Measures of Disease Frequency and Occurrence

Prof. Afif Ben Salah
Department of Family and Community Medicine
College of Medicine and Medical Sciences, Arabian Gulf University (AGU)
2016-2017
OUTLINE

1- Define and discuss measures of disease frequency
   a- Count
   b- Proportion
   c- Ratio
   d- rate
   e- Risk

2- Define measures of disease outcomes
   a- Incidence : cumulative incidence, incidence density rate
   b- Prevalence: point prevalence, period prevalence
   c- relationship between incidence and prevalence

3- Define measures of mortality
   a- Drude death rate
   b- Specific death rate
   c- Other death rates

4- Define the dependency rates
Measures of disease frequency

1. Count (absolute numbers): the number of individuals who meet the case definition

Exemples:
1. Number of new cases (incidence)
2. Number of existing (new and old) cases (Prevalence)
3. Number of deaths due to one or all diseases

Main Limitation?
2. Proportion (relative numbers):

\[
\frac{A}{(A+B)}
\]

- A fraction in which the numerator (A) includes only individuals who meet the case definition and denominator totals the number of individuals who meet the case definition and those in the study population who do not meet the case definition and are at risk,
- i.e. The numerator is included in the denominator

Ex: 30% of adult males in Bahrain are cigarette smokers.
Measures of disease frequency(3)

3. Ratio: A/B

- A fraction in which the numerator includes only individuals who are meeting one criterion and the denominator includes only individuals in the study population who are meeting another criterion.

- Examples:
  - male-to-female ratio (1:2) means, for every male there are 2 females
  - Death-to-case (case-fatality) ratio: 1 death/100 case (with the disease)
Measures of disease frequency (4)

4. Rate

- A fraction in which the numerator includes only individuals who Meet the case definition and the denominator includes individuals in the study population. **A rate is dependent upon time.**

- It is calculated by dividing case or death counts in the numerator and size of the population in the denominator as well as a time Period during which the event occurred.

- A key requirement for a rate is **population at risk, and time of exposure**

- A rate is a proportion over a time period.

EX: 100 cases of sickle cell disease per 100,000 population in Bahrain during 2017.
5. Risk

- The risk is the probability of an individual meeting the case definition. Risk is dependent upon time.
Ex: 0.01 sickle cell disease cases per person-year.

Discuss:
1-What is the difference between a proportion and a ratio?
2- Find an example of a proportion, rate, count or risk estimate related to breast cancer in Bahrain? (homework)
Measures of disease Occurrence

- **Incidence**: counts *new cases* of the disease (or outcome)

- **Prevalence**: counts *new and existing cases* of the disease (or outcome)
Incidence

- Incidence quantifies development of disease.
- Incidence can be estimated using data from a disease registry data or a cohort study.
- There is an assumption of a period of time, such as new cases within a month or a year.
- The denominator include all persons at risk.
These persons are disease-free at the start of the time period.
The denominator will not include persons who already have the disease.

Incidence can be expressed in person time at risk.
Rates are expressed per 100, 1,000 or 10,000.
What is a population at risk?

- Group of people who are at risk of disease or death because of a common characteristic like age, race, sex, marital status or where people live.

Ex:

- Whole population or a sector of it (region, ethnic)
CUMULATIVE INCIDENCE RATE VERSUS INCIDENCE DENSITY RATE

- The cumulative incidence rate (known as incidence rate):
  Consists of the number of persons who newly experience the disease during a specified period of time divided by the average total population at risk.

- Incidence density rate (known as person –time rate):
  Consists of the number of persons who newly experience the disease during a specified period of time divided by the sum of the time that each person of The population is at risk.
The table below describes a study for 5 years of a disease A among 5 individuals

<table>
<thead>
<tr>
<th></th>
<th>Year 1</th>
<th>Year 2</th>
<th>Year 3</th>
<th>Year 4</th>
<th>Year 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Individual 1</td>
<td>Good Health</td>
<td>Good Health</td>
<td>Good Health</td>
<td>No Information</td>
<td>No Information</td>
</tr>
<tr>
<td>Individual 2</td>
<td>Good Health</td>
<td>A</td>
<td>Good Health</td>
<td>Good Health</td>
<td>Good Health</td>
</tr>
<tr>
<td>Individual 3</td>
<td>Good Health</td>
<td>Good Health</td>
<td>Good Health</td>
<td>Good Health</td>
<td>Good Health</td>
</tr>
<tr>
<td>Individual 4</td>
<td>Good Health</td>
<td>Good Health</td>
<td>Good Health</td>
<td>A</td>
<td>Good Health</td>
</tr>
<tr>
<td>Individual 5</td>
<td>Good Health</td>
<td>Died</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Incidence rate = (2/5) \times 100 = 40% 
Incidence density = \frac{2}{17} \times 1,000 = 117.6 
= 117.6 new cases per 1000 person-years
Prevalence

- Number of **existing cases** of a disease in a population at a point or during a period of time
- Provides estimate of the probability or risk that one is affected at a point in time

Example
- City A has 7000 people with arthritis on Jan 1st, 1999
- Population of City A = 70,000
- Prevalence of arthritis on Jan 1st = .10 or 10%
Types of prevalence

- **Point prevalence** = prevalence of disease or condition at a specific time.
  
  Number of existing cases at a specific time/ The population size at a specific time
  
  (ranges from 0 to 100 in %)

- **Period prevalence** = prevalence of disease or condition during a specified period of time.
  
  Number of cases that occurred in a specific period of time/ The population size during this period
  
  (ranges from 0 to 100%)
A survey was conducted in 2015 in which 10000 adults were examined for blood pressure. The results revealed that 2000 individuals have hypertension. After one year follow-up of those without the disease 400 additional individuals developed the disease.

- The prevalence of Hypertension in 2015 = \( \frac{2000}{10000} \times 100 = 20\% \).
- The incidence of Hypertension = \( \frac{400}{10000 - 2000} \times 100 = 5\% \).
- The prevalence in 2016 = \( \frac{(2000+400)}{10000} \times 100 = 24\% \).
Prevalence = Incidence x Average duration

Prevalence can be viewed as describing a pool of disease in a population. Incidence describes the input flow of new cases into the pool. Deaths and cures reflect the output flow from the pool.
Number of cases of disease beginning, developing, and ending during a period of time, January 1, 2016 – December 31, 2016 among a population of 60 individuals followed up for the same period. Length of each line corresponds to duration of each case.

1- What is the numerator for incidence in 2016?
2- What is the numerator for point prevalence if a survey was done in May?
3- Calculate the prevalence rate in 2016?
Measures of mortality

• **Crude Death Rate or Mortality Rate:**
  Is the most common national indicator of mortality and is calculated as follows:

\[
\text{Number of deaths in a specified period} \div \text{Total population during that period} \times 1000
\]
• Death rates can be usefully expressed for specific subgroups in the population according to their age, sex, occupation, cause of death or other characteristics related to the risk of death.
Examples of specific death rates

• Annual age-sex-specific death rate among males in the age of 20 to 29 years is calculated as follows:

Total number of deaths occurred in 20-29 years old males in one year
----------------------------------------------------------------------------------------------------------------- X 10^5
Midyear population of males aged 20-29 years during the same year

• Annual Death rate due to hypertension among Bahraini in 2013:

Total number of deaths due to hypertension among Bahraini in 2013
----------------------------------------------------------------------------------------------------------------- X 10^5
Midyear population of Bahraini during the same year
Exercise: Calculate the Age specific death rates of the population from the following data

<table>
<thead>
<tr>
<th>Age-group (Years)</th>
<th>Mid-year Population</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>Under 10</td>
<td>20,000</td>
<td>600</td>
</tr>
<tr>
<td>10-20</td>
<td>12,000</td>
<td>240</td>
</tr>
<tr>
<td>20-40</td>
<td>50,000</td>
<td>1,250</td>
</tr>
<tr>
<td>40-60</td>
<td>30,000</td>
<td>1,050</td>
</tr>
<tr>
<td>Above 60</td>
<td>10,000</td>
<td>500</td>
</tr>
</tbody>
</table>
Neonatal mortality rate (NMR):

$$NMR = \frac{\text{Deaths of infants up to 4 weeks}}{\text{No. of live births}} \times 1000$$

Early neonatal mortality rate (ENMR):

$$ENMR = \frac{\text{Deaths of infants in the first week of life}}{\text{No. of live births}} \times 1000$$
Post-neonatal mortality rate (PNMR)

Number of infants deaths after 28 days to less than 1yr (between 4 weeks to 52 weeks) of age per 1000 live births in a given year.

\[
PNMR = \frac{\text{No. of deaths of newborns between 4 weeks or less than 1yr old in a year}}{\text{No. of live births during the same yr}} \times 1000
\]
Infant mortality

• It is commonly used as an indicator of the level of health in a community. It measures the death rate in children during the first year of life (Before celebrating their first birthday).

• Accordingly, the denominator (population at risk) is the number of live births in the same year. The infant mortality rate (IMR) is calculated as follows:

\[
\text{IMR} = \frac{\text{Number of deaths in a year of infants less than 1 year of age}}{\text{Number of live births in the same year}} \times 10^3
\]
Child mortality rate (CMR)

Defined as the total number of deaths of children aged 1 to 4 years (< 5 years) per 1000 population of the same age in a given year.

\[
\text{CMR} = \frac{\text{No. of deaths of children less than 5 years in given year}}{\text{tot. population aged 0 to 5 in the given year}} \times 1000
\]

MDG4 target is to reduce the CMR by 2/3 between 1990 and 2015

CMR = 1 for 12 children in Africa, 1 for 19 children in Asia and 1 for 147 in Developed countries

Source: Unicef, 2015
Peri-natal mortality rate (PMR)

No. of late foetal deaths (after 22 weeks of gestation) plus deaths within first week of life in a year for 1000 total births (live and foetal) in a year.

\[
PMR = \frac{\text{Foetal deaths after 22 weeks of gestation + deaths of newborns within 7 days}}{\text{No. of live births + foetal deaths during the same year}} \times 1000
\]
Time reference for mortality in childhood and infancy

22 weeks of gestation completed

Live Birth

Still Birth (Foetal)

Perinatal Death

Early Neonatal Death

Late Neonatal Death

Neonatal Death

Post Neonatal Death

Infant Death

Child Death (<5 Years)
Maternal mortality ratio (MMR)

No. of deaths of women while pregnant or within 42 days of termination of pregnancy from any cause related to pregnancy/childbearing and child birth per 100,000 live births in a given year.

Deaths of pregnant women and women after termination of pregnancy within 6 weeks from any cause related to pregnancy

$$\text{MMR} = \frac{\text{No. of deaths of pregnant women and women after termination of pregnancy within 6 weeks from any cause related to pregnancy}}{\text{No. of live births during the same year}} \times 100000$$

MDG5: reduce by $\frac{3}{4}$ the MMR
Maternal mortality rate (MMRT)

Number of maternal deaths while pregnant or within 42 days of termination of pregnancy from any cause related to pregnancy/childbearing and childbirth per 100,000 women in reproductive ages 15-49.

\[
\text{MMRT} = \left( \frac{\text{No. of maternal deaths of women in age 15-49}}{\text{No. of women in age 15-49 in a given yr}} \right) \times 1000
\]
Case fatality rate

- Case-fatality is a measure of the severity of a disease and is defined as the proportion of persons with a specified disease or condition (cases) who die from that condition within a specified time period.

\[
\text{Case-fatality (\%)} = \frac{\text{Number of cause-specific deaths among the incident cases in a specified period (year)}}{\text{Number of incident (new) cases diagnosed in the same period (year)}} \times 100
\]
The **ratio** of non-economically active to economically active people in the population is called the dependency ratio.

\[
\text{Dependancy Ratio} = \frac{\text{Children} + \text{Elderly}}{\text{Working Age}} \times 100
\]

\[
= \frac{\text{Pop (below 15 + 65 & above)}}{\text{Pop (15 – 64 years)}} \times 100
\]

Dependency Ratio of Pakistan = 95.1
Dependency Ratio of UK = 66.5
Old-age Dependency Ratio

\[
\text{Population aged } \geq 65 \quad \text{----------------------------------} \quad \times 100
\]

\[
\text{Population aged } 15 - 64
\]

- This is of interest in many developed countries because of increase in older population and decrease in fertility.
- Can also calculate child dependency ratio – those under 15 to those aged 15 – 64.
Summary

1- Measures of disease frequency:
   Counts, Proportion, Ratio, Rate

2- Measures of disease outcome:
   Incidence: Cumulative Incidence, Incidence density rate
   Prevalence: Point Prevalence, Interval Prevalence

3- Measures of mortality: Crude Mortality, Specific Mortality
   Millenium Development Goals (MDG 4 and 5)

4- Dependency ratios