Measures of Disease Frequency, Effect and Impact

Objectives:

1. Define & calculate Incidence & Prevalence (measures of disease frequency)
2. Interpret the relation between incidence and prevalence rates
3. List the measures of effect & impact showing relative difference in risks & absolute risk difference in reference to those exposed & not exposed to risk factor.

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1. To define and distinguish the different types of measures of disease frequency
2. To calculate the different measures of disease frequency
3. To understand the difference between frequency, proportion, rate, and ratio
4. To understand the difference between association and effect

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Resources:

• 436 Lecture Slides + Notes

Important – Notes

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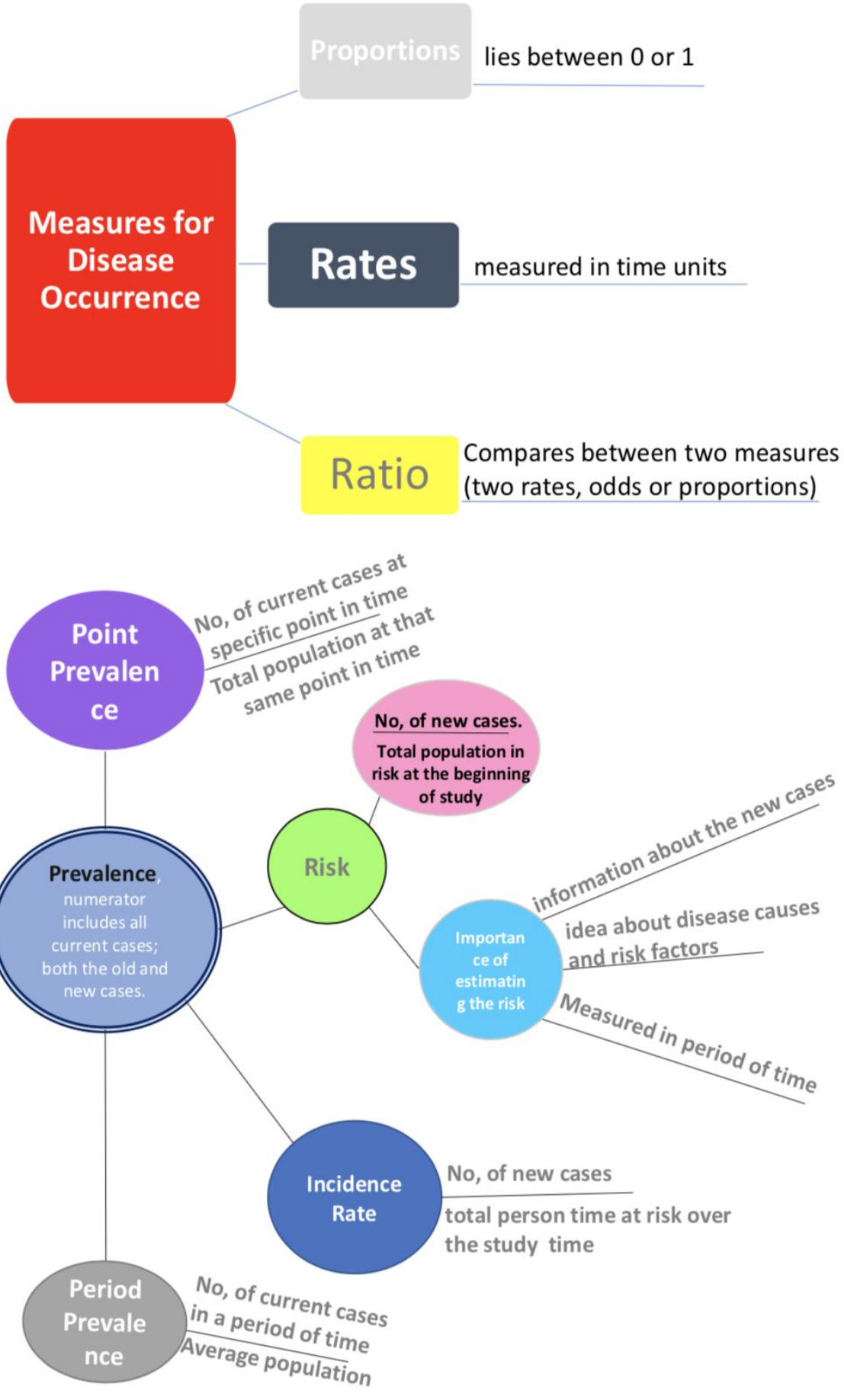
Editing file

Feedback link


Measures for Disease Occurrence
Proportions
lies between 0 or 1
Rates
measured in time units
Ratio
Compares between two measures (two rates, odds or proportions)
Point Prevalence
No, of current cases at specific point in time
Total population at that same point in time
Prevalence, numerator includes all current cases; both the old and new cases.
Risk
No, of new cases.
Total population in risk at the beginning of study
Importance of estimating the risk
information about the new cases
idea about disease causes and risk factors
Measured in period of time
Incidence Rate
No, of new cases
total person time at risk over the study time
Period Prevalence
No, of current cases in a period of time
Average population

Measures of Disease Frequency:

- Morbidity rates are indicators of health
- The main measures of disease frequency are:
  - Incidence Rate
  - Attack Rate
  - Prevalence Rate

Types of Fractions Used in Describing Disease Frequency (disease occurrence)

- Proportions
  - prevalence
  - Incidence proportion (risk)
- Percentages
- Ratios
  - Odds for a certain disease.
- Rates
  - Incidence rates.

Important terms to understand:

- **Proportion:** يعني عشان تحسبه تحتاج وقت معين
  - unitless, % or fraction of a population with an illness or other characteristic [prevalence]
  - They are dimentionless (do not have a unit of measure, because the unit of measure in the denominator is the same as the numerator so they cancel each other)
  - Always lies between 0 or 1

- **Rate:**
  - How fast the disease is occurring in population with time specification [incidence](معدل)
  - denominator is measured in **time** units
  - Can exceed 1 if no. of new cases > person-time spent at risk

- **Ratio:**
  - dividing one quantity by another e.g. male female, waist hip, MMR
  - Compares between two measures (two rates, odds or proportions)
  - what is counted in numerator isn't always in the denominator

- **Exposure (E)**
  risk factor,
  potential health determinant;
  the independent variable
  e.g. Smoking
- **Disease (D)**
  outcome after exposure to the risk factor
  development of disease (death, or disability included)
  the dependent variable
  e.g. Lung cancer

What is Prevalence ?

Prevalence is a term referring to the number of existing (old) and new cases of the disease present in a particular population at a given time

$$Prevalence = \frac{all\ new\ and\ pre\text{-}existing\ cases\ during\ a\ given\ time\ period}{population\ during\ the\ same\ time\ period} \times 10^{n}$$

-It thus means that numerator includes all current cases; both the old and new cases.
-It is an important measure of the burden of disease in a community

- The **numerator** for prevalence includes:
  - **all** persons ill from a specified cause during a specified time interval (or at a specified point in time)
  - **regardless of when the illness began**.
- The **denominator** for prevalence includes
  - total population in the same place during a specified time interval (or at a specified point in time)
  - mid year population is used in very large populations

- Divided into two types: **1.** Point Prevalence **2.** Period Prevalence

1- Point prevalence

The proportion of the population that has the disease at a specific point in time

prevalence = Number of current cases at a specific point in time
Total population at that same point in time

- "Current cases" means new and pre-existing cases (all the cases that were there at that point in time)

(when the type of prevalence rate is not specified it is usually point prevalence)

Example:

- Question asked:

Does your child has diarrhea today? Yes/No

- e.g. 80 mothers said yes and 1000 were questioned

➢ What is the point prevalence of diarrhea in children?

prevalence = 80 / 1000 = 8%

2-Period prevalence

The proportion of the population that has the disease during a specified period of time OR Proportion of individuals in a specified population who have the disease of interest over a specified period of time e.g. annual prevalence, lifetime prevalence rate

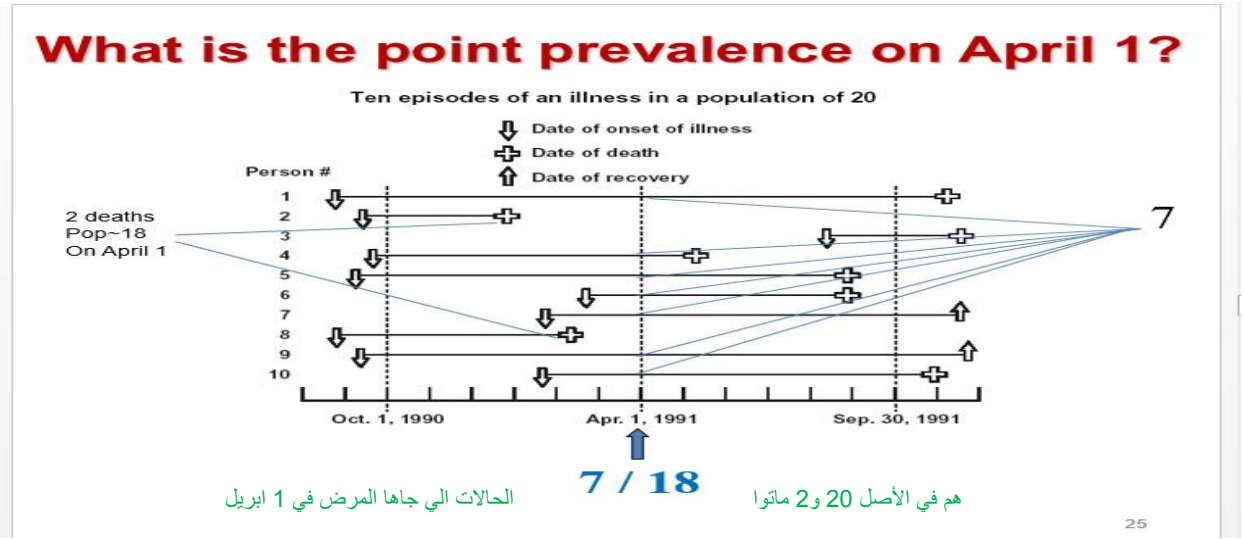
Period prevalence = Number of current cases during a specific period of time
Average or mid-interval population

The difference between point and period prevalence is in the denominator (المقام):
Point prevalence → **total** population
Period prevalence → **mid-interval** population.
(what does mid interval mean? for example if the specified time period is 1 year I will take the population size in june which is in the middle of the year)
The numerator (البسط) is the same in both.

Question asked:
'Had you ever had asthma?' Response was either Yes /No
Those who said yes (~100) / All from whom question was asked (~1000)
= 10%
This is an example of a lifetime prevalence rate, a period prevalence rate in this population

➢ **What is the point prevalence on April 1, 1991?**

7/18 = 38.8%



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Incidence Proportion (Risk):

- In a **cohort** study, investigators can also estimate the incidence proportion (risk)

Risk= Number of new cases
total population at risk at the beginning of the study

- The population at risk is a well-defined population that is **free of the disease at the beginning of the study** and has certain characteristics that put them **at risk for developing the disease**
- Example if I want to calculate risk of cervical cancer in riyadh in 2015:
  risk = new cases who developed cervical cancer in 2015 (so if they got it in 2014 we don't include them)
  all females who have uterus (so we don't include those who don't have uterus because they can't get it)

Why is it important to estimate risk?

- Gives us information about the new cases of the disease
- Important in order to estimate associations between exposure and outcome that can give us an idea about disease causes and risk factors
- Risk can only be interpreted in the period of time in which it was measured. e.g. it does not make sense to say that xx person has a risk of 3% for CVD, without explaining the period of time or the context.

Question: what is the prevalence & risk? "Important"

In a study that followed up people above 60 years of age for the development of CVD, there were 80 men with CVD when screened at baseline, and 60 women with CVD when screened at baseline. However, 200 men and 200 women did not have CVD at baseline.

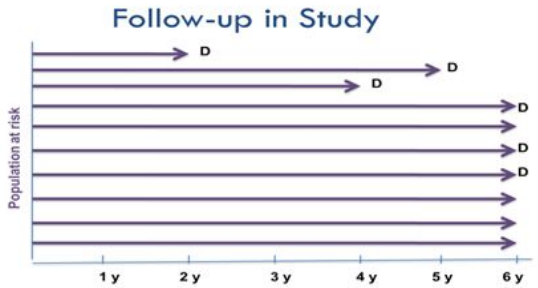
After 3 years follow-up, 50 new cases of CVD developed in men, and 30 new cases of CVD developed in women.

$$\text{prevalence} = \frac{80+60+50+30}{200+200+80+60} = 0.41 = 41\%$$

$$\text{Risk} = \frac{50+30}{200+200} = 0.2 = 20\%$$

*people who have the disease are not at risk to have it again!

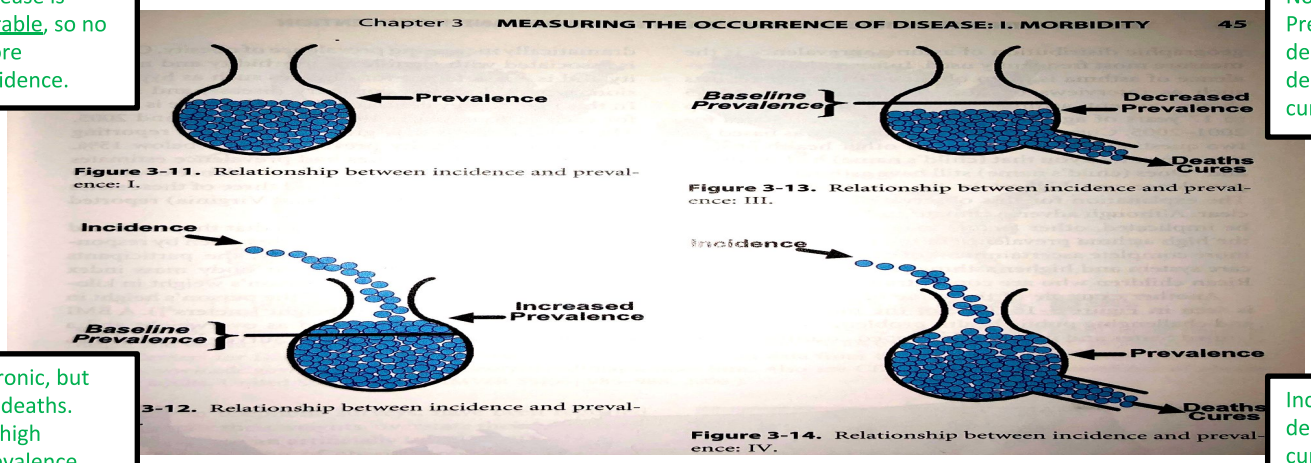
Question:



# of people at risk at baseline? 10 people (all of them)
# of cases developed during the 6 year follow-up period? 6 people
Total person-time at risk? Risk = 6/10 = 60%

Relationship between prevalence and incidence

Disease is curable, so no more incidence.



No incidence, Prevalence decreases by deaths or cures.

Chronic, but no deaths. So high prevalence

Incidence = deaths or cured cases

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Incidence Proportion (Risk) and incidence rate are not the same. there is different way to calculate each of them.

Incidence rate: specific period and population

* it is the time relationship between being exposed to certain risk factors and developing the disease.

- Cumulative incidence rate: measures the number of new cases of a disease that occur in a specified time period in a population at risk

$$Incidence\ rate = \frac{new\ cases\ ocurring\ during\ a\ given\ time\ period}{population\ at\ risk\ during\ the\ same\ time\ period} \times 10^n$$

- In a cohort study, investigators are usually interested in disease *incidence rates*

Incidence rate = $\frac{Number\ of\ new\ cases}{the\ total\ person\ time\ at\ risk\ over\ the\ study\ period\ of\ time}$

كون الشخص في مجتمع لايعني انه عرضه دائما

Incidence rate give me information about the etiology or the causing effect of a disease while the risk does not

يعني اعرف اذا شخص جاءه المرض بعد سنتين بنما الثاني جاءه المرض بعد 4 او 6 سنوات

✓ Here we are taking into consideration the time that each person spent being at risk before developing the disease

✓ By contrast the incidence proportion only considers the total population at risk without also incorporating time in the equation

Incidence rate = numerator

denominator

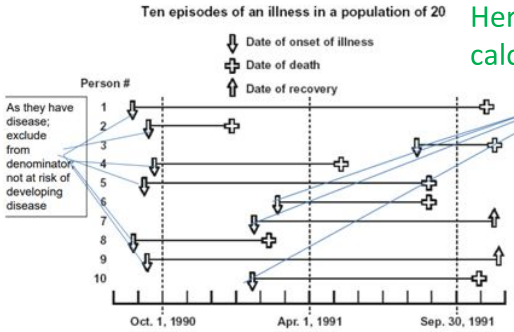
The **numerator** should:

- reflect new cases of a disease occurring in a given time period
- not include cases which occurred earlier than the given time.
- come from the population at risk for developing disease
- be a part of the denominator

The **denominator** should:

- include persons at risk to develop the disease that is being described during the time period covered.
- The denominator may change over time as people develop disease

What is the incidence rate from October 1, 1990 to Sep 30, 1991?



Here we calculated Risk

4

4 / 14

why it is 14 not 20? because 6 of them they have already the disease so they will not going to have the disease again so we exclude them and the question need a specific time.

Example: Incidence: RISK

There were 50 cases of Cancer of breast that developed during January to December in 2010 among the 10,000 women above 40 years of age living in city X
~ 50/10,000 is the incidence rate of Ca breast in women above 40 years of age from January 1, 2010 to December 31, 2010 living in City X

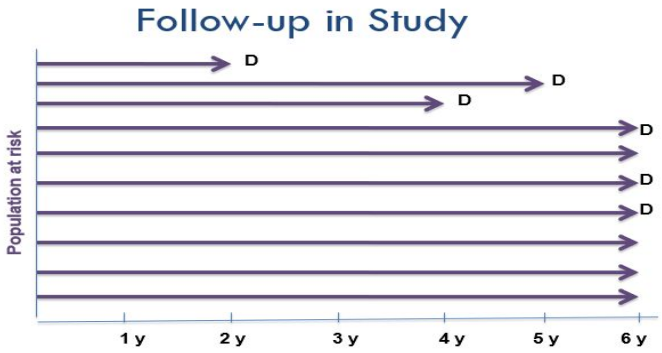
Incidence of Ca Breast was 5/1000 women above the age of 40 yrs in 2010 in City X

E.g. if ca breast needs to be studied in 2011 ; all those women who developed Ca breast in 2010 will be excluded from the denominator during 2011

Only in female slides.

- **Rate vs. Risk**
  - A study followed 3,000 males ages 45 years and older for 5 years to assess the development of MI.
  - During the study period, 150 men developed MI, who accumulated a total person-time of 14,625 person-years.

  - What is the *incidence proportion* after 5 years (risk)? 150\3000 = 0.05 * 100= 5%
  - What is the *incidence rate* after 5 years (rate)? 150\14625 = 0.01. 10\1000 persons per year.



# of people at risk at baseline?
# of cases developed during the 6 year follow-up period?
Total person-time at risk?

Answer:
2+4+5+(6*7)=53
Then, 6\53= 0.11 per person year.
"110 cases per 1000 person year"

If I lost the follow up of a patient after 3 years, I won't know if she\he got the disease or not so I won't count her\him in the number of cases because I lost the follow up.

الانسدنت ريت البسط تبعه نفس البسط تبع الانسدنت بروبورشن (risk) لكن المقام مختلف! انتبهوا, المقام بالانسدنت ريت يسمى total person time وحسبته مختلفه شوي بس سهله,
احنا مثلا عندنا 10 اشخاص في خطر انه يجيهم مرض, و 6 منهم جاهم المرض.
لكن ال 6اشخاص جاهم باوقات مختلفة في المدة المحددة بعضهم بعد سنتين وبعضهم بعد اربع سنوات وبعضهمبعد خمس سنواتاو ستة.
لذلك نبي نعرف كل شخص كان في مرحلة الخطر ايش صار له
فنجمع 2+4+5+6+6+6+6+6+6+6
و يطلع لنا المقام.
في المقام نحسب كل الاشخاص سواء جاهم المرض او لا.

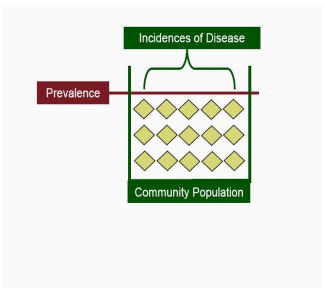
Only in male slides.

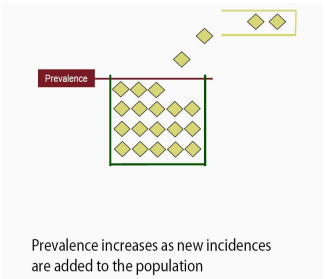
Factors affecting incidence rate:

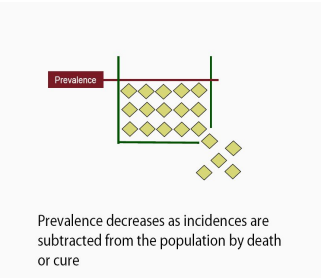
- **New risk factor**
  - oral contraceptives as exposure and increase in thrombo-embolism in women;
  - food additives and cancer
  - New virus (HIV and AIDS)
- **Changing habits**
  - increased smoking and development of lung cancer
  - fluoridated water and decrease in dental caries
- **Changes in virulence of causative organisms**
  - drug-resistant bacteria (TB)
  - Influenza virus mutation Increase influenza (H1N1)
  - drug resistance to malaria prophylaxis and increase in malaria
- **Changes from intervention programs**
  - vaccination against measles DECREASE incidence of measles
  - polio eradication campaigns DECREASE incidence of polio
  - chemoprophylaxis DECREASE meningitis ,rheumatic fever

- **Selective migration** of susceptible persons to an endemic area increase incidence
- **Population pattern**
  - Aging increase incidence of Degenerative diseases
- ***Reporting***
  - Increased reporting increase incidence
- ***Screening***
  - Early detection of cases increase incidence
- ***New diagnostic tools***
  - New diagnostic tools increase detection of cases

Relation between incidence and prevalence:







Prevalence ~ incidence x duration of disease

- Higher incidence results in higher prevalence
  (with short duration of illness & recovery prevalence may or may not change)
- Longer disease duration leads to higher prevalence

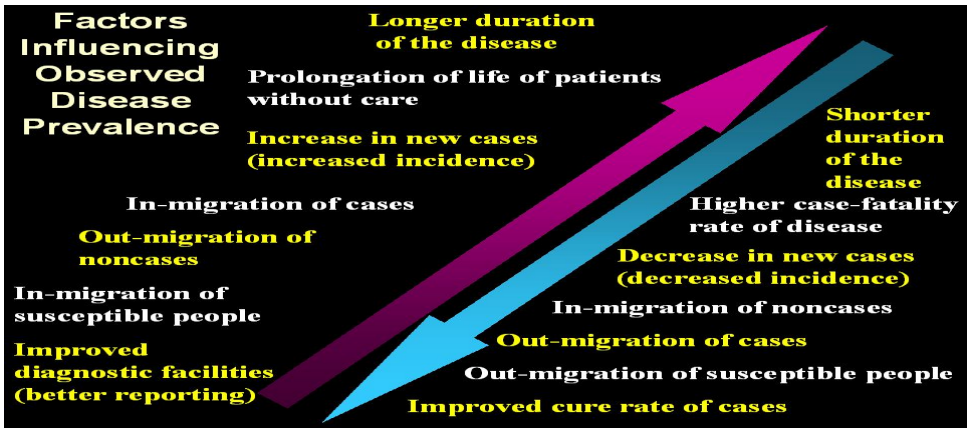
Only in male slides.

Several factors may affect prevalence rate:

- Incidence
- Duration of disease
- Selective Migration
- disease treatment and out come

Factors affecting Prevalence:

- Changes in incidence
  - Prevalence rate= Incidence rate x average duration of disease.
  - High incidence produces high prevalence
- Changes in disease duration and chronicity
  - Longer duration of disease, higher the prevalence rate
  - Chronic diseases are accumulating so increase the prevalence
  - Acute diseases of a high recovery rate or high case fatality rate decrease prevalence



- Intervention programs
  - Better treatment with high cure rate decrease prevalence
  - If treatment only increase survival without cure, increase prevalence
- Selective attrition
  - selective migration of cases, or susceptible or immune persons
- Changing classifications:
  - the data coding according to various disease categories often changes, and variations in prevalence may be reported due to misclassification).

Attack Rate:

An attack rate is a variant of an incidence rate, applied to a narrowly defined population observed for a limited time, such as during an epidemic.

The attack rate is usually expressed as % **percent.**

$$Attack\ rate = \frac{Number\ of\ new\ cases\ among\ the\ population\ during\ the\ period}{Population\ at\ risk\ at\ the\ beginning\ of\ the\ period} \times 100$$

Attack rate: is it really a rate?

It's proportion not rate

- In the context of an outbreak:

The proportion of new cases during a specific time period divided by the total population at risk during that same period

- Attack rate is the *"incidence proportion"* that they calculate during *outbreak investigations* for acute illnesses

Example:

Of 76 persons who attended a picnic, 46 subsequently developed gastroenteritis.

Calculate the attack rate of gastroenteritis:

Attendees = 76

ILL= 46

Attack rate = (46 ÷ 76) X 100

= 61%

Only in male slides.

Measure of potential impact:

- Quantifies the potential impact of removing a hazardous exposure as to how much disease development is prevented if the risk factor is removed from population .

- Assumption of causality need to be satisfied meaning that cause effect relationship must exist between risk factor and disease outcome

Attributable Risk: Incidence in exposed – Incidence in unexposed

Measure of Impact: Attributable risk:

- Absolute comparison is derived by subtraction
- Incidence of lung cancer among smokers =20%
- Incidence of lung cancer among non smokers is 3%
- 17% of lung cancer cases can be prevented if smoking is removed from the population
  - For better understanding : If I have 100 person 50 of them are smokers and other are not and I apply Cohort study on them for 10 years then I found that 3 of the non-smokers got lung cancer and 20 of the smokers got lung cancer so the attributable risk =20%-3%= 17% It mean the lung cancer attributed 17% to tobacco used
  - It is for causation rather for association

Measures of Effect :

- **Measures of association:**

Relative comparison derived by division

Quantifies the relative relationship between an exposure and a disease (risk factor & disease development)

- Two types mainly
  1. Relative Risk (RR)
  2. Odds Ratio (OR)

Measure of Effect: 1. Relative Risk:

- Risk in the exposed / Risk in the unexposed
- Incidence in exposed/incidence in unexposed
- Risk is studied after following up population over a time period
- Usually two groups of population are followed
- One group exposed to risk factor (e.g. smokers) and another not exposed to risk factor (e.g. non smokers)
- Is the risk of developing lung cancer twice more in those exposed to smoking compared to those who do not smoke ?
- If yes then Relative risk is 2 calculated from = incidence in exposed/incidence in unexposed

Only in male slides.

Measure of Effect: 2. Odds Ratio:

- If it is not possible to follow up in time; disease cases can be inquired about the exposures they had in past; and compared to healthy people (controls) exposures in past
- Diseased cases of coronary heart disease (CHD) were interviewed as to how many were smokers and similarly healthy persons were interviewed for smoking prevalence in past.
- If smoking is associated with CHD then a higher prevalence would be found in CHD cases compared to non cases.
- Relative comparison would be between two odds
- Odds of exposure in cases / odds of exposure in non cases
- An Odds ratio of 2 would be explained as Odds of exposure to cigarette smoking were twice more in CHD cases compared to non cases

Only in female slides.

Odds for disease

	GD Genetic Disease	No GD No Genetic Disease
Genetic variant **present**	A	B
Genetic variant **absent**	C	D

Odds among GV+ve = a/b

Odds among GV-ve = c/d

Odds ratio = (a/b) / (c/d) = ad / cb

1- the odds can proximate the risk
2- odds ratio = a\b \ c\d
"it compares two groups"

Odds= prevalence/ 1-prevalence
Odds of GD in people with genetic variant:
(a / a+b) / (b / a+b) = a / b

Getting probability 1\6

Not getting probability 5\6 = 1\5

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Examples, Risk, Rate or Odds?

	Cervical ca	no cervical ca	Total person time (person year)	Total
Tobacco use	64	106	35.000	170
no tobacco use	55	125	56.000	180
total	119	231	91.000	350

Solution:

Risk = 119 / 350 = 0.34 (or 34%)

Rate = 119 / 91000 = 1.3 per 1000 person-years

Odds = 119 / 231 = 0.52 (or 52 in 100)

لما نبي نقنع الناس نستخدم ال odds لانها اكبر ثم risk ثم rate .

- أحيانا ال rate يصير اكبر منهم كلهم لما تكون السنوات قليلة مثل الامراض المعدية.

Risk, Rate or Odds:

- It is important to distinguish between these measures of disease frequency, and not to mistake them with each other when interpreting your results

- The type of study determines the type of estimate we can use:
  - If we can follow-up people through time (**cohort** study) then we will be able to calculate: **Risk and Rate**.
  - If we do not have the information from when the person was free of disease until they developed a disease then we can only estimate **odds ratios** (odds alone are rarely expressed)

Theory behind Cause and Effect:

- **Cause:**

a specific event or condition that is necessary for the occurrence of the disease at the moment it occurred, given that other conditions are fixed

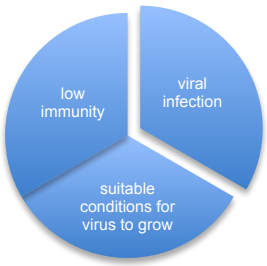
In other words, a cause is an event that must precede the disease in order for the disease to occur, in such a way that if we removed that event, given all other conditions being fixed, the disease would not have occurred

- **Effect:** The effect can not be measured

A change in a population measure brought upon by a certain event

Example:

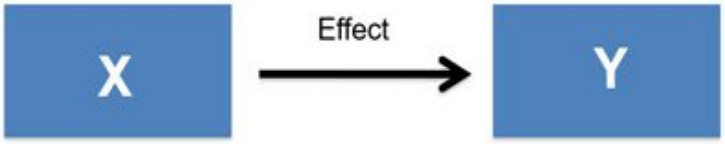
We need a sufficient causal mechanism for the disease to occur



Only in female slides.

Need assumptions in order to:
Be certain that X caused Y
Measure the "effect" of X on Y

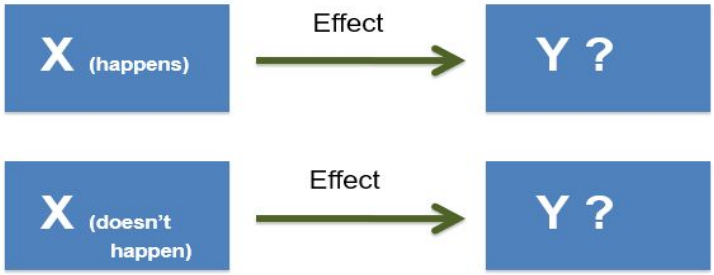
Not compatible with our world !



In order for me to be certain that X causes Y, I need to be able to measure all the component causes that would complete this causal mechanism, and be 100% certain that they all occurred. And that removing x from the equation will definitely make Y impossible to happen, given all other conditions are fixed.

In the same population, at the same time, all other things fixed

You will need to bring a population (let's call them A), and then expose them to X, follow them over time to see if they develop Y or not. Then you go back in time, to the same population A, do not expose them to X, follow them over time to see if they develop Y or not, all other conditions similar to the first scenario.



We can only measure associations NOT effects:

- In reality as researchers we can never measure effects, because there is no way we can compare occurrence of an event vs. absence of that event, given all other things fixed, in the SAME population, at the SAME exact period of time
- At best, we try to ***estimate*** effects by measuring association (after controlling for confounding and making many other assumptions)

Summary:

- **Measures of disease frequency: Incidence, Attack Rate, & Prevalence**
- **Measures of Association (Effect): Relative Risk (RR) & Odds Ratio (OR)**
- **Measures of Impact: Attributable Risk**

THE END

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