

MEASURES OF DISEASE OCCURRENCE

MORBIDITY MEASURES

Dr. S H Nzala

Frequency: Disease Occurrence

N u m e r a t o r (events, cases)

Proportion



Ratio



Rate



Event

x

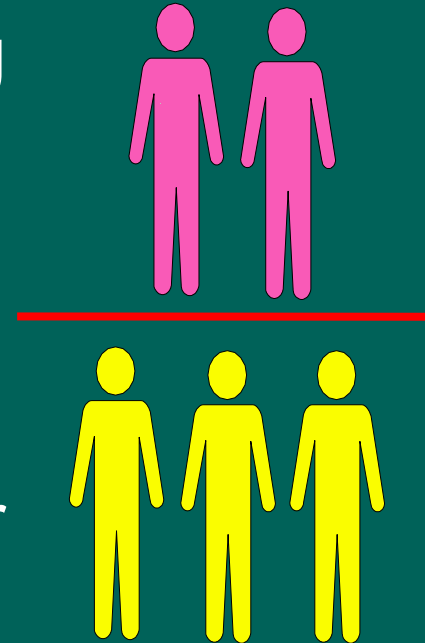
Time



D e n o m i n a t o r (sample, population)

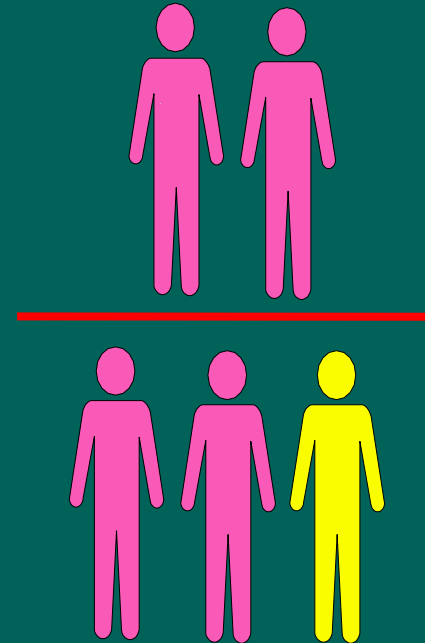
Ratio

- A **ratio** is a relative size of two quantities, calculated by dividing one quantity into another
- The comparison of any two values
- The numerator and denominator need not be related.
- E.g. Male: Female sex ratio;
Apple and Oranges



Proportion

- Comparison of a part to a whole
- Numerator **MUST BE INCLUDED** in the denominator
- A proportion may be expressed as a decimal, a fraction, or a percentage.
- Often expressed as %
- Percentage = proportion x 100



$$\frac{A}{A + B}$$

....e.g. of rate....

$$\text{Death rate} = \frac{\text{\# of deaths in 2022}}{\text{mid year population}} \times 1000$$

Mid-year population

Used because pop size changes daily due to:

Birth

Death

Migration

Mid-year pop estimate on 1st July of a year.

Risk

Definition: proportion of an initially disease free population that develops disease during a specified (usually limited) period of time

$$\frac{\text{\# new cases during a specified period}}{\text{size of population at start of period}}$$

Synonyms:

- "Attack rate"

MORBIDITY MEASURES

- **RATIO:** expresses relationship between two numbers e.g. $x:y$ or $x/y \times k$. example male: female
- **PROPORTION:** This is a specific type of ratio in which the numerator is included in the denominator and the resultant value is expressed as a percentage

MORBIDITY MEASURES

- RATE is a special form of proportion that includes specification of time.
- CRUDE RATE: Summary rates based on the actual number of events in total population over a given time period.
- SPECIFIC RATES : Summary rates based on the actual number of events in a population subgroup over a given time period.

INCIDENCE

- INCIDENCE measure the probability that health people will develop a disease during a specific period of time; i.e. it is the number of new cases of a disease in a population over a period time
- $IR = \frac{\text{No. of new cases of disease}}{\text{Population at risk}} \times \text{time p.}$

Incidence

- Occurrence of new cases

Number of new cases

Population at risk overtime

- A measure of absolute risk
- Involves three components

-New cases

-Population at risk

-Interval in time

Can be expressed as a proportion or rate

Incidence Proportion

- Incidence per 1000=
Number of new cases during specified time period *1000
Number of persons at risk

AT RISK

- Individuals are at risk of disease if they:
 - do not have the disease at the start of the follow up period
 - Are capable of developing the disease
 - have the organ of interest
 - have not been immunized against the disease

Example of Cumulative Incidence

- 200 people free of disease get observed for 3 years
- 10 cases of disease develop
- 3-year cumulative incidence= $10/200=0.05$

Incidence Rate (Incidence Density)

- Incidence per 1000=

No. of NEW cases of a disease occurring in the population during specified time period*1000

Total person-time of observation

Incidence Rate (Incidence Density)

- Average rate at which a disease develops in a population over a specified time period
- Is a true rate and has the units of time
- Ranges from 0 to infinity
- Accounts for differing lengths of follow-up
- Assumes risk of developing disease is constant over time

Person Time

- Sum, over all individuals, of time at risk until the event of interest, death, loss to follow-up, or the end of the study

Example of Incidence Density

Subject	Follow-up(yrs)	Died
1	2	N
2	2	Y
3	1	N
4	1	N
5	1	Y
6	3	N
7	1	Y
8	1	Y
9	1	N
10	2	Y
	15	5

Incidence Density-Example

- Incidence Density = $\frac{5 \text{ deaths}}{15 \text{ person-years}}$
= 0.33 deaths per person-year
= 33 deaths per 100 person-years

Incidence density-Example

- Among 14 exclusively breastfed infants, there were 18 episodes of pneumonia over a total follow-up period of 287 child months.
- Incidence rate
 $= (18/287) \times 100$
 $= 6.27$ episodes of pneumonia per 100 child months of follow-up

CALCULATING INCIDENCE - REQUIREMENTS

- Need to follow prospectively a defined group of people and determine the rate at which new cases appear

CALCULATING INCIDENCE - REQUIREMENTS

- a) Knowledge of the health status of the study population:
- b) Determine time of onset
- c) Specification of numerator i.e. number of persons versus number of conditions. If numerator is not specified then it is taken as persons (risk per person)

CALCULATING INCIDENCE - REQUIREMENTS

- d) Specification of denominator – always a defined population
 - Use population at midpoint for time
 - Only those at risk form the denominator
- e) Always state definite period of time.
(period of observation)

PREVALENCE

- Measures the number of people in a population who have the disease at a given time
- $PR = \frac{\text{No. existing cases of disease}}{\text{Total Population}} \times \text{time}$
- Prevalence depends on
 - a) The number of people who have been ill in the past (previous incidence)
 - b) The duration of their illness

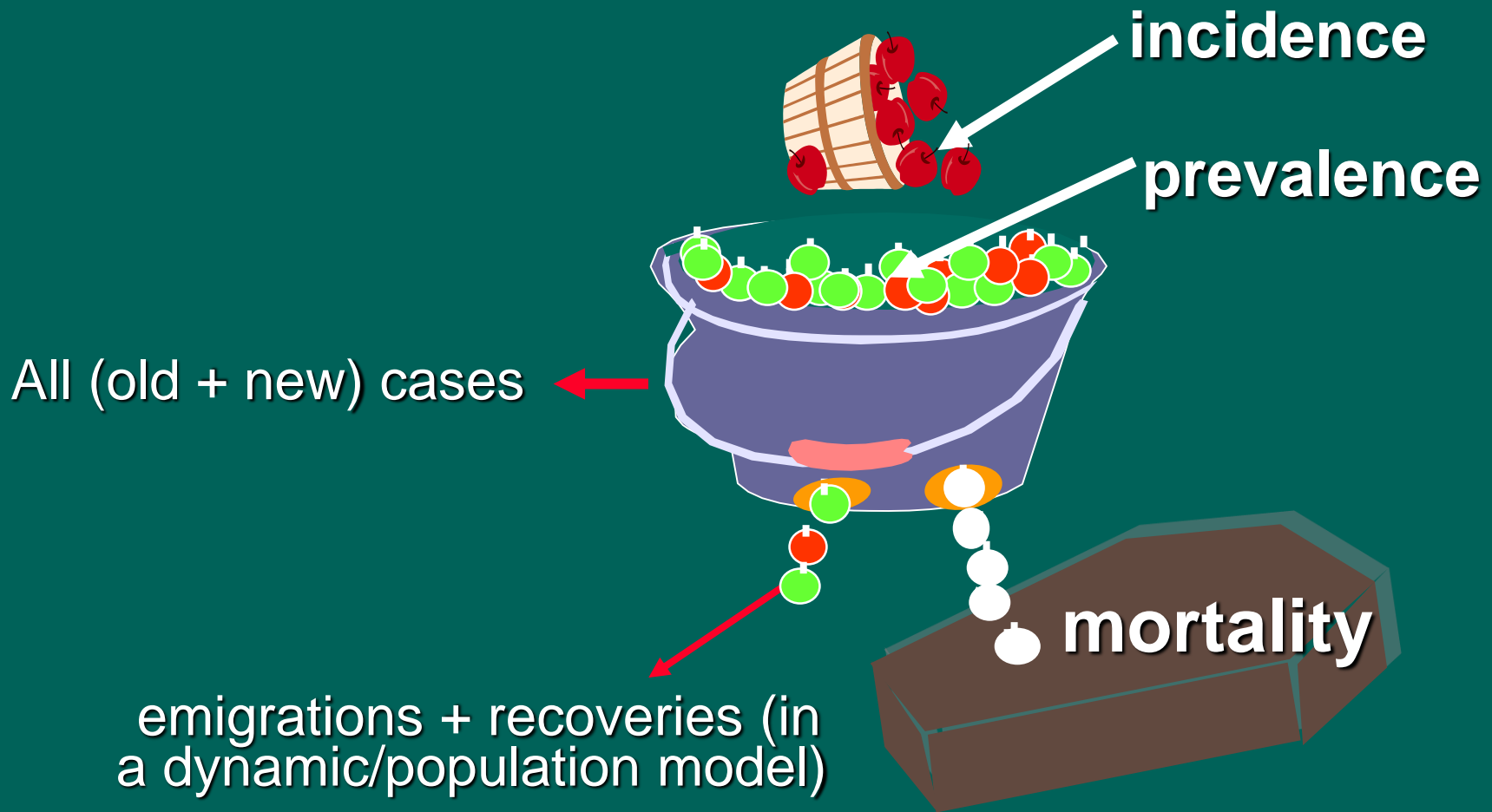
PREVALENCE

- POINT PREVALENCE – measures the probability of people having a disease at a given point in time
- PERIOD PREVALENCE = Prevalence at a point in time, plus new cases (incidence) and recurrences during a succeeding period (e.g. one year)

REQUIREMENTS FOR CALCULATING PREVALENCE

- Similar to those for incidence EXCEPT
 - a) Knowledge of time of onset is not required
 - b) Denominator always includes the entire related population since numerator contains both old and new cases

Measures at Population Level



USES OF PREVALENCE

- Determine workload, especially in chronic diseases
- Planning of facilities and manpower needs
- To express the burden of some attribute or condition in a population
- To monitor control programmes for chronic conditions; e.g. mental illness (reflects duration as well as incidence)

USES OF PREVALENCE

- To estimate importance of a disease in a population (calculation of incidence)
- Useful in tracking changes in disease patterns over time (can determine point prevalence by a series of cross sectional surveys)

USES OF INCIDENCE

- Fundamental tool for aetiologic studies of both acute and chronic diseases (as direct indicator of risk of disease)
- it is the basis for statements about probability or risk of disease
- **NB:** Incidence is direct measure of risk. High prevalence does not necessarily signify high risk. (it may signify increase in survival)
- Low prevalence may reflect a rapidly fatal process or rapid cure of disease as well as low incidence.

Measures of Mortality

- Mortality refers to death
- (cf morbidity for illness)

MORTALITY RATES

- Annual (crude) mortality rate
= Total number of deaths from all causes in one year/number of persons in the population at midyear x 1,000
- Age-specific mortality rate
= Number of deaths from all causes in children under five years old in one year/number of children less than 5 years old in the population at midyear x 1,000

MORTALITY RATES

- Disease or cause-specific mortality rate
=Number of deaths from cancer in one year/number of persons in the population at midyear x 1,000
- Case-Fatality rate (percent)
=Number of individuals dying during a specified period of time after disease onset or diagnosis/individuals with the specified disease x 100

MORTALITY RATES

- Case-Fatality rate (percent)
=Number of individuals dying during a specified period of time after disease onset or diagnosis/individuals with the specified disease x 100

Example: Case Fatality Rate

- Assume a population of with 1000 deaths in the year. In one year, 20 individuals became sick with cholera and 6 died from the disease
- The cause-specific cholera mortality rate for that year was:

$$6/1000 = 0.006 = 0.6\%$$

- The case-fatality rate from cholera for that year was:

$$6/20 = 0.3 = 30\%$$

MORTALITY

- is an index of the severity of a problem both from the clinical and public health standpoint
- may also be used as an index of risk of disease e.g. when case fatality is high and when the duration of illness (survival) is short.

Measures of Association

Epidemiologic Measures

- **Measures of disease frequency - measures disease risk or burden in a population**
 - **Prevalence**
 - **Incidence**

Measurement of Risk

- Information about the risk of contracting a disease is of great value.
- The knowledge that something is a risk factor for a disease can be used to help:
 - *Prevent the disease.*
 - *Predict its future incidence and prevalence.*
 - *Diagnose it (diagnostic suspicions are higher if it is known that a patient was exposed to the risk factor).*
 - *Establish the cause of a disease of unknown etiology.*

Epidemiologic Measures

- **Measures of association**
 - Calculations used to measure disease frequency relative to other factors
 - Indications of how more or less likely one is to develop disease as compared to another

Epidemiologic Measures of Association

- **Absolute**

- Risk difference

exposed - unexposed

- **Relative**

- Risk ratios

- Odds ratios

exposed / unexposed

Epidemiologic Measures of Association

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

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

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

$$5 \text{ cases/1000 PY} - 1 \text{ case/1000 PY} = 4 \text{ cases/1000 PY}$$

Epidemiologic Association

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



- **Statistical relationship between exposure and disease**
- **Association is not causation!**

Risk Factor

- **A factor (exposure) found to be associated with a health condition**
- **an attribute or exposure that increases the probability of occurrence of disease**
 - **behaviour**
 - **genetic**
 - **environmental**
 - **social**
 - **time**
 - **person**
 - **place**

Epidemiologic Measures of Association

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

2 x 2 Tables in Epidemiology

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

Exposure	Disease		Total
	Yes	No	
Yes	a	b	$a + b$
No	c	d	$c + d$
Total	$a + c$	$b + c$	$a + b + c + d$

2 x 2 Tables: Contents of Cells

a = number of individuals who are exposed and have the disease

b = number who are exposed and do not have the disease

c = number who are not exposed and have the disease

d = number who are both non-exposed and non-diseased

2 x 2 Tables in Epidemiology

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

Exposure	Disease		Total
	Yes	No	
Yes (exposed)	<i>a</i>	<i>b</i>	<i>total # exposed</i>
No (unexposed)	<i>c</i>	<i>d</i>	<i>total # unexposed</i>
Total	<i>total # with disease</i>	<i>total # with no disease</i>	<i>Total Population</i>

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

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

		<u>Disease</u>		Total
		Yes	No	
<u>Exposure</u>				
Yes		<i>a</i>	<i>b</i>	<i>a + b</i>
No		<i>c</i>	<i>d</i>	<i>c + d</i>
Total		<i>a + c</i>	<i>b + d</i>	<i>a + b + c + d</i>

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

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 and 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: $.5$ = half as likely to experience disease

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

**At times, epidemiologists will
choose to express disease
frequency in terms of odds**

What are odds?

Measures of Disease Association

The chance of something happening can be expressed as a risk and/or as an odds:

Risk = the chances of something happening
the chances of *all* things happening

Odds = the chances of something happening
the chances of it *not* happening

Measures of Disease Association

Example: Among 100 people at baseline, 20 develop influenza over a year.

The risk is 1 in 5 (i.e. 20 among 100)
= 0.2 The odds is 1 to 4
(i.e. 20 compared to 80) = 0.25

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

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

Exposure	Disease		Total
	Yes	No	
Yes	a	b	$a + b$
No	c	d	$c + d$
Total	$a + c$	$b + d$	$a + b + c + d$

$$\text{Odds Ratio} = \frac{[a / (a + b)] / [1 - (a / (a + b))]}{[c / (c + d)] / [1 - (c / (c + d))]}$$

Odds Ratio

		Disease		Total
		Yes	No	
Exposure	Yes	a	b	$a + b$
	No	c	d	$c + d$
Total		$a + c$	$b + d$	$a + b + c + d$

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

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	# of smokers	# of nonsmokers	
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.

Difference Measures

- **Attributable risk**

- # of cases among the exposed that could be eliminated if the exposure were removed

- = **Incidence in exposed - Incidence in unexposed**

- **Population attributable risk percent**

- Proportion of disease in the study population that could be eliminated if exposure were removed

- = **Incidence in total population - Incidence in unexposed**
incidence in total population

Attributable Risk

- Rate of disease in the population that can be directly attributed to the exposure
- equals incidence rate in exposed minus incidence rate in the unexposed

$$= \frac{A}{A + B} - \frac{C}{C + D}$$

AR: Fast driving and Automobile Deaths

	Dead	Not dead		Risk	RD
Fast	100	1900	2000	0.05	
Slow	80	7920	8000	0.01	0.04
	180	9820	10000		

Population Attributable Risk Percent (PAR%)

- PAR expressed as a percentage of total risk in population

$$\text{PAR\%} = \frac{I_{\text{population}} - I_{\text{unexposed}}}{I_{\text{population}}} \times 100$$

PAR: Fast driving

	Dead	Not dead		Risk
Fast	100	1900	2000	0.050
Slow	80	7920	8000	0.010
	180	9820	10000	0.018

$$\text{PAR} = 0.018 - 0.010 = 0.008$$

$$\text{PAR}\% = \frac{0.018 - 0.010}{0.018} \times 100 = 44\%$$

Conclude

- **44% of driving-related deaths in population were presumably due to fast driving**