Measures of Morbidity and Mortality

Part 1

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Definitions of Epidemiology

- The study of the **distribution**, **determinants** and **deterrents** of morbidity and mortality in human populations. (Oleckno)

- Numerators and denominators

The Numerator: What is Health and Disease

How do we define "health"?
-WHO: physical, mental and social well-being

Problems with definition of health from an epidemiologic /research perspective?
-Must define health or lack thereof in quantifiable terms, usually measure disease (morbidity and mortality)

How do you define a disease?

Changes in Disease definitions

- Definitions change as more is learned about disease and better tests developed to measure the disease

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Changing disease definitions
source: Aschengrau and Seage

TABLE 2–2   Changes in the Definition of AIDS over Time

Year	Existing knowledge about AIDS	Conditions included in disease definition
1982	Very limited	Only a few conditions including Kaposi's sarcoma, Pneumocystis carinii pneumonia, and other severe opportunistic infections
1985	HIV virus discovered as cause of AIDS; antibody test developed	23 clinical conditions with laboratory evidence of infection
1993	Discovered importance of CD4 T lymphocytes in monitoring immunodeficiency and disease progression	26 clinical conditions and asymptomatic cases with low CD4 T lymphocyte counts

Sources: Data from Centers for Disease Control. Update on acquired immune deficiency syndrome (AIDS)—United States. MMWR. 1982;31:507–514. Centers for Disease Control. Revision of the case definition of acquired immunodeficiency syndrome for national reporting—United States. MMWR. 1985;34:373–375. Centers for Disease Control. 1993 revised classification system for HIV infection and expanded surveillance case definition for AIDS among adolescents and adults. MMWR. 1992;44:1–19.

The Denominator: Definition of a population

- What is a "population"?
Group of people with a common characteristic(s)

- How can we define populations?
Residence, catchment area, common event (disease etc), occupation etc

- Why do we need to know?
Determine who is at risk of disease

Studying the Distribution of Disease The basic measures of epidemiology

- **Counts - n**

- **Ratios - a/b one number divided by another (numerator and denominator are usually mutually exclusive)**
- **Proportions - a/a+b (no time period in the equation itself) – often expressed as a percent**
- **Rates - a/a+b per 1,000, 10,000, 100,000 over a _specified period of time_**

Counts: Most basic measure of disease frequency

· Count # in numerator: reflects the number of affected individuals in a population
· Count # in denominator: reflects the population at risk

· Numerator counts: useful for allocation of health resources

· Counts only of numerators: limited usefulness for epidemiologic purposes without knowing the size of the population at risk

Ratios

Ratio = A/B where A and B are usually mutually exclusive of one another

**There is no implied relationship between the numerator and denominator

Ratios are typically used to _compare_ the _magnitude_ of two or more measures:

- 60 students, 35 females, 25 males

Ratio of female to male students

= 35:25 = (35/25=1.40) = 1.40:1 = 40% more females

Proportions

- Everyone in **numerator always included in the denominator (a/a+b)**

- **Tells what fraction of the population is affected**

- **Always ranges from 0 to 1(commonly expressed as percentage)**

- **Has _no element of time_ within the calculation**

Proportions

- 60 students:
  - 35 female, 25 male
  - 30 students aged 25 years and over, 30 younger than 25 years
- **What is the proportion of females?**
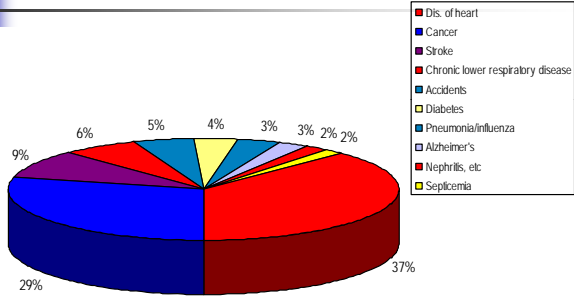- **What is the proportion of younger individuals (<25)?**

35/60 = **58%**
30/60 = **50%**

Articulate Quizmaker Quiz Placeholder - review1_lecture2_part1

Top 10 causes of death as proportions of all deaths, all ages, 2000 (NCHS/CDC faststats)

Legend:
- Dis. of heart
- Cancer
- Stroke
- Chronic lower respiratory disease
- Accidents
- Diabetes
- Pneumonia/influenza
- Alzheimer's
- Nephritis, etc
- Septicemia

Percentages shown: 9%, 6%, 5%, 4%, 3%, 3%, 2%, 2%, 29%, 37%

Rates

Rates - $a/a+b$ per 1,000, 10,000, or 100,000 over a _specified period of time_

**number of events
population at risk per time unit (per 10^3, 10^4, etc.)**

Counts

Example
- Location   New cases   Reporting period (yr)   Population
- City A   20   2005   100
- City B   100   2005   1000

Counts: 100 in City B vs. 20 in City A - Does City B have " **more**" of the disease than City A?

Rates

- Location   New cases   Reporting period (yr)   Population
- City A   20   2005   100
- City B   100   2005   1000

Which city has the higher Annual **RATE** of new cases City A or City B?

Hypothetical data on the frequency of hepatitis in two cities

Location	New cases of hepatitis	Reporting period	Population
City A	58	1985	25,000
City B	35	1984-1985	7,000

Does City A have a higher rate of hepatitis than City B?

Using new cases: City A: 58 vs City B: 35

Using rates: City A 58/25,000= .00232 or 232 per 100,000 per year (1985)

City B 35/7,000 = .005 or 500 per 100,000 over 2 years 500/2=$250/10^5$/year

Conclusion: Cities A and B have a very similar rate of hepatitis per year but B's is higher
Source: Hennekens and Buring, 1986

Proportions vs. rates

For proportions and rates, numerator is included in the denominator : $a/a+b$
Indicates the magnitude of a part related to the total. It indicates what fraction of the population is getting the disease

- Proportion varies from 0-1. Multiply by 100 to get percentage.

Rate is a proportion that includes a measure of **time in the denominator**. (How fast an event is occurring- a rate of speed)

Terminology

- Rate is often used loosely when really a ratio
- Must determine how reported measures were calculated
- Check carefully to determine the numerator and denominator- is it measuring the speed at which an event is happening????

SPEED LIMIT 10

Some commonly used measures of disease frequency

- Birth rate = $\dfrac{\text{number live births in a population for one calendar year}}{\text{population at midyear}}$ X 100,000

- Death rate (crude) = $\dfrac{\text{number of deaths in a population in a year}}{\text{population at midyear}}$ X 100,000

- Age-specific death rate = $\dfrac{\text{number deaths age 15-19 in a year}}{\text{population age 15-19 at midyear}}$ X 1,000 or 100,000

- Age- sex-specific death rate= $\dfrac{\text{number deaths among men age 65+ in a year}}{\text{population of men age 65+ at midyear}}$ X 100,000

Some commonly used Prognostic Rates

- **Case fatality rate**: a measure of prognosis or the rate at which people die of a disease

$\dfrac{\text{\# deaths from specific disease in a specific time}}{\text{\# cases of the disease during the same time period}}$ X 10 ,000

- **Survival rate**: a measure of prognosis, measures the probability of surviving a specified time period

$\dfrac{\text{\# new cases with dis X- \# deaths among these cases in time period}}{\text{\#new cases with Disease X in same time period}}$ X100

Years of Potential Life Lost (YPLL)

- **Measures the relative impact of premature death on society**
- **Used in health economics and other disciplines**
- **May be useful in establishing health priorities**
- **Endpoint may vary – selected by investigator**
- **Represents the age NOT considered premature death**
- **Every (age at) death that occurs before the selected endpoint is subtracted from the endpoint and the number of years summed**

Data: *SEER Cancer Statistics Review*, 1973-95. National Cancer Institute, 1998
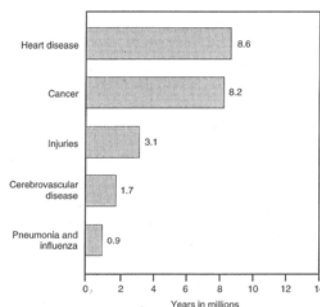

Figure 4–21. Person-years of life lost from selected leading causes of death in the United States, 1995. (Data from Ries LAG et al: *SEER Cancer Statistics Review*, 1973-95. National Cancer Institute, 1998.)

Two VERY Important Measures

- Prevalence

- Incidence

Prevalence

- # cases of a given disease that exists in a defined population at a specific time

Prevalence rate

- The proportion of a defined population that has a specific disease or attribute at a specified time.
- Maybe point prevalence rate, period prevalence rate or lifetime prevalence rate

Prevalence

· Measures BURDEN of disease - how many people have the condition (numerator), what proportion of the population has it; Prevalence is most often referred to as a rate but it is a proportion not really a rate.

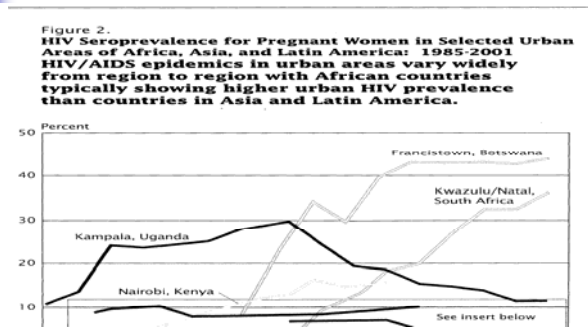· Useful for planning health services and understanding needs in a population.

·Most commonly measured in cross-sectional studies

Seroprevalence Of HIV
Source: USAID/US Dept of Commerce, 2004

Figure 2.
HIV Seroprevalence for Pregnant Women in Selected Urban Areas of Africa, Asia, and Latin America: 1985-2001
HIV/AIDS epidemics in urban areas vary widely from region to region with African countries typically showing higher urban HIV prevalence than countries in Asia and Latin America.

Prevalence

- Point Prevalence: a "snapshot"

- <u>number of existing cases of a disease at a point in time</u>
     Total population (sick and healthy)

Example: survey of eye conditions conducted on January 1/2005 found 310 of 2477 persons, aged 52 to 85 had cataracts = **12.3%** on January 1/05
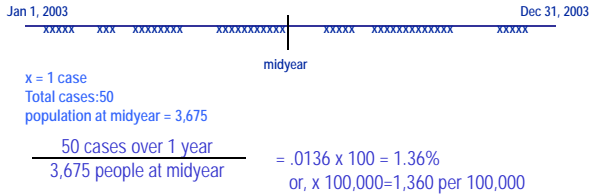
- **May be a date (8/30/050) or event**

Period Prevalence

- Over a period of time
- Numerator includes all cases at the beginning off the time and new cases occurring during the time period (such as a year)
- Denominator includes everyone in population - sick and healthy

Example: 310 cases of eye disease on 1/1/05 and 15 occurring during the rest of the year in total population
325/2477 = .1312 = 13.12% prevalence in 2005

Period Prevalence: Example

Jan 1, 2003   Dec 31, 2003
xxxxx xxx xxxxxxxx   xxxxxxxxxxx   xxxxx xxxxxxxxxxxxx   xxxxx

midyear

x = 1 case
Total cases:50
population at midyear = 3,675

$$\frac{50 \text{ cases over 1 year}}{3{,}675 \text{ people at midyear}}$$

= .0136 x 100 = 1.36%
or, x 100,000=1,360 per 100,000

Lifetime Prevalence Rate

- The proportion of individuals in a population who have had a given disease at any time in their life.
- Examples include an automobile injury, common illness etc.

Incidence

- The number of new cases or events occurring in a defined population during a specified time period
- Incidence rate: The rate at which new cases occur in a defined population

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Incidence

- Concerned about the number of new events
- Incidence rate:
  # new cases/population at risk of the disease
- Measures the risk or probability of an event

R / I D =

Two kinds of incidence

Cumulative Incidence Rate

Incidence Rate or Incidence density

Cumulative Incidence (CI)

CI = number of new cases of disease
       total population at risk

- Measures the probability (risk) that *an individual will develop a disease* during a specified period of time

- Must follow (observe) people over time who were previously non-diseased until an outcome occurs or the observation period ends
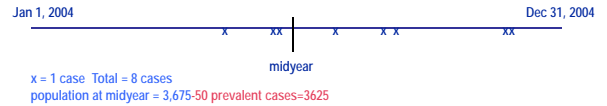
NOTE: exclude PREVALENT CASES

Cumulative Incidence

The cumulative incidence refers to how frequently new cases of the condition develop in **previously disease-free individuals** (usually for a specific disease) over a specified period of time

You must have *COMPLETE* follow-up on all individuals in the study to calculate CI (i.e., no one leaves the study, and everyone begins at the same time)

Incidence rates

Incidence rate is how frequently new cases of the disease develop in an at risk population over a specified time period

Jan 1, 2004   x   xx   x   x x   xx   Dec 31, 2004

midyear

x = 1 case Total = 8 cases
population at midyear = 3,675-50 prevalent cases=3625

$$\frac{8 \text{ new cases over 1 year}}{3,625 \text{ persons at risk at midyear}}$$ = .0022 x 100= 0.22%
or, x 100,000=220.69 per 10^5

IMPORTANT! When calculating incidence, be careful not to count already existing (prevalent) cases in time period. To get incidence, often must do a prevalence study first.

Incidence Rate/Incidence Density

Incidence Rate:

number of new cases of a disease during given time period
total person-time of observation

- **denominator is the sum of individual person time at risk/under observation and may be expressed as person-months, person-years etc**
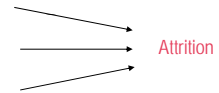

Person-time

Why do we need to use person-time?
Person-time accumulates when we observe a group of individuals over a period of time in order to ascertain the DEVELOPMENT of an event.

Although we would like to follow everyone in the sample indefinitely, (cumulative incidence), the actual time each individual is observed will most likely vary, since:

- Subjects may be recruited at different times
- Subjects migrate (move)
- Subjects choose to leave study (dropout)
- Subjects die
- Subjects develop the disease of interest
- The study ends

Attrition

Person-time Example
Source: Hennekens and Buring,1986

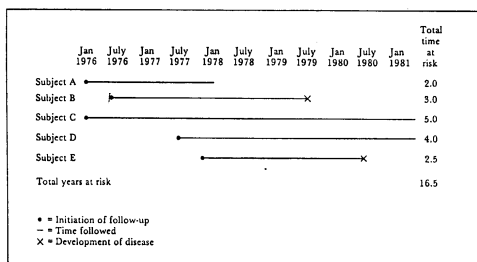*4. MEASURES OF DISEASE FREQUENCY* 59

Fig. 4-1. Calculation of person-years for incidence density.

Incidence Density

Incidence Density =
2 cases/16.5 person-years
Or
- 12.1/100 person-years of observation
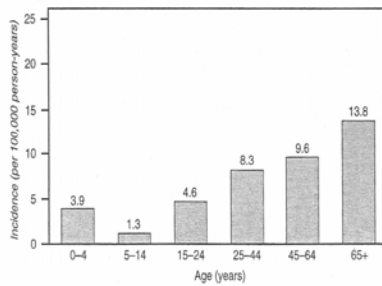
Incidents rates Example

Figure 3-3. Incidence rates for reported tuberculosis, grouped by age, in the United States, 1997. (Data from CDC: Reported tuberculosis in the United States, 1997. July 1998.)

Incidents rates Example

Legend: (rate per 100,000 population)
0.0 – 3.5 (year 2000 target) 3.6 – 7.4 >7.4 (national average)
New York City
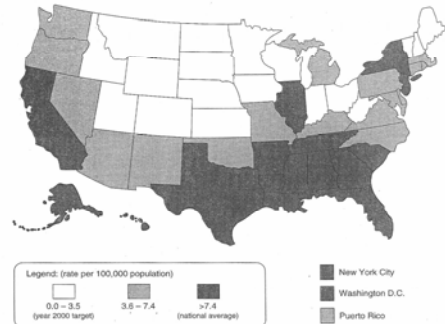Washington D.C.
Puerto Rico

Figure 3-7. Incidence rates for reported tuberculosis, grouped by state, in the United States, 1997. (Reproduced from CDC: Reported tuberculosis in the United States, 1997. July 1998.)

Incidents rates Example

Figure 3-6. Estimated incidence rates per 100,000 person-years for tuberculosis in regions of the developing world in 1997. (Data from WHO: Global tuberculosis control. WHO Report, 1999.)

Incidence Rate (Density) vs Cumulative Incidence

- Two year study of gastric ulcer in 5000 men
- 45 developed gastric ulcers
- 100 dropped out of study
- 9860 person-years of observation
- IR=45/9860 = 4.6 cases/1,000 py
- IC=45/5000 = 9.0 cases/1,000 population (over 2 years) 4.5 /1,000/yr

Cumulative Incidence vs Incidence Density

- Why did they differ?

- Cases occurred over 2 years- CI doesn't have a time component to the denominator

- Some people dropped out of study

Relationships between incidence and prevalence

Since incidence numerator = # new cases, and prevalence = # existing cases:

Prevalence rate = Incidence rate x Duration of disease

(P = I x D)

Example: incidence rate of multiple sclerosis (MS) = 5/100,000/yr

Individuals live a normal life expectancy and usually live 40-50 yrs with the disease.
So prevalence = 5/100,000/yr x (mean) 45=225/100,000/in 2000. If 281 million Americans are alive in 2000, 14,050 cases of MS are diagnosed each year and 632,250 cases existed in America in 2000.

3 assumptions must hold for P= I x D to be true:

1. Incidence rate must be constant over time

2. Duration of disease must be constant over time (e.g., improvements in survival due to better medical treatment of disease will negate this assumption)

3. The prevalence of the disease must be relatively low (<10%).

Prevalence vs Incidence

- Prevalence useful to health care providers to assess the public health impact of a disease and project needs for medical care facilities
- Prevalent cases are determined by both disease occurrence and duration/survival
- Using prevalent cases may identify prognostic factors rather than etiologic factors – who survives a disease rather than who gets disease

Articulate Quizmaker Quiz Placeholder – review2_lecture2_part1