Measures Of Disease Frequency

Lecture 1: Incidence & Prevalence

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Learning objectives

- **By the end of this lecture, the students will be able to:**

1. Understand the meaning of epidemiology
2. Know the importance of disease measurement and methods to measure it.
3. Calculate different disease measures.
4. Realize the difference between disease incidence and prevalence

Definition of Epidemiology

- Epidemiology is the study of the frequency, distribution, and determinants of *diseases* and health-related states in populations to prevent and control disease.

Importance of Measuring Disease

- Measuring disease frequency:

1. Helps track trends, allocate resources, and plan interventions.
2. Allows comparison across populations and assessment of public health interventions.

Measures of Disease Occurrence and Frequency

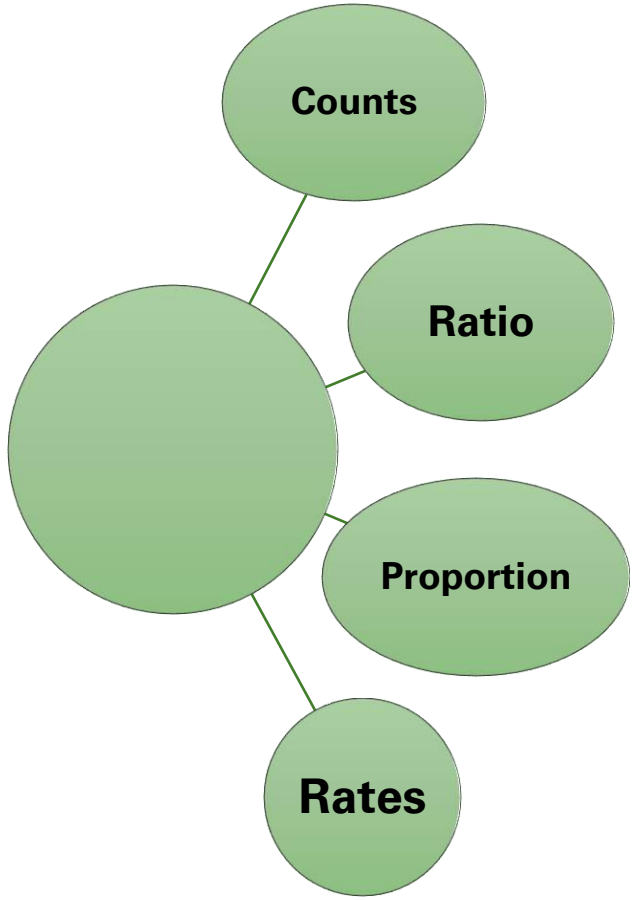
Measures of disease frequency in mathematical quantities:

- Counts
- Ratio
- Proportion
- Rates

Measures of disease frequency in epidemiology:

- Prevalence
- Incidence

Measures of disease frequency in mathematical quantities:



1. Counts:

- **Definition: The simplest measure of disease occurrence. The absolute number of persons who have a disease or characteristic of interest.**

Examples:

A. Counting the number of flu cases in a city over a month (3000 cases).

B. Total COVID-19 cases in a country from 2020 to 2022. (100000 cases)

2. Ratio:

- **Definition: A ratio is a fraction in which the numerator is not part of the denominator.**
- **Formula of** ratio is $\frac{a}{b}$ (where a and b are independent of each other)

Example:

- Male-to-female ratio in lung cancer cases. (200/300 cases)

3. Proportion

- **Definition: A proportion is a type of ratio in which the numerator is a subset of the denominator, representing a part-to-whole relationship. Always presented as a percentage.**

- **The formula of Proportion** = $\frac{number\ of\ cases}{total\ population}$ x 100 = $\frac{a}{a+b}$ x100

(Where the **total population** includes both those with and without the condition)

- **Example:** From 1000 females aged 16 – 45 years, 675 use modern contraceptive methods.

The proportion of those who use modern contraceptive method?

- Proportion= $\frac{675\ x100}{1000}$= 6.75%

4. Rates:

- **Definition: Is the measure of an event, condition (disease, disability ,or death), within a *unit population and within a time period*.**
  - **Formula:** $\text{Rate} = \dfrac{\text{Number of events in a population}}{\text{Population at risk during a given time}} \times k$

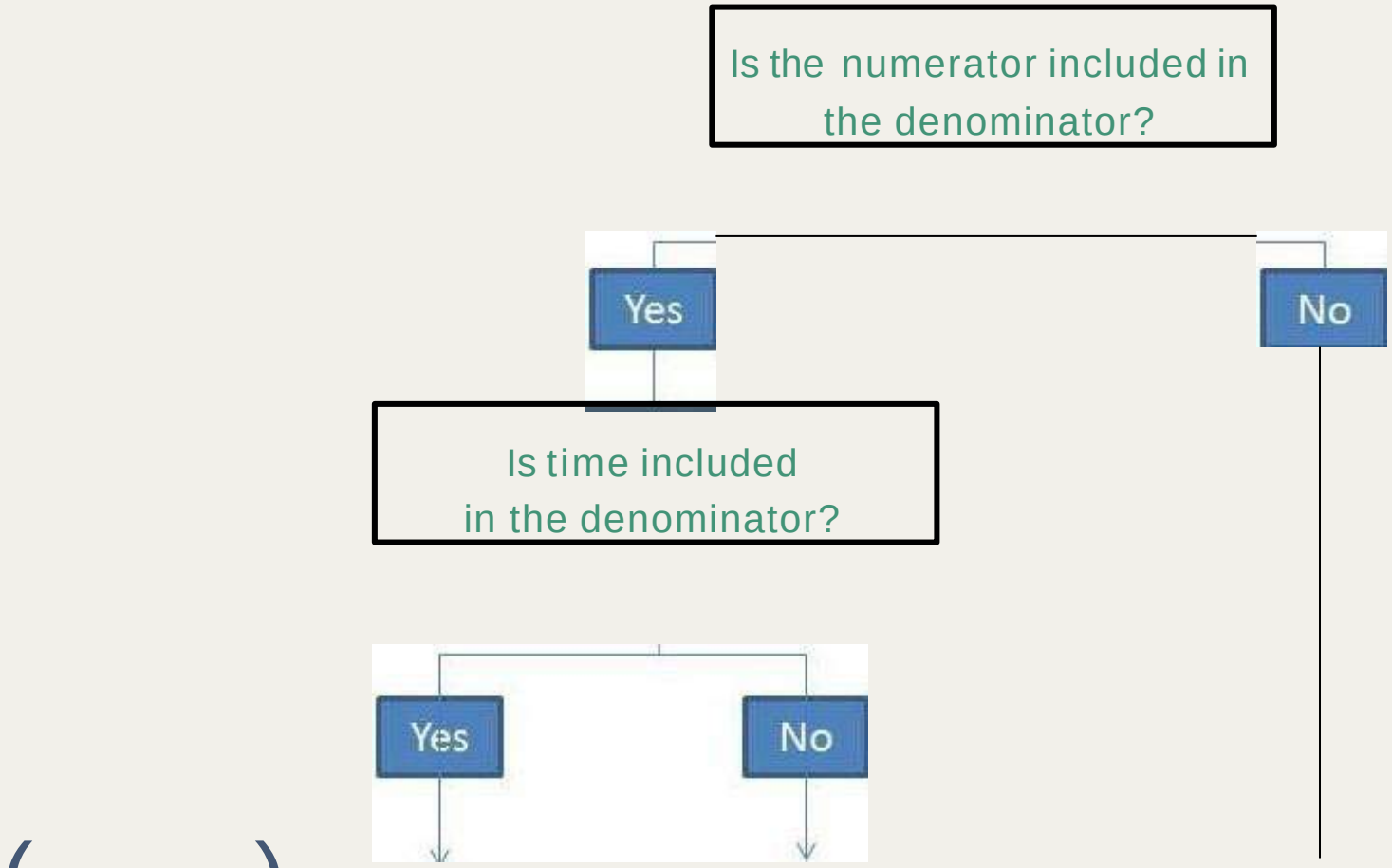
- **Number of events: the occurrences of the health outcome (e.g., new disease cases).**
- **Population at risk: includes only those who are susceptible to the condition.**
- **Time: is included to reflect the period over which the events occur.**
- **k is the constant (e.g., 1,000, 10,000, or 100,000)**

Example:

Incidence rate of heart attacks: $= \dfrac{\text{5 heart attacks}}{\text{2000 people per year}} \times 1000 =$

2.5 cases per 1,000 people per year

Distinguishing Proportions, Rates, and Ratios



Measures of disease Frequency in epidemiology

There are two main measures of disease frequency:

Prevalence	Point prevalence
	Period prevalence
Incidence	Cumulative incidence (risk)
	Incidence rate

A. Prevalence

- DEFINITION:

"Prevalence is an estimate of individuals in the population with a given disease, disability, or health state at a particular point in time."

- Prevalence is a ***proportion*** and should usually be reported as one. Denominators in prevalence always include the entire population; the numerator encompasses both new and old cases.
- **Categories of prevalence:**

1. Point prevalence
2. Period prevalence

Point prevalence

Prevalence means **ALL.** (**Pre existing + New**)

Attempts to measure disease at one point in time.

$$\text{Point prevalence} = \frac{\text{Number of cases of disease at a point in time}}{\text{Total number of people in the defined population at the same point in time}}$$

Example on disease prevalence:

Among 10000 population. We found 50 with Type 1 Diabetes Mellitus (T1DM).

Calculate The Prevalence؟؟

The prevalence is 50/10000= 0.005=0.5%

Period prevalence

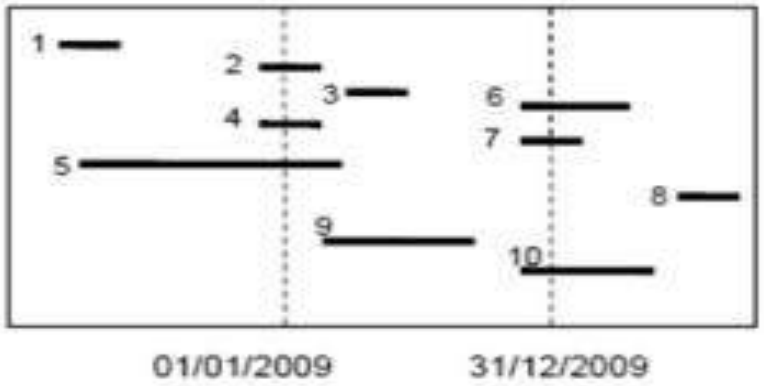
$$\text{Period prevalenc} = \frac{\text{Number of cases of disease at any time during a specified period (usually short)}}{\text{Total number of people in that defined population}}$$

- **Point prevalence** represents a single moment in time (e.g., how many people have a disease on January 1st). Pre-existing cases present at the specific time point
- **Period prevalence** covers a time frame (e.g., how many people had the disease at any point during launna ,.g.E .doirep eht gnirud sesac gnitsixe-erP .(2023 .etar ecnelaverp

- It describes the prevalence of disease over a period of time.

- *When the type of prevalence rate is not specified, it is usually point prevalence*.

Prevalence divided into two types:



Point prevalence

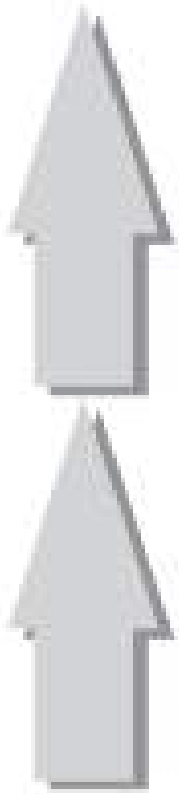
01/01/2009: case No. 2, 4, 5

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

Factors influencing prevalence



Increased by:

- Longer duration of the disease
- Prolongation of life of patients without cure
- Increase in new cases (increase in incidence)
- In-migration of cases
- Out-migration of healthy people
- In-migration of susceptible people
- Improved diagnostic facilities (better reporting)

Decreased by:

- Shorter duration of the disease
- High case-fatality rate from disease
- Decrease in new cases (decrease in incidence)
- In-migration of healthy people
- Out-migration of cases
- Improved cure rate of cases

B. Incidence

- Incidence measures the number of new cases or new events of disease that develop in a given population during a specified time period.

  To determine incidence, it is necessary to follow prospectively a defined group of people and determine the rate at which new cases of disease appear.

  Categories of incidence:

  1. Cumulative incidence (risk)
  2. Incidence rate (Density)

Cumulative Incidence (Risk)

- The **cumulative incidence (CI)** is a measure of the probability that a particular event (the development of a disease) will occur within a defined period in a specified population.

- Cumulative Incidence (CI) or Risk is defined as the number of new cases divided by the total population-at-risk at the beginning of the follow-up period.

CI is a proportion

- $Risk = \frac{\#new\ cases}{total\ \#\ of\ individuals\ at\ risk} x10^{n}$

Who is the population at risk (PAR)?

- "The total number of people who are *susceptible* to developing the disease or event being studied during a specific period."
- It includes **only individuals who are disease-free** (or event-free) **at the beginning of the study** and **capable of developing it**.

How to calculate PAR?

- Population *at Risk* = *Total population* – *Not* at risk *individuals*

Who is NOT at risk?

1. People **already having the disease** at baseline
2. People **immune** to the disease (e.g., vaccinated or genetically immune)
3. People **not exposed** to the risk (depending on the study definition)
4. People **incapable** of developing the disease (e.g., men for cervical cancer)

Examples

Example 1:

- A village has **1,000** people at the start of the year, and **50** already have diabetes.
- **Population at risk = 1,000 – 50 = 950 persons**
- If 95 new cases develop during the year: **Calculate CI?**
- Cumulative Incidence $= \frac{95}{950} = 0.10 = 10\%$

Example 2:

- A study of lung cancer among **smokers,** 2,000 total adults, 600 are non-smokers (not exposed), 100 already have lung cancer. If you study *incidence among smokers per 10 years,* ***calculate PAR?***
- Population *at risk* $= 2{,}000 - 600 - 100 = 1{,}300$
- If 10 new cases developed in that period, **calculate CI?**
- **CI= 10/1300=0.008 ⟶ 0.8%**

Incidence rate = incidence density

- Measures the rapidity with which new cases are occurring in a population.
- A way of taking into account time in the study, i.e. person- time at risk
- Unlike cumulative incidence, which considers new cases over a fixed period, the incidence rate accounts for the exact time each individual is observed (useful when follow-up times vary).
- **The rate at which new cases of a disease arise**

Incidence rate = incidence density

$$\text{Incidence Rate (IR)} = \frac{\text{Number of new cases during the study period}}{\text{Total person-time at risk}}$$

The sum of the time each individual was observed and at risk of developing the disease (measured in person-years, person-months, etc., depending on the study).

- **Example:**

A study tracking a disease in 100 people, with follow-up times that vary:

- 60 people are observed for 1 year, 30 people for 2 years, and 10 people for 3 years.
- The total person-time would be (60×1)+(30×2)+(10×3)=60+60+30=150 person-years.
- If there are 15 new cases during this period, the **incidence rate** would be:
- $\text{Incidence Rate (IR)} = \frac{15 \text{ cases}}{150\, person\ years}$ = 0.1 cases per person-year

A study followed a population of 150 smokers for one year, and 25 had lung cancer at the start of follow-up, and another 15 new cases developed during the year.

1) What is the period prevalence for the year?	– pp = (25+15)/150 = 0.27 or 27%
2) What is the point prevalence at the start of the period?	– pp = 25/150 = 0.17 = 17%
3) What is the cumulative incidence for the one-year period?	– CI = 15/125 = 0.12 = 12%

Relationship Between Incidence and Prevalence

- Prevalence depends on two factors: the number of people who have been ill in the past (previous incidence) and the duration of their illness. If incidence and duration have been stable over a long period, then:
  - **Prevalence = *Incidence* × *Duration of Disease***

- If incidence increases → prevalence rises (if survival remains constant).
- If duration shortens (due to cure or death) → prevalence decreases even if incidence is high.
- If both incidence and survival increase → prevalence increases markedly.

Practical Use of disease incidence and prevalence in Decision-Making

Area	Measure Used	Example
Infectious disease control	Incidence	Detecting outbreaks, evaluating vaccination programs
Chronic disease management	Prevalence	Planning long-term care
Health policy formulation	Both	Combining incidence and prevalence data for setting priorities
Screening program design	Incidence	Determines need and frequency of screening (e.g., cancer)

References

1. A Textbook of Public Health Dentistry, CM Marya, **Jaypee Brothers** A Textbook of Public Health Dentistry, CM Marya, **Jaypee Brothers Medical Publishers, 1st ED;** 2011 (**Chapter 2, Page 9-23)**
2. Medical statistics at a glance, Aviva Petrie and Carolen Sabin, **Wiley Blackwell Publisher. 3rd edition; 2009. (Chapter 44, page 133-135)**

- ***Thanks***