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

Changing disease definitions

source: Aschengrau and Seage

**Table 2-2** Changes in the Definition of AIDS over Time

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


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)

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

Rates

Rates - \( \frac{a}{a+b} \) 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

<table>
<thead>
<tr>
<th>Location</th>
<th>New cases</th>
<th>Reporting period (yr)</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>City A</td>
<td>20</td>
<td>2005</td>
<td>1000</td>
</tr>
<tr>
<td>City B</td>
<td>100</td>
<td>2005</td>
<td>1000</td>
</tr>
</tbody>
</table>

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

Rates

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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

<table>
<thead>
<tr>
<th>Location</th>
<th>New cases of hepatitis</th>
<th>Reporting period</th>
<th>Population</th>
</tr>
</thead>
<tbody>
<tr>
<td>City A</td>
<td>58</td>
<td>1985</td>
<td>25,000</td>
</tr>
<tr>
<td>City B</td>
<td>35</td>
<td>1984-1985</td>
<td>7,000</td>
</tr>
</tbody>
</table>

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 \( \frac{58}{25,000} = 0.00232 \) or 232 per 100,000 per year (1985)
City B \( \frac{35}{7,000} = 0.005 \) or 500 per 100,000 over 2 years \( \frac{500}{2} = 250/10^5 \) per 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: \( \frac{a}{a+b} \)
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?

**Some commonly used measures of disease frequency**

- Birth rate = number live births in a population for one calendar year X 100,000 population at midyear
- Death rate = number of deaths in a population in a year X 100,000 population at midyear
- Age-specific death rate = number deaths age 15-19 in a year X 1,000 or 100,000 population age 15-19 at midyear

**Some commonly used Prognostic Rates**

- **Case fatality rate**: a measure of prognosis or the rate at which people die of a disease
  
  \[ \frac{\text{# deaths from specific disease in a specific time}}{\text{# cases of the disease during the same time period}} \times 10,000 \]

- **Survival rate**: a measure of prognosis, measures the probability of surviving a specified time period
  
  \[ \frac{\text{# new cases with dis X} \times \text{# deaths among these cases in time period}}{\text{#new cases with Disease X in same time period}} \times 100 \]

**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


**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

Prevalence

- Point Prevalence: a “snapshot”

  - number of existing cases of a disease at a point in time
  - 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 (8/30/05) or event

Period Prevalence

- Over a period of time
- Numerator includes all cases at the beginning of 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

\[
\frac{325}{2477} = .1312 = 13.12\% \text{ prevalence in 2005}
\]
**Period Prevalence: Example**

Jan 1, 2003 - Dec 31, 2003

- \( x = 1 \) case
- Total cases: 50
- Population at midyear = 3,675

\[
\frac{50 \text{ cases over 1 year}}{3,675 \text{ people at midyear}} = .0136 \times 100 = 1.36\%
\]
- or, \( x \times 100,000 = 1,360 \) 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

**Incidence**

- Concerned about the number of new events
- Incidence rate:
  \[
  \# \text{ new cases} / \text{population at risk of the disease}
  \]
- Measures the risk or probability of an event

**Two kinds of incidence**

- Cumulative Incidence Rate
- Incidence Rate or Incidence density

**Cumulative Incidence (CI)**

\[
\text{CI} = \frac{\text{number of new cases of disease}}{\text{total population at risk}}
\]
- 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 to Dec 31, 2004

8 new cases over 1 year

\[ \frac{8}{3,625 \text{ persons at risk at midyear}} = 0.0022 \times 100 = 0.22\% \]

or, \[ \frac{8}{100,000} = 0.00008 \] per 10,000

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:

\[ \frac{\text{number of new cases of a disease during given time period}}{\text{total person-time of observation}} \]

- 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

Person-time Example

Source: Hennekens and Buring, 1986

<table>
<thead>
<tr>
<th>Subject</th>
<th>Start of Observation</th>
<th>End of Observation</th>
<th>Person-time</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Jan 1, 2004</td>
<td>Dec 31, 2004</td>
<td>12</td>
</tr>
<tr>
<td>B</td>
<td>Jan 1, 2004</td>
<td>Dec 31, 2004</td>
<td>12</td>
</tr>
<tr>
<td>C</td>
<td>Jan 1, 2004</td>
<td>Dec 31, 2004</td>
<td>12</td>
</tr>
<tr>
<td>D</td>
<td>Jan 1, 2004</td>
<td>Dec 31, 2004</td>
<td>12</td>
</tr>
<tr>
<td>E</td>
<td>Jan 1, 2004</td>
<td>Dec 31, 2004</td>
<td>12</td>
</tr>
<tr>
<td>Total person-time</td>
<td></td>
<td></td>
<td>60</td>
</tr>
</tbody>
</table>

Incidence Density

\[ \text{Incidence Density} = \frac{2 \text{ cases}}{16.5 \text{ person-years}} \]

Or

\[ 12.1/100 \text{ person-years of observation} \]
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

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 $P = I \times D$ 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