Measurement in Epidemiology: Frequency, Association, and Impact

Mayfong Mayxay M.D., Ph.D. (Trop Med)

GFMER - WHO - UNFPA - LAO PDR

Training Course in Reproductive Health Research

Vientiane, 12 October 2009

Types of Epidemiologic Measures

1. Measures of disease frequency
2. Measures of association
3. Measures of potential impact

Rationale

1. Careful & accurate measurement of disease occurrence (morbidity & mortality): constitutes fundamental basis of studies

2. Studies are designed to:

   - describe & compare disease trends;

   - identify disease determinants;

   - evaluate public health interventions aimed at controlling health problems

Measures of Disease Frequency

- Measures of disease frequency in mathematical quantity
  - Count
  - Proportion (percentage)
  - Rate
  - Ratio
- Measures of disease frequency in epidemiology
  - Prevalence
  - Incidence

Importance of Denominator

$$\frac{a}{b}$$

a → Numerator

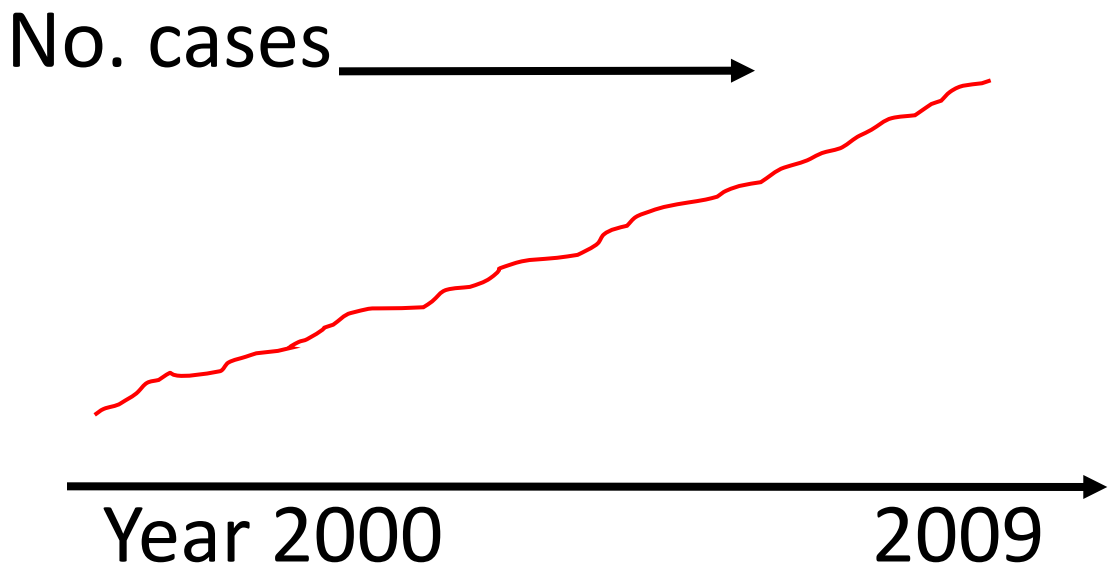
b → Denominator

Example 1:

- 500 cases of dengue fever in Vientiane
- 120 cases of dengue fever in Phongsaly

  Which one is more infected?
- Vientiane: 200/800,000 = 0.25/1,000
- Phongsaly: 120/300,000 = 0.4/1,000

Example 2: Dengue outbreak in Savannakhet



Is the situation worse?

Answer: depends on population size, difference in reporting method (more sensible), definition of case !!!

Count, Proportion, Rate, Ratio

- **Counts:**

❖ Simplest & most basic measure - absolute number of persons who have disease or characteristic of interest.

❖ Useful for health planners & administrators: for allocation of resources (e.g. quantity of ORS needed by diarrheal cases)

❖Count of No. cases of a disease, is used for surveillance of infectious disease for early detection of outbreaks.

Limited values of counts

- Number of persons with characteristic, e.g., cases of dengue hemorrhagic fever, depends on the size of the population at risk of the disease in an area.

  The bigger this group, the higher is the expected number of cases.

- The duration of observation also affects the frequency of cases; the longer the observation period, the more cases can occur.

  → **Count does not contain these elements !**

Proportion (percentage, frequency)

- **Proportion:** + a included in the denominator

$$\frac{a}{a+b}$$

+ No measurement unit; > 0 to $\leq$ 1

+ Often expressed as %

Example: From 7,999 females aged 16 – 45 y, 2,496 use modern contraceptive methods.

The proportion of those who use modern contraceptive methods = 2,496 / 7,999 x 100 = 31.2%

Rate

Definition: **Frequency of events, that occur in a defined time period, divided by the average population of risk.**

$$\text{Rate} = \frac{\text{Numerator}}{\text{Denominator}} \times \text{Constant multiplier}$$

$$\text{Crude death rate} = \frac{\text{Number of deaths (defined place and time period)}}{\text{Mid-period population (same place and population)}} \times 1000$$

Ratio

- **Ratio:** A fraction in which the numerator is not part of the denominator.

$$\frac{a}{b}$$

- a and b are two mutually exclusive frequency

- Example:

- Number of hospital beds per 100,000
- Male and female dengue infection ratio = 70/35 or 2 males to one female (2 : 1)

Mortality, Fatality, Death

- **Mortality rate:** Death of a particular disease/event in the total population (e.g., maternal mortality)

$$\frac{\text{Number of pregnancy – related death (defined place and time period)}}{\text{Number of live birth (same place and time period)}} \times 100{,}000$$

Maternal mortality rate in Laos in 2000 ~ 530/100,000

- **Fatality rate:** Mortality among cases of a particular disease
- **Death rate:** Mortality of all diseases among the total population

Commonly Used Rates for Population Study

Age-specific death rate = $\frac{\text{Number of death in a particular age group (defined place and time period)}}{\text{Mid-period population (same age group, place and time period)}}$ x 1,000

Cause specific death rate = $\frac{\text{Number of death due to a particular cause (defined place and time period)}}{\text{Mid-period population (same place and time period)}}$ x 1,000

Infant mortality rate = $\frac{\text{Number of death to infants <1 year of age (defined place and time period)}}{\text{Number of live births (same place and time period)}}$ x 1,000

Infant mortality rate in Laos in 2005 ~ 70 / 1,000

Peri-natal mortality rate =

$$\frac{\text{Number of stillbirth (defined place and time period)} + \text{Number of deaths to infants <7 days of age (same place and time period}}{\text{Number of stillbirth (same place and time period)} + \text{Number of live births (same place and time period)}} \times 1{,}000$$

Prevalence

- Number of existing cases of disease
- Proportion of individuals in a population with disease or condition at a specific point of time

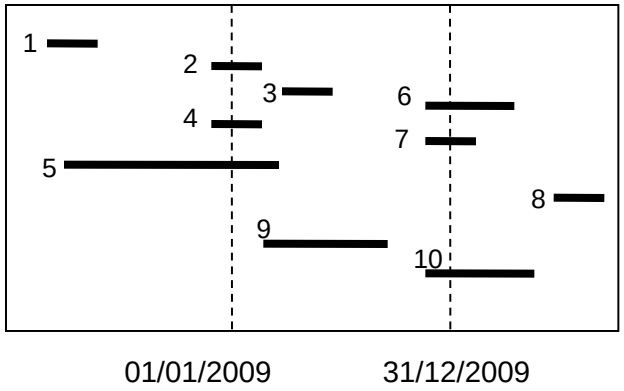
$$\text{Prevalence} = \frac{\text{No. of cases observed at time t}}{\text{Total No. of individuals at time t}}$$

Example of Prevalence

- The prevalence of hypertension (systolic BP $\geq$ 95 mmHg) on May 1-2, 2009 in Lao men aged 30-69 years in Xienglairkhok village was:

$$\frac{\text{276 persons with systolic BP} \geq \text{95 mmHg}}{\text{1,853 Lao men aged 30-69 years at the time of survey}} \times 100 = 15\%$$

Prevalence divided into two types:



*** Point prevalence**

- **01/01/2009: case No. 2, 4, 5**
- **31/12/2009: case No. 6, 7, 10**

*** Period prevalence between 01/01-31/12/2009:**

Case No. 2, 3, 4, 5, 6, 7, 9, 10

Incidence

- Measures of **new cases** of disease that develop in a population during a specified period of time

- 2 types of incidence
    1. Cumulative incidence (incidence)
    2. Incidence rate = incidence density

Cumulative Incidence (CI) = Incidence

$$CI = \frac{\text{No. of individuals who get the disease during a certain period}}{\text{No. of individuals in the population at the beginning of the period}}$$

- A proportion
- Has no dimension
- Varies between 0 and 1

Example of Cumulative Incidence

- The population statistic of Lab Lair District in 2001 revealed that there were 5,572 women aged 20-39 years who were sex workers. Based on the record of CHAS, among those women, 45 were HIV + ve during 2002-2005.
- What is the cumulative incidence of HIV + ve among those women during a period of 4 years?
- Cumulative incidence = 45 / 5,572 = 0.008 or 0.8%

Incidence Rate or Density (ID)

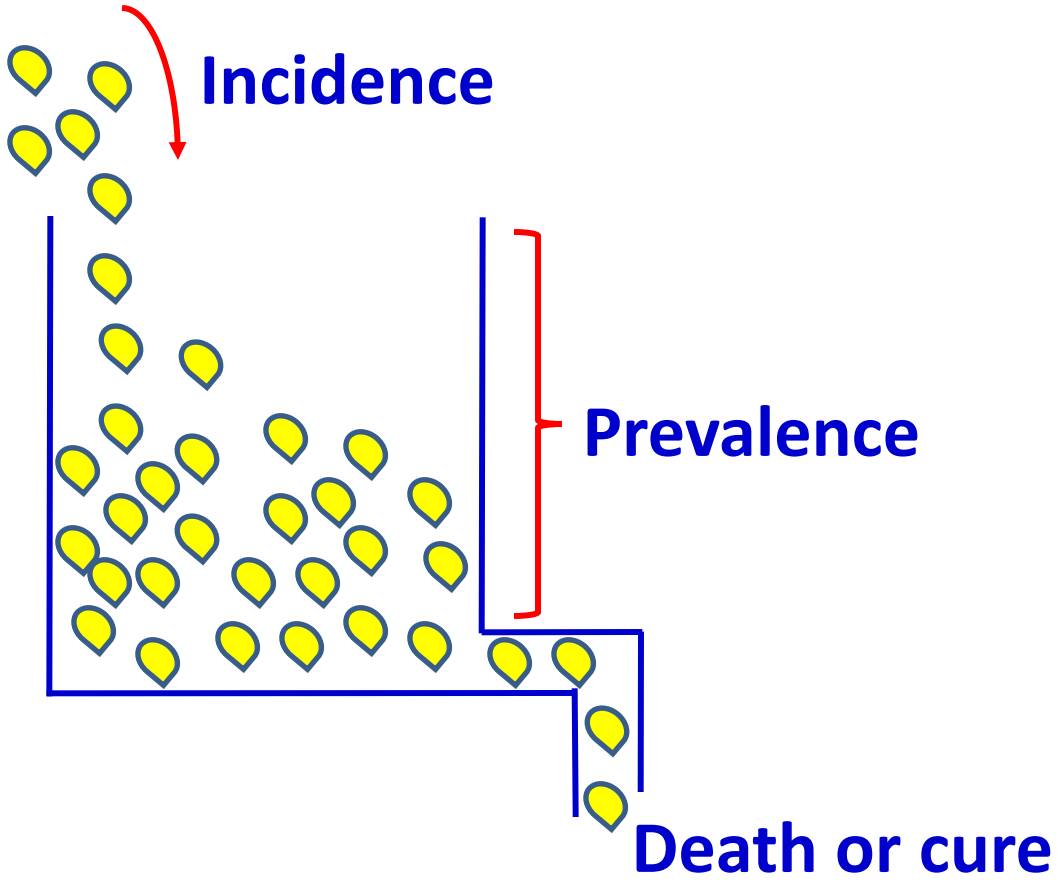
$$ID = \frac{\text{No. of new cases that occur during a calendar period}}{\text{Amount of pop-time contributed by the observed candidate pop. During that period (time at risk)}}$$

- Not a proportion
- Has dimension (unit of ID is time)
- Varies between 0 to infinity

Example of Incidence Density

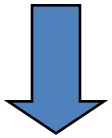
- In 2003, the number of new cases of STI was 29 among the men aged 40-44 years in Lab Leu District. The person-years was 41,532 among that group of people.
- What is the incidence density or incidence rate of STI + ve among those people?
- Incidence density = 29 / 41,532 person-years = 0.0007/year

Prevalence vs Incidence



Measures of Association

- Statistical relationship between two or more events, characteristics, or other variables



- Statistical relationship between exposure and disease

- Association is not causation!

- **Absolute**
  - Risk difference

    exposed - unexposed

- **Relative**
  - Risk ratios
  - Odds ratios

    exposed / unexposed

- **The relative risk of myocardial infarction in men compared with women is : 5**

$$\text{Risk ratio} = \frac{\text{Risk}_{\text{men}}}{\text{Risk}_{\text{women}}} = \frac{\text{5 cases/1000 PY}}{\text{1 case/1000 PY}} = 5$$

- **The absolute risk difference between men and women is : 4 cases/1000 PY**

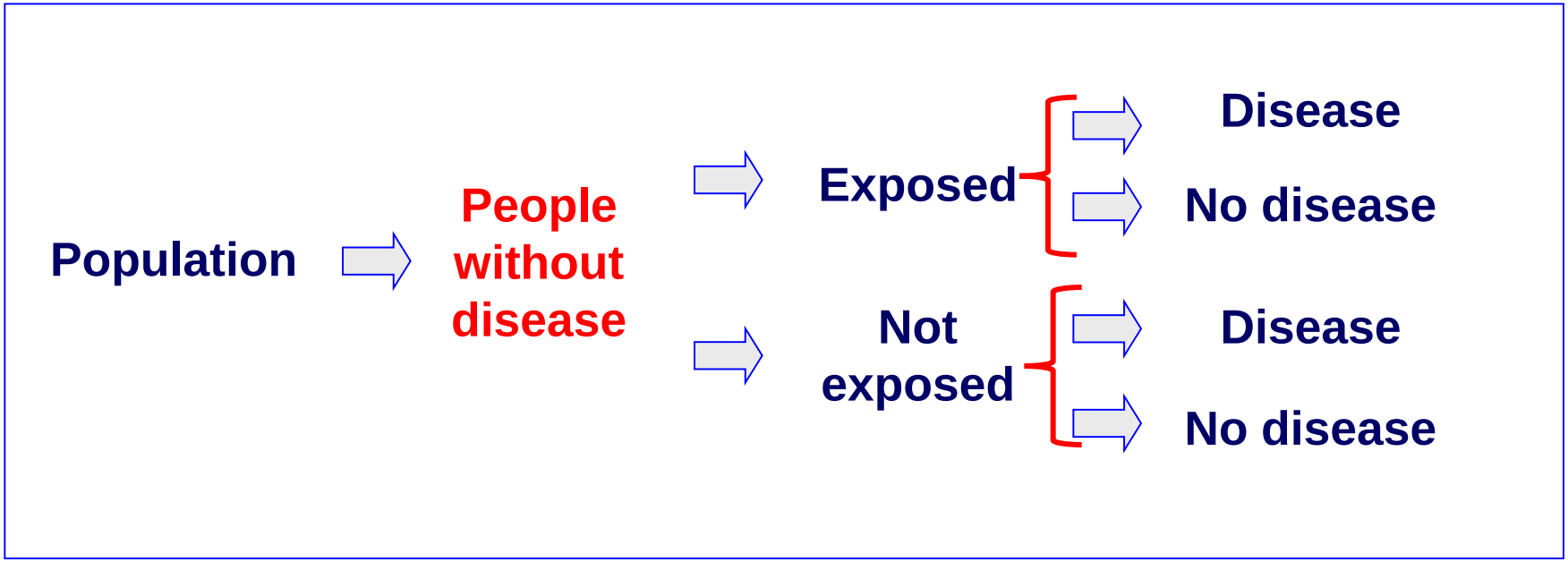
5 cases/1000 PY - 1 case/1000 PY = 4 cases/1000 PY

Epidemiologic Measures of Association

- Relative risk
- Odds ratio
- Attributable risk/population attributable risk percent
- Standardized mortality ratios

Cause - Effect Relationship

Cause/risk/exposure → Effect/disease/outcome



2 x 2 Tables in Epidemiology

Used to summarize frequencies of disease and exposure and used for calculation of association

		Disease: Yes	Disease: No	Total
Exposure	Yes	*a*	*b*	*a* + *b*
	No	*c*	*d*	*c* + *d*
Total		*a* + *c*	*b* + *c*	*a* + *b* + *c* + *d*

2 x 2 Tables in Epidemiology

Used to summarize frequencies of disease and exposure and used for calculation of association

Exposure	Disease: Yes	Disease: No	Total
Yes (exposed)	*a*	*b*	*total # exposed*
No (unexposed)	*c*	*d*	*total # unexposed*
Total	*total # with disease*	*total # with no disease*	*Total Population*

Relative Risk

- The ratio of the risk of disease in persons exposed compared to the risk in those unexposed
- Often, a measure of association between incidence of disease and exposure of interest

$$RR = \frac{\text{Incidence rate of disease in exposed}}{\text{Incidence rate of disease in unexposed}}$$

Exposure	Disease: Yes	Disease: No	Total
Yes	*a*	*b*	*a* + *b*
No	*c*	*d*	*c* + *d*
Total	*a* + *c*	*b* + *c*	*a* + *b* + *c* + *d*

$$\text{Relative Risk} = \frac{a / (a + b)}{c / (c + d)}$$

Example: Relative Risk

	Develop CHD	Do Not Develop CHD	Totals	Incidence per 1000/yr
Smokers	84	2916	3000	28.0
Non-smokers	87	4913	5000	17.4

Incidence in smokers = 84/3000 = 28.0

Incidence in non-smokers = 87/5000 = 17.4

Relative risk = 28.0/17.4 = 1.61

Interpretation of Relative Risk

- 1 = No association between exposure & disease
  - incidence rates are identical between groups
- > 1 = Positive association
  - exposed group has higher incidence than non-exposed group
- < 1 = Negative association or protective effect
  - non-exposed group has higher incidence
  - example: 0.5 = half as likely to experience disease

Interpretation of Relative Risk

- **A relative risk of 1.0 or greater indicates an increased risk**
- **A relative risk less than 1.0 indicates a decreased risk**

Odds Ratio

- **The ratio of the odds of a condition in the exposed compared with the odds of the condition in the unexposed**

- **Usually applied to prevalence studies rather than incidence studies**

$$OR = \frac{\text{odds of disease in exposed}}{\text{odds of disease in unexposed}}$$

Odds Ratio

Exposure	Disease: Yes	Disease: No	Total
Yes	*a*	*b*	*a* + *b*
No	*c*	*d*	*c* + *d*
Total	*a* + *c*	*b* + *c*	*a* + *b* + *c* + *d*

$$\text{Odds Ratio} = \frac{[\,a / b\,]}{[\,c / d\,]} = \frac{[\,ad\,]}{[\,bc\,]}$$

Based on the Odds Ratio formula, what is the Odds Ratio for each disease status in this famous smoking study?

Smoking and Carcinoma of the Lung

Disease Status	Number of smokers	Number of non-smokers	
Males Lung cancer	647	2	
Males Controls	622	27	
Females Lung cancer	41	19	
Females Controls	28	32	

Doll R. Bradford, Hill A. Smoking and carcinoma of the lung: preliminary report. British Medical Journal 1950, 2: 739-748.

Measures of Potential Impact

Reflect the expected contribution of a study factor to the frequency of a disease in a particular population. These measures are useful for predicting the efficacy or effectiveness of therapeutic maneuvers and intervention strategies within a specific population, e.g., vaccine

Essentially, potential impact measures are a combination of frequency and association measures


S 14:57