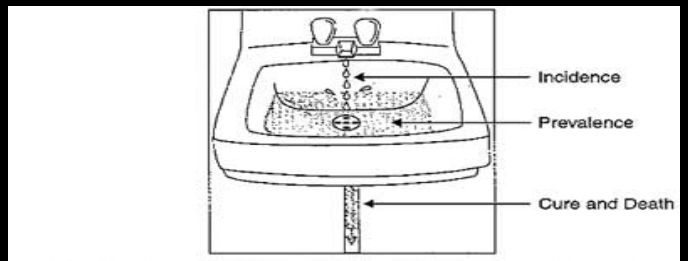


FIGURE 2–4. Relationship between Incidence, Prevalence, Mortality and Cure

- If disease is short-lived, there will be low prevalence in the population

- If incidence is high but the disease duration is short then the prevalence will be low relative to the incidence

Relationship Between Prevalence and Incidence

- Example: a follow up study of the Framingham data showed males and females had same IR for heart disease but females had a higher prevalence of disease – WHY?

- PR = What proportion of the population has this condition?

- IR = At what rate do new cases arise over time in the population?

Relationship Between Prevalence and Incidence

- Example: in Richmond City, 2006, there were a total of 5,000 hepatitis B cases of which 1,000 were newly diagnosed.
  - The total population of Richmond City is 200,000.
  - Prevalence in 2006: 5,000/200,000*1000=25 per 1,000 population
  - Incidence in 2006: 1,000/200,000* 1000=5 per 1,000 population

Uses of Prevalence and Incidence Measures

- Prevalence is mostly used for planning, evaluating
- Incidence is used to identify causal relationships

Attack Rate

1) **Attack Rate**: Is a variant of an incidence rate, applied to a narrowly defined population observed for a limited time, such as during an epidemic or outbreak of a disease. It is usually expressed in %.

   A measure of probability of risk.

Attack Rates and Picnics

Attack Rate

$$\text{Attack rate} = \frac{\text{No. of new cases in the population during the period}}{\text{Population at risk at the beginning of the period}} \times 100$$

Example: Of 75 persons who attended a church picnic, 46 subsequently developed gastroenteritis. The attack rate of gastroenteritis is:

$$\frac{46}{75} \times 100 = 61\%$$

- The risk of developing gastroenteritis in this population was 61%.

Secondary Attack Rate

2) Secondary attack rate: is a measure of the frequency of new cases of a disease among the contacts of known cases.

$$\frac{\text{No. of case among contacts of primary cases during the period}}{\text{Total number of contacts}} \times 100$$

Secondary Attack Rate

- Example:
  - Seven cases of hepatitis A occurred among 70 elderly patients in an adult day care center.
  - The total number of persons in the 7 affected families were 32.
  - In several weeks, 5 family members of the 7 infected patients also developed hepatitis A.

- Calculate the attack rate and the secondary attack rate among family contacts of those cases.

Secondary Attack Rate

- Cases of hepatitis A among the elderly = 7
- Number of elderly in the adult care center = 70
  - Attack rate = 7/70 x 100 = 10%
- Cases of hepatitis A among family contacts = 5
  - Number of persons at risk in the families (total number of family member with elderly already infected) = 32-7 = 25
- Secondary attack rate = 5/25 x 100 = 20%

Mortality Measures

- **Crude Mortality Rate**: is a measure of the frequency of occurrence of death in a defined population during a specified interval i.e. for a defined population over a specified period of time

Crude MR = $\frac{\text{Death occurring during a given time period}}{\text{Total mid population among the deaths occurred}}$ x10n

Example: In 2001, there were 12,000 deaths from all causes among 2 million population of Atlanta, Georgia.

Crude MR = $\frac{12{,}000}{2{,}000{,}000}$ x 1000 = 6 deaths per 1000 population per year

Mortality Measures

- **Case Fatality Rate:** is the proportion of persons with a particular condition (cases) that die from the condition. It is usually expressed in percent.

$$\text{Case Fatality Rate} = \frac{\text{Number of deaths due to a disease}}{\text{Number of people with the same disease}} \times 100$$

Example: in Richmond city, there were 500 cases of colon cancer, of whom five died within a year after their initial diagnosis. The case fatality rate for colon cancer in Richmond city was:

$$5/500 \times 100 = 1\%$$

Mortality Measures

- **Age-specific MR** = is a mortality rate limited to a particular age group.

Mortality Measures

- **Infant Mortality Rate:** is one of the most commonly used measures for comparing health service among nations.

$$\text{IMR} = \frac{\text{Number of infant deaths less than one year of age}}{\text{Total number of live births during the same year}} \times 1000$$

Example: Denver, Colorado, with a population of 2.37 million, reported a total of 270 infant deaths and 30,000 live births in 1981.

- IMR = 270/30,000 x 1000 = 9 infant deaths per 1000 live births per year.

Mortality Measures

- **Neonatal Mortality Rate:** is defined as the period from birth up to 28 days.

$$NMR = \frac{\text{Number of neonatal deaths}}{\text{Total number of live births during the same year}} \times 1000$$

E.g. Memphis, Tennessee, with a population of 1.37 million, reported a total number of 150 neonatal deaths and 30,000 live births in 1982.

NMR = 150/30,000 x 1000 = 5

Five neonatal deaths per 1000 live births per year.

Mortality Measures

- **Post neonatal mortality rate:** The post neonatal period is defined as the period from 28 days of age up to but not including 1 year of age.

$$\frac{\text{No. of deaths in children between 28 days and 1 yr. of age}}{\text{Number of live births during the same time period}} \times 1000$$

Mortality Measures

- Example: In Oakland California there were 2 million births in 1995, of which 10,000 died before they reach their first birth day. 7,500 of the infant died within the first 28 days. Calculate the IMR, NMR and PNMR

  - Live births 2,000,000
  - Infant deaths 10,000
  - Neonates 7,500
  - Post-neonates 2,500 = 10,000-7,500

IMR = 10,000/2,000,000 x 1,000 = 5 per 1,000 live births
NMR = 7,500/2,000,000 x 1000 = 4 per 1,000 live births
PNMR = 2,500/2,000,000 x 1000 = 1 per 1,000 live births

Mortality Measures

- **Years of Potential Life Lost (YPLL)** = measure of premature death
  - Premature death = when a death occurs earlier than expected if disease were not present.
  - YPLL == Years lost before age 75 years or set age
  - Difference between age 75 years and the age of death is calculated for each decedent in population and summed

Adjusted Rates

- A statistically manipulated rate controlling for the factor of interest (age, race, etc)

  - Specific rates give more valuable information when comparing rates between sub-groups
    - However, specific rates do not provide accurate comparison with other population.
  - Adjusted rates provide a summary statistic that corrects for differences in age or other factors in populations – making comparisons possible between different populations
- The computational process for adjusted rate is called "standardization" or "adjustment"

Adjusted Rates

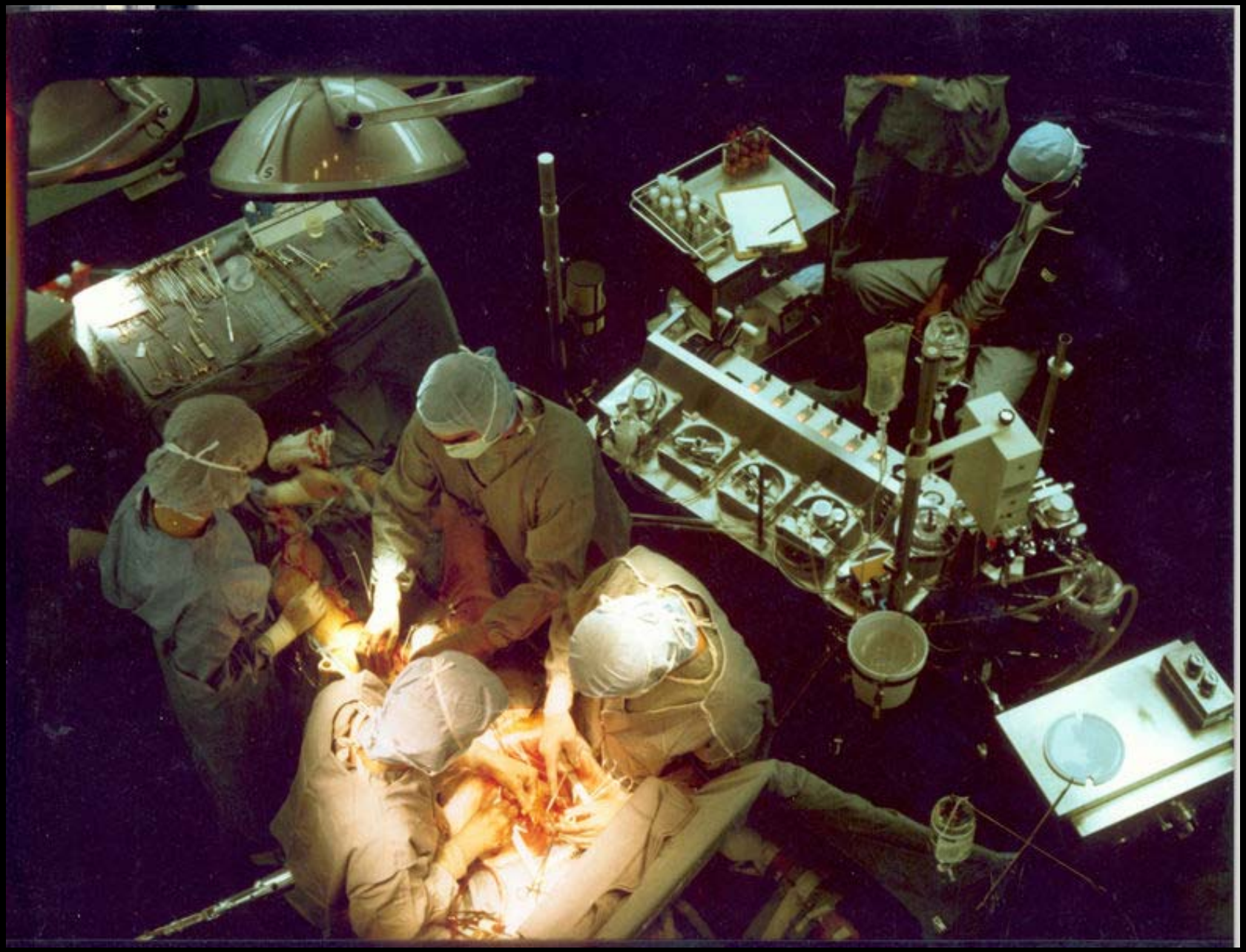
- Advantages
- Provides summary statement
- Differences in groups removed to permit unbiased comparisons

- Disadvantages
- Statistically manipulated rates (fictional)
- Absolute magnitude dependent on choice of reference population

Adjusted Rates

- Two methods of adjustment:
  - 1) Direct
  - 2) Indirect

- Direct Method is commonly utilized in practice
  - **But is this necessarily the most accurate?**



Adjusted Mortality Rates

- Example:
  - You are a primary care practitioner in a suburb of a medium-sized city.
  - Some of your patients lately have been older men with cardiac chest pain, and after appropriate testing you have decided that several of them should undergo coronary artery bypass surgery.
  - There are 2 groups of surgeons and you want to send your patients to the group with lowest mortality rate.

Direct Comparison of Mortality Rate

Age Group	Clinic A			Clinic B		
	Surgeries	Operative Deaths	Operative Mortality	Surgeries	Operative Deaths	Operative Mortality
45-54	500	6	1.2%	300	3	1%
55-64	300	15	5%	300	12	4%
65-74	200	20	10%	400	36	9%
Total 45-74	1000	41	4.1%	1000	51	5.1%

Adjusted Rates

- **Step 1:** Calculate age-specific rates in the populations you want to compare

Age Group	Clinic A			Clinic B		
	Surgeries	Operative Deaths	Operative Mortality	Surgeries	Operative Deaths	Operative Mortality
45-54	500	6	1.2%	300	3	1%
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65-74	200	20	10%	400	36	9%
Total 45-74	1000	41	4.1%	1000	51	5.1%

Adjusted Rates

- **Step 2**: Choose a reference population whose age composition is known.

- US 2000 standard population
  - 45-54 years 134,834
  - 55-64 years 87,247
  - 65-74 years 66,037

Adjusted Rates

- **Step 3:** Calculate Expected deaths in reference population if the Clinic A- or Clinic B-specific rates were the true rates

Age Group	No. in ref pop (1)	Operative Mortality		Expected # of deaths in ref pop using rates from	
		Clinic A (2)	Clinic B (3)	Clinic A (1)x(2)	Clinic B (1)x(3)
45-54	134,834	1.20%	1.00%	1618.0	1348.3
55-64	87,247	5.00%	4.00%		
65-74	66,037	10.00%	9.00%		
Total	288,118			12,584.1	

Adjusted Rates

- **Step 4**. Add up the total number of deaths expected in the reference population under each clinic's set of rates.

Age Group	No. in ref pop (1)	Operative Morality		Expected # of deaths in ref pop using rates from	
		Clinic A (2)	Clinic B (3)	Clinic A (1)x(2)	Clinic B (1)x(3)
45-54	134,834	1.20%	1.00%	1618.0	1348.3
55-64	87,247	5.00%	4.00%	4362.35	3489.88
65-74	66,037	10.00%	9.00%	6603.70	5943.33
Tot (45-74)	288,118			12,584.1	10,781.5

Adjusted Rates

- **Step 5**. Calculate the age-adjusted operative mortality rate for each study group by dividing the sum of expected deaths by the total size of the reference population:

$$\frac{\text{Expected \# of deaths} \times 100}{\text{Total size of the ref. pop.}}$$

Adjusted Rates

- Clinic A: 12,584.1 / 288,118 * 100 =
  - 4.37 / 100 surgeries
- Clinic B: 10,781.5 / 288,118 * 100 =
  - 3.74 / 100 surgeries

- **Which clinic would you recommend now?**

THE END

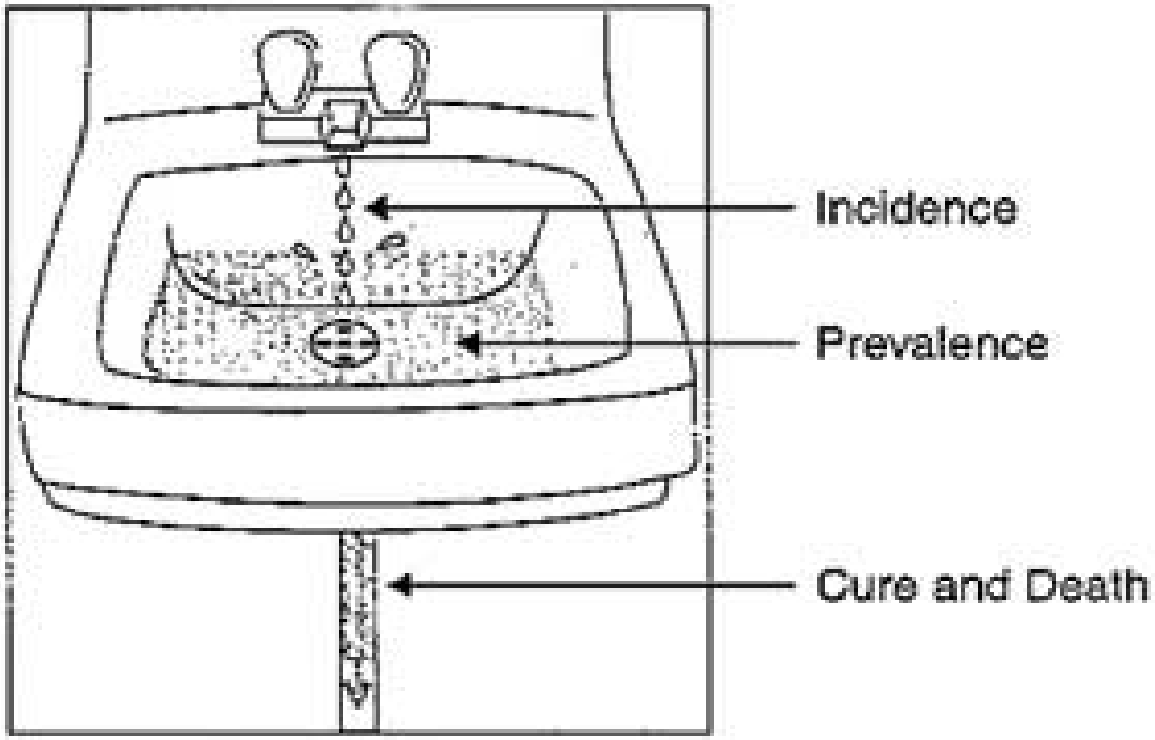

FIGURE 2-4. Relationship between Incidence, Prevalence, Mortality and Cure

Measures of Disease Frequency