QUANTITATIVE MEASURE 1
FREQUENCY

Dr.Natthaprang Nittayasoot

Division of Epidemiology,
Department of Disease Control, Ministry of Public Health

OVERVIEW

01 INTRODUCTION

Importance of measure, Fraction in epidemiology, Type of epidemiologic measure

02 MEASURE OF FREQUENCY

Incidence, Prevalence, Risk

03 BRAIN EXERCISE

Questions

INTRODUCTION

Importance of measure, Fraction in epidemiology,
Type of epidemiologic measure

Definition of Epidemiology

Epidemiology is the study of the **distribution** and **determinants** of health-related states or **events** in specified populations and the **application** of this study to control of health problem

Determinants and Health-related Outcomes

Exposure → **Outcome**

Smoking

Lung cancer

HOW EPIDEMIOLOGIST WORK?

1. Counting:

Counts cases or health events, and describes them in terms of time, place, and person

2. Dividing:

Divides the number of cases by an **appropriate denominator** to calculate “rates”

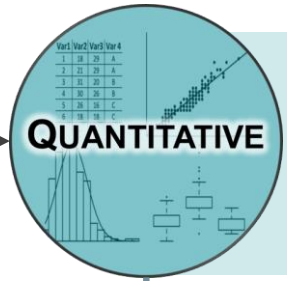
3. Comparing:

Compares these “rates” over time or for different groups of people

“Rates”, in this slide, simply means division of one number by another

TYPE OF DATA

- Based on observation or experience



- Can be measured or counted
- Expressed in number

Discrete

- Can be categorized into a classification

Continuous

COUNTING

Number of cases

“we have 5 cases of rabies”

Simple
but not informative!

How big of the population in which the cases occurred?
These cases occurred in what length of period?

COUNTING

Need to find

appropriate denominator

and **specify time period**

COUNTING

Number of cases

“From 1 Jan to 15 Jun, we have 4 cases of rabies in a village of 1,000 population

Just counting is not enough

We usually need to **divide** it!

DIVIDE

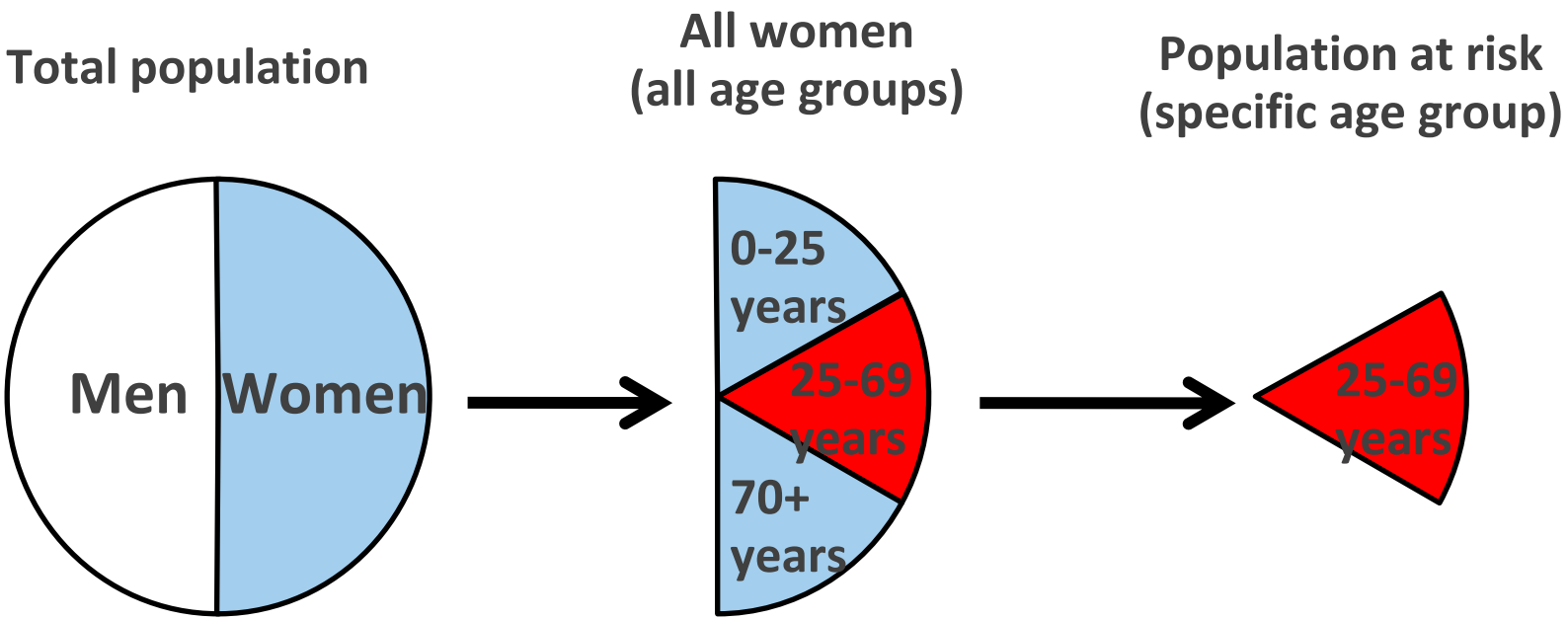
When you divide a number by another,

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

A → Numerator

B → Denominator

Appropriate Denominator for Cervical Carcinoma?



Source: Basic Epidemiology, 2nd Ed., R Bonita, 2006

FRACTION IN EPIDEMIOLOGY

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

A → Numerator

B → Denominator

You will get **ratio** or **proportion** or **rate**

RATIO

- Ratio is the relationship of one quantity (numerator) to another quantity (denominator).
- The quantities **may be** **related** or **unrelated** and are **not necessary to have the same units.**

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

$A \longrightarrow$ Any quantities

$B \longrightarrow$ Any quantities

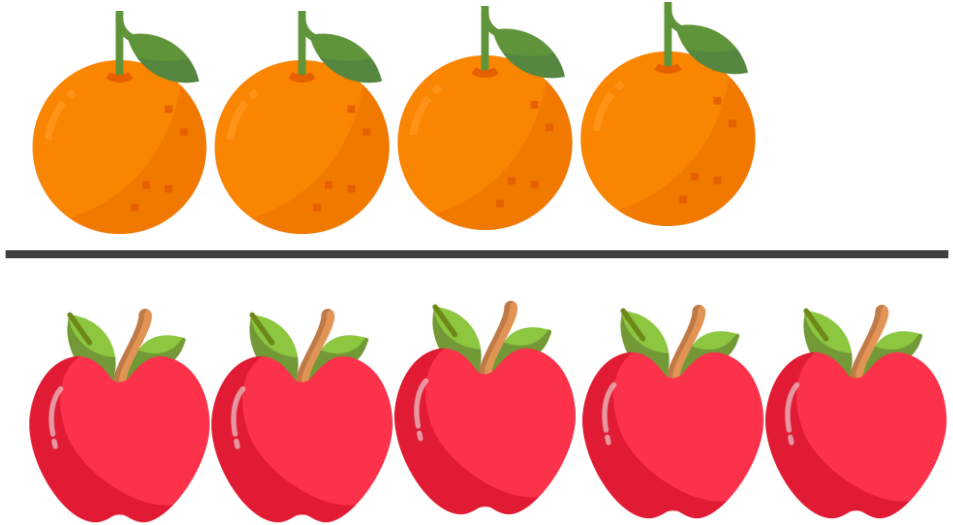
RATIO

Example:

$$\frac{\text{Females}}{\text{Males}} = 30/20 = 1.5/1 = 1.5$$

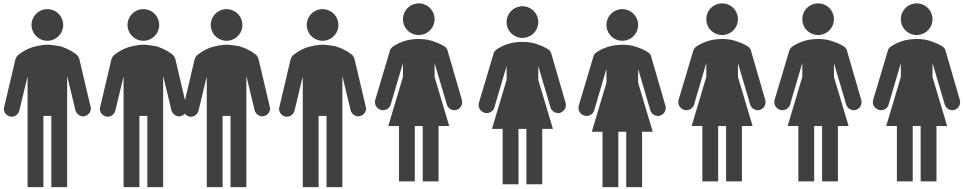
$$\frac{\text{Beds}}{\text{Doctors}} = 120/6 = 20/1 = 20$$

RATIO



$$\frac{\text{4 oranges}}{\text{5 apples}}$$

RATIO



Male: Female = 4/6 = 1:1.5

Male: total pop = 4/10

PROPORTION

Proportion is a **ratio** in which the **numerator** is **included in the denominator**

- It has **no dimension** because the unit of the numerator cancels out the unit of the denominator
- Proportion always ranges **between 0 and 1**
- **Percentage** = proportion x 100

PROPORTION

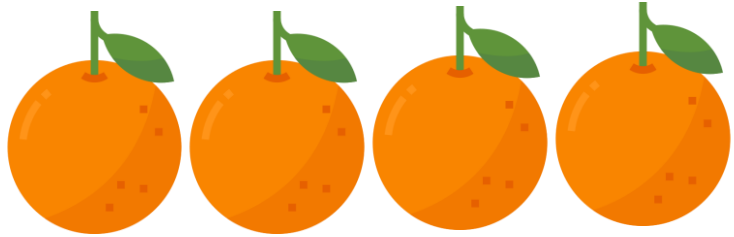
$$\frac{A}{A+B}$$

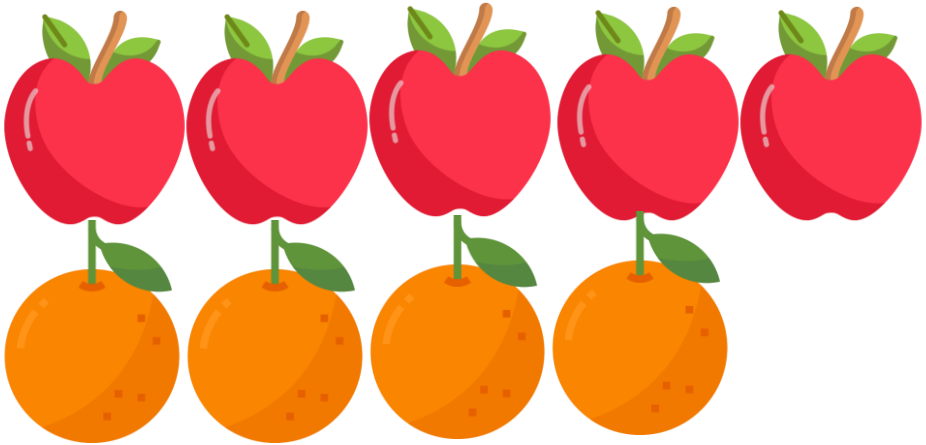
A → **A part** of **denominator**

A+B → Always Includes numerator

$$\frac{\text{Females}}{\text{Total population}} = 30 / 50 = 0.6 = 60\%$$

PROPORTIOB





4 oranges

Total fruits = 9

RATE

The speed at which something happens or **changes, or**

The amount or **number of times it happens** or **changes in a particular period**

By definition, rate is **ratio** representing relative change in two quantities

RATE

Nonetheless, a possible consensus is emerging on the technical use of rate, ratio, and risk. Following the work of Elandt-Johnson[2] and Vandenbroucke,[3] many modern epidemiology or biostatistics texts[4],[5] define a rate as varying with time, having **a dimension of time^{-1}**.

Although agreement on this is not universal,[6] rate defined as varying with time appears to be the most common usage.

Case Fatality: Rate, Ratio, or Risk?
Kelly, Heath; Cowling, Benjamin J. Epidemiology: July 2013 - Volume 24 - Issue 4 - p 622–623

RATE

In Epidemiology, rate is **measure of change per unit of time**, where time might be expressed or just implied in denominator

It is speed of occurrence of an event over time

$$\frac{A}{time}$$

A → Number of events (e.g. # cases)

time → Sum of follow-up time contributed by the people at risk of the event (person-time)

Rate, Ratio or Proportion ?

Indicator	Numerator	Denominator	Answer
General fertility rate	Number of births	Number of women ages 15-49	ratio
Infant mortality rate	Total number of infant deaths under one year of age in a year	Total live births in a year	ratio
Case-fatality rate	Number of deaths due to the disease during specific period	Number of cases of the disease during the sam period	Proportion
Mortality rate	Deaths occurring during a given time period	Size of the population among which the deaths occurred	Proportion
Attack rate	Number of new cases of disease during specified time interval	Population at start of time interval	Proportion

Note:

The term “Rate” is wrongly, and commonly, used as a synonym for ratio (e.g. fertility rate or infant mortality rate), or proportion (e.g. case-fatality rate, mortality rate, or attack rate)

TAKE HOME POINT

RATIO

- One number divided by another (a fraction) of the form
- **a/b**

PROPORTION

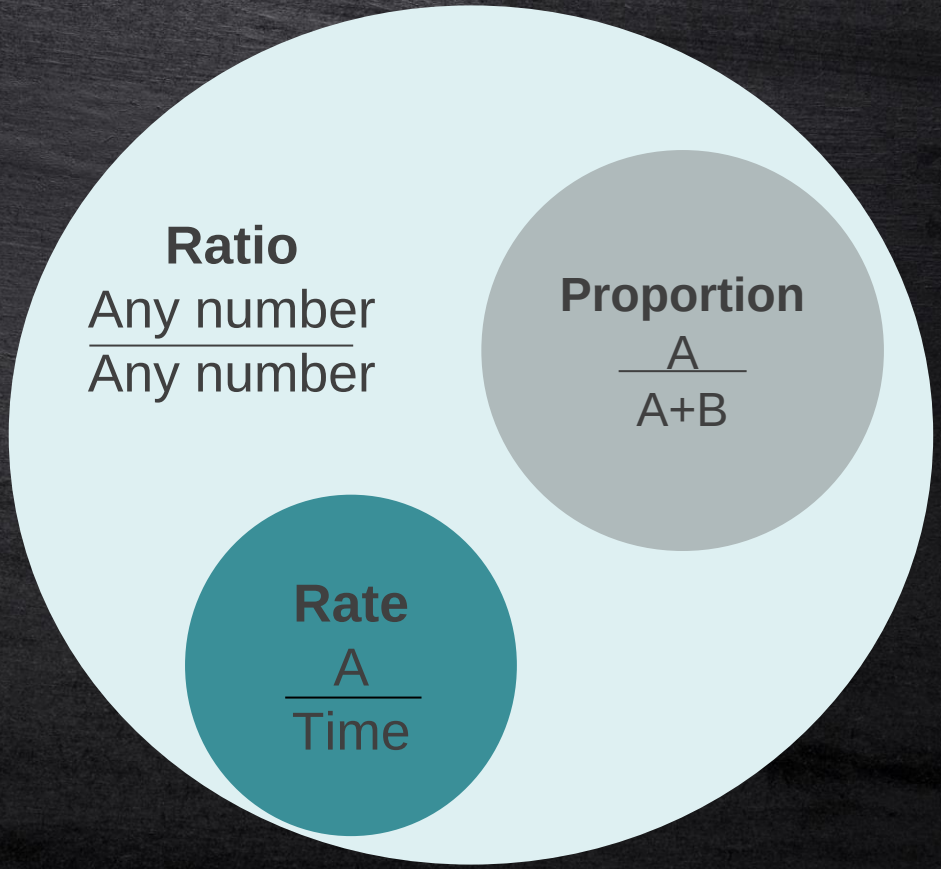
- A ratio in which the numerator is a subset (or part) of the denominator
- **a/(a + b)**

RATE

- A ratio of the form **a/Time**

TAKE HOME POINT

Rate, Ratio and Proportion



MEASURE IN EPIDEMIOLOGY

MEASURE OF **FREQUENCY**

MEASURE OF **ASSOCIATION**

MEASURE OF **IMPACT**

MEASURE OF

FREQUENCY

Incidence, Prevalence, Odds

MEASURE OF FREQUENCY

Must know:

- Definition of prevalence and incidence
- Difference between prevalence and incidence
- Calculate prevalence and incidence
- What affect prevalence?

Should know:

- Explain the relationship between incidence and prevalence
- Commonly used proportion/ratio in public health

HEALTH-RELATED STATES, EVENTS AND PROCESSS

State: Existing/presenting of a characteristics

Event: Happening/occurrence of a characteristics (or changing of one state to another)

Process is a series of events

PREVALENCE AND INCIDENCE

Epidemiology is concerned with health-related "**states**" or "**events/processes**"

1. Prevalence measure:

- Measure existing or presenting of "**states**" at either a specified point of time or a specified period of time
- Count both **new and old cases**

2. Incidence measure:

- Measure happening or occurrence of "**events/processes**" during a specified period of time
- Count **only new cases**, i.e. new events

MEASURE OF FREQUENCY

ODDS

ODDS

Odds is a **ratio** of the **probability** of an **event** and its **complement**

$$\textbf{Odds} = \frac{\text{Number of people who } \textbf{have} \text{ an } \textbf{outcome}}{\text{Number of people who } \textbf{don't have} \text{ an } \textbf{outcome}}$$

MEASURE OF FREQUENCY

PREVALENCE

PREVALENCE

Prevalence is a **proportion** of the **individuals** in the **population** who have an **outcome** at **a specific point of time**

$$\textbf{Prevalence} = \frac{\text{Number of people who } \textbf{have} \text{ an } \textbf{outcome}}{\text{Number of population}}$$

Do not forget time point !

PREVALENCE

POINT PREVALENCE

How many people have disease at a **point of time**?

PERIOD PREVALENCE

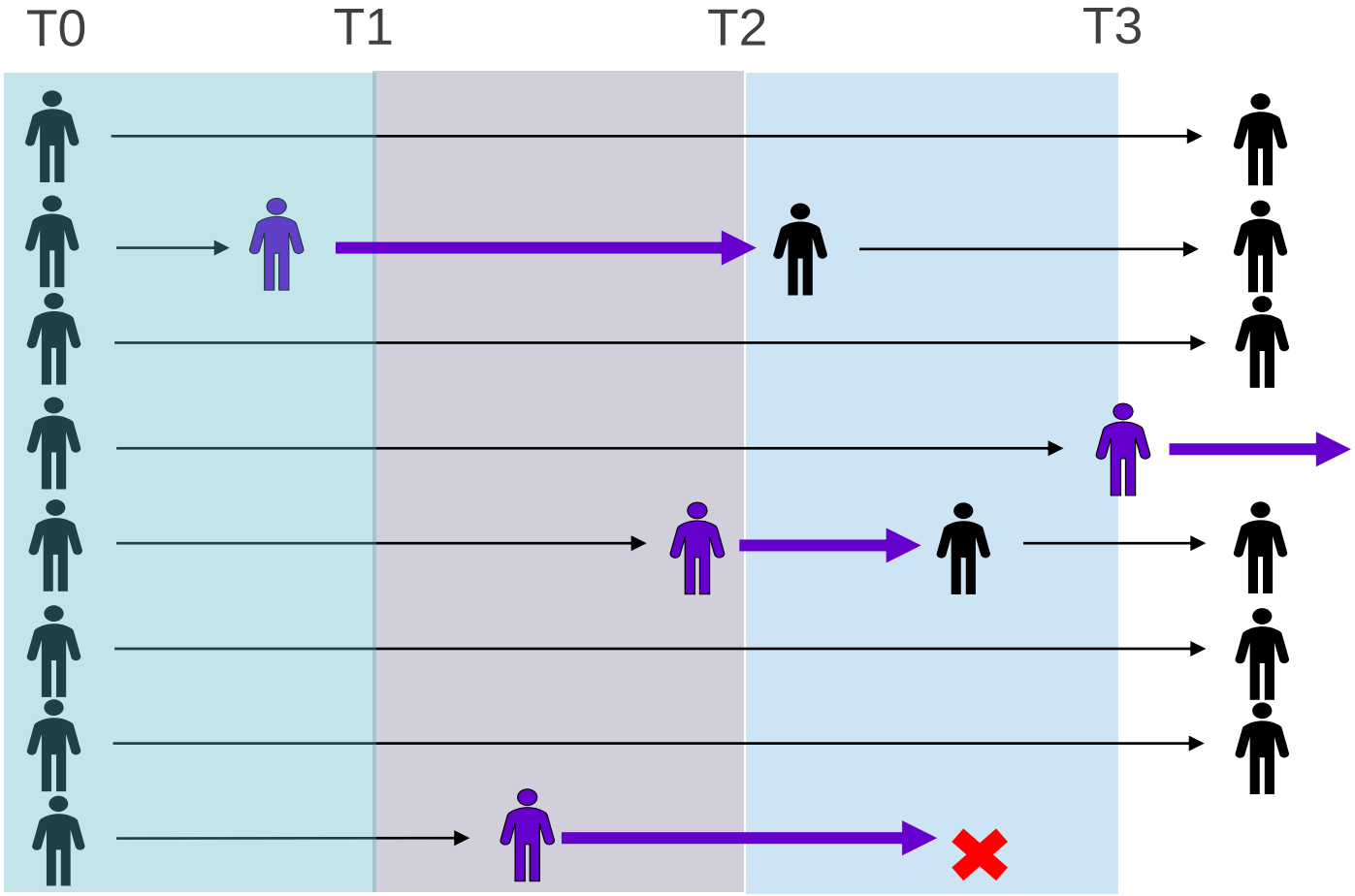
How many people have had the disease at **any point during a certain time period**?

POINT PREVALENCE

Amount of disease in the population at a given point in time

$$\frac{\text{Number of cases of the disease present at given point in time}}{\text{Total population at that time}}$$

Count No. of cases for Point Prevalence



EXAMPLE: POINT PREVALENCE

- On Jan 1st , 2015, company A has 5000 employees,
- 100 of which have hypertension
- Point Prevalence on Jan 1st, 2015 = ?

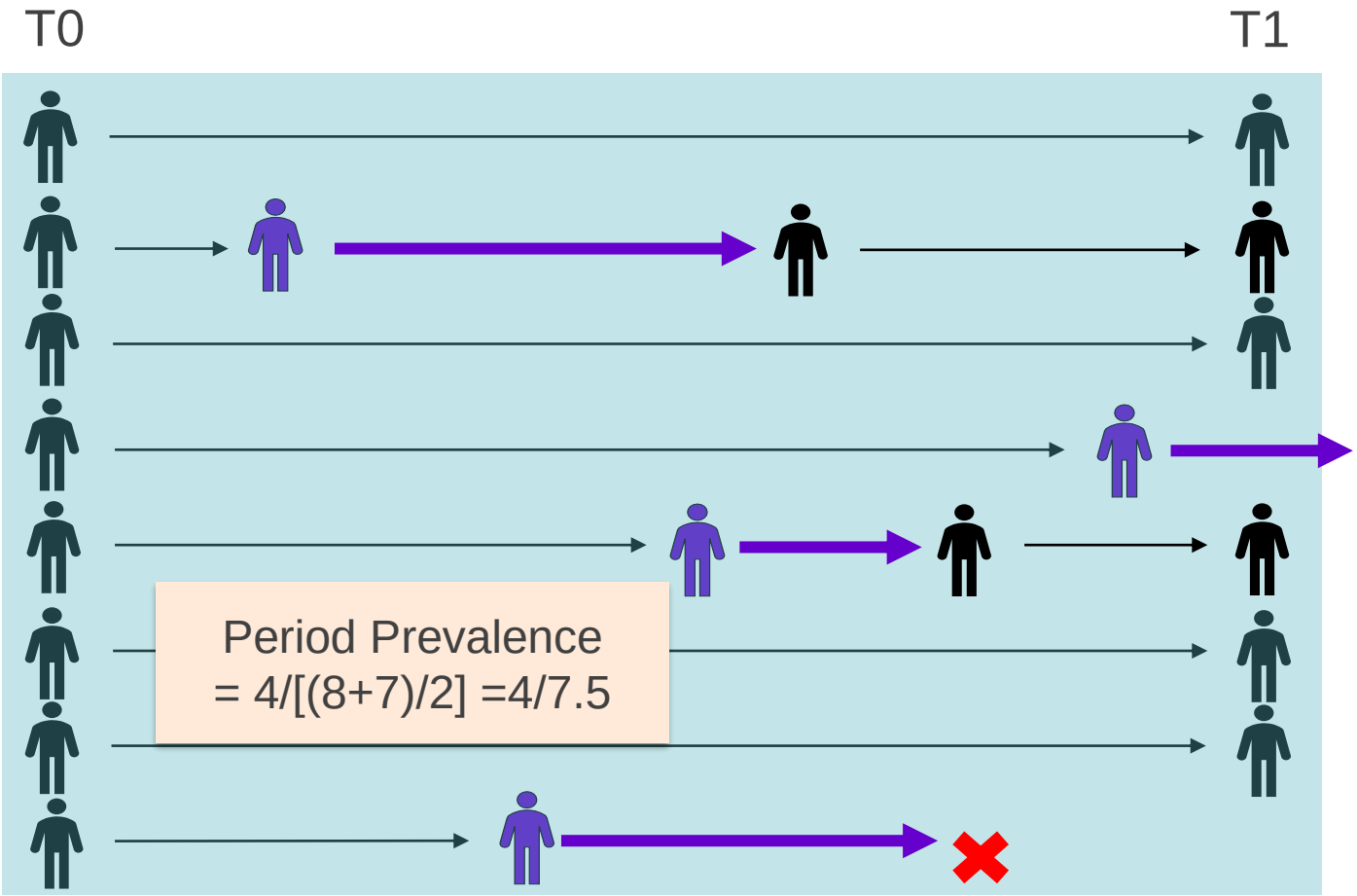
- **Point prevalence = 100/5000 = 0.02 = 20 per 1000**

PERIOD PREVALENCE

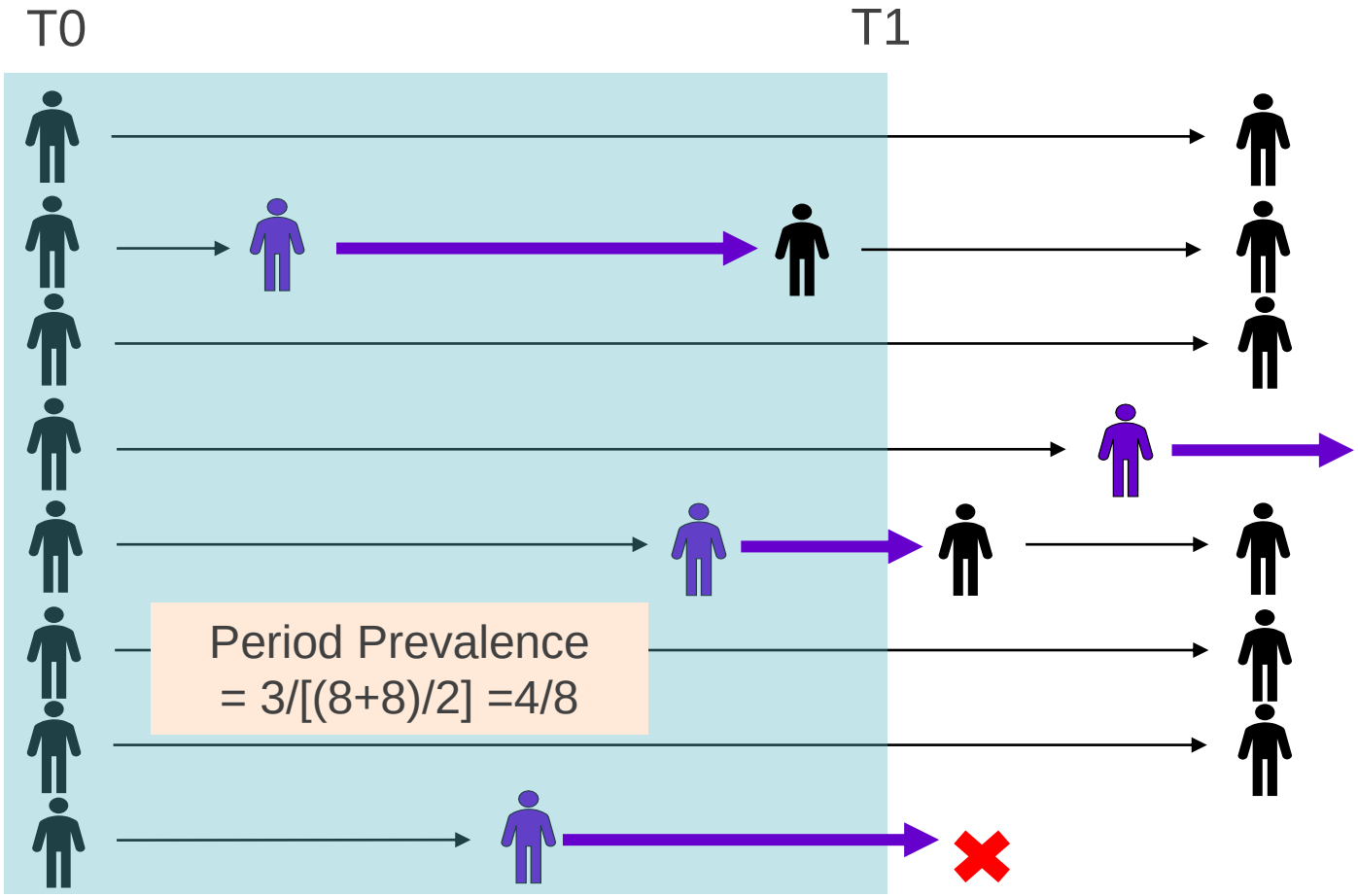
Amount of disease in the population during a specific time period

$$\frac{\text{Number of cases presenting anytime during specific time interval}}{\text{Average population during the time interval or mid-interval population}}$$

Count No. of cases for Period Prevalence



Count No. of cases for Period Prevalence



EXAMPLE: PERIOD PREVALENCE

- In 2015, company X
- total employees of 5000 in Jan and 4900 in Dec
- Of these 100 cases were diagnosed cancer prior to Jan 1st , 2015 and 5 new cases were diagnosed in 2015
- Of these 105 cancer cases, 10 died in 2015
- Period Prevalence (from 1 Jan – 31 Dec) in 2015 = ?

- **Period prevalence = 105/[(5000+4900)/2] = 0.021 = 21 per 1000**

PREVALENCE

Reflect both **occurrence** and **duration** of an outcome

Not provide information on a new case of an outcome!

PREVALENCE

- Because prevalence depends on both **incidence and disease duration**, it is not as useful as incidence for studying causes of a disease.
- It is useful for measuring **disease burden** on a population, especially if those who have the disease require specific medical attention.

MEASURE OF FREQUENCY

INCIDENCE

INCIDENCE

The number of

new cases

of a disease that occur during a **specified period of time** in a **population at risk** for developing the disease.

Incidence proportion

People at risk are observed throughout a defined time period

Incidence rate

People at risk are not observed for the full time Period

INCIDENCE

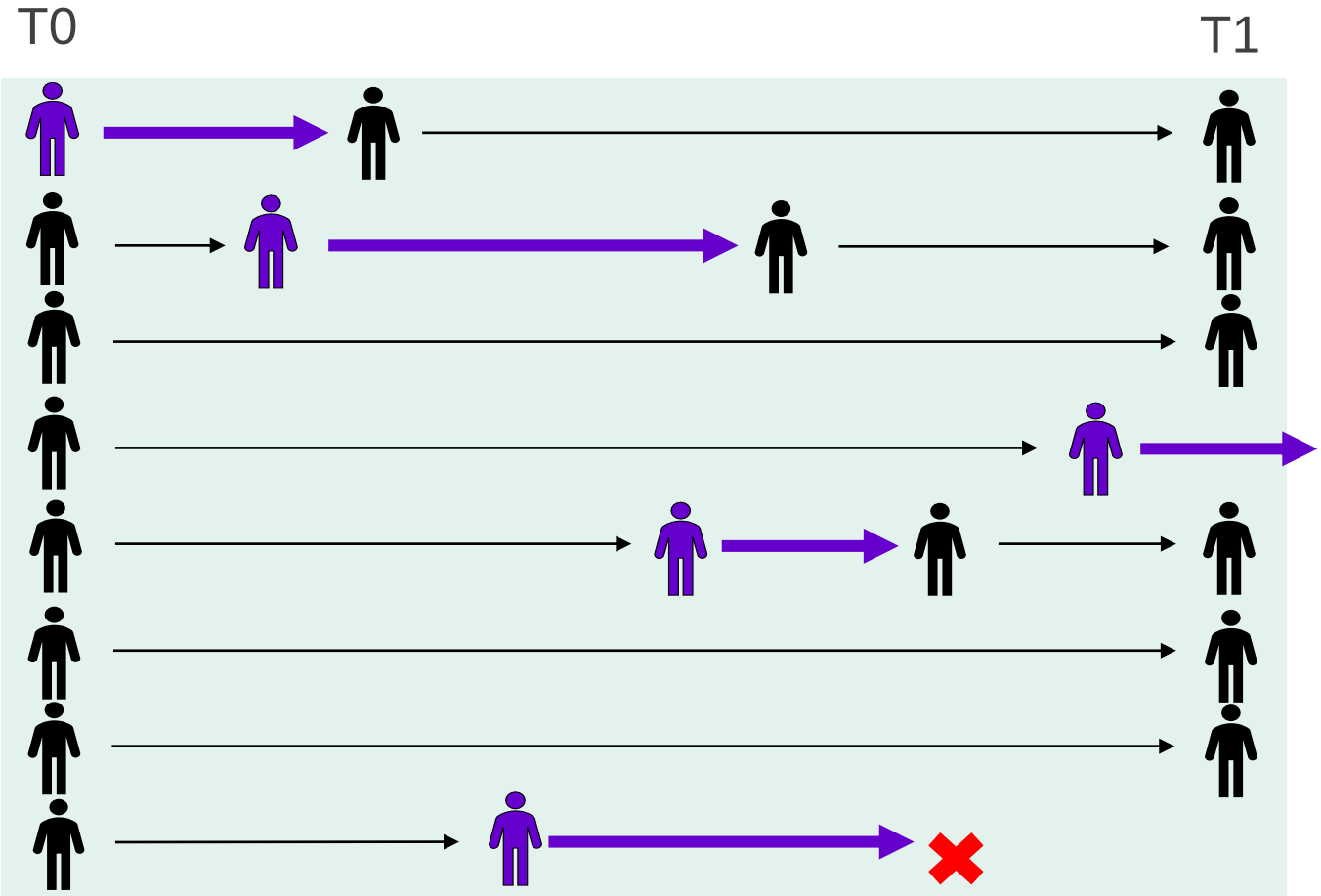
Incidence proportion

- incidence risk
- risk
- cumulative incidence
- cumulative proportion
- cumulative incidence proportion
- attack rate (in an epidemic)

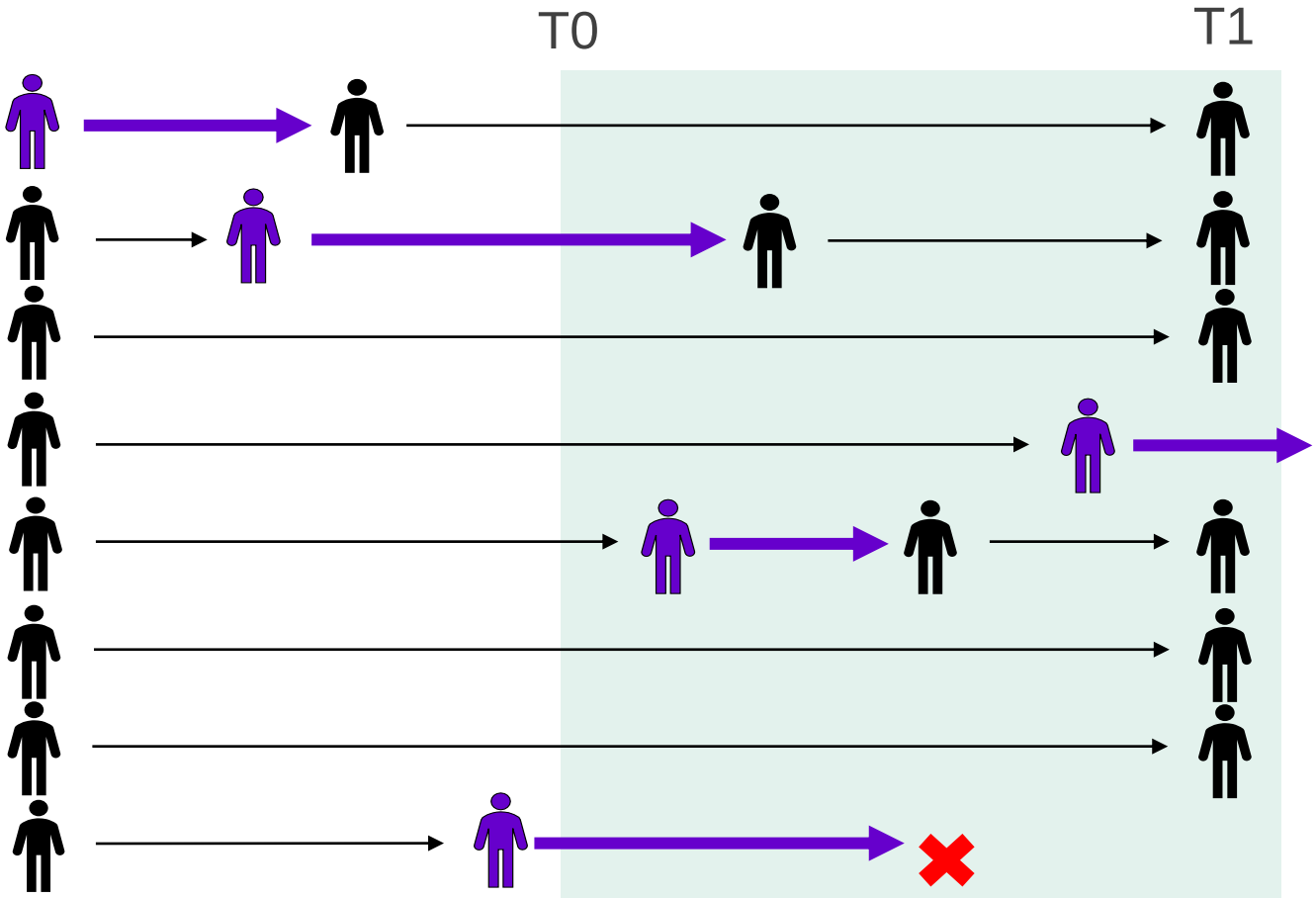
Incidence rate

- incidence density
- force of morbidity/force of mortality
- hazard rate
- person-time rate
- disease intensity

Count No. of new cases for incidence



Count No. of new cases for incidence



INCIDENCE PROPORTION

Cumulative incidence is a **proportion** of the **individuals** **developing outcome** in the **population at risk** during a **given time period**

$$\textbf{Incidence Proportion} = \frac{\text{Number of new cases during a given time period}}{\text{Number of population at risk (disease free) at the start of the study}}$$

Do not forget time period !

EXAMPLE: INCIDENCE PROPORTION

- On Jan 1st , 2015 company X has 5000 employees free of cancer
- During the course of the year, 5 employees are diagnosed with cancer
- Incidence proportion during 2015 = ?

- Incidence proportion = 5/5000 =0.001 = 0.1% = 1 per 1000

INCIDENCE PROPORTION

Two assumptions required when calculating incidence proportion:

- **Entire population at risk has been followed** from the beginning of the study till the end
- **All participants are at risk** of the outcome of interest

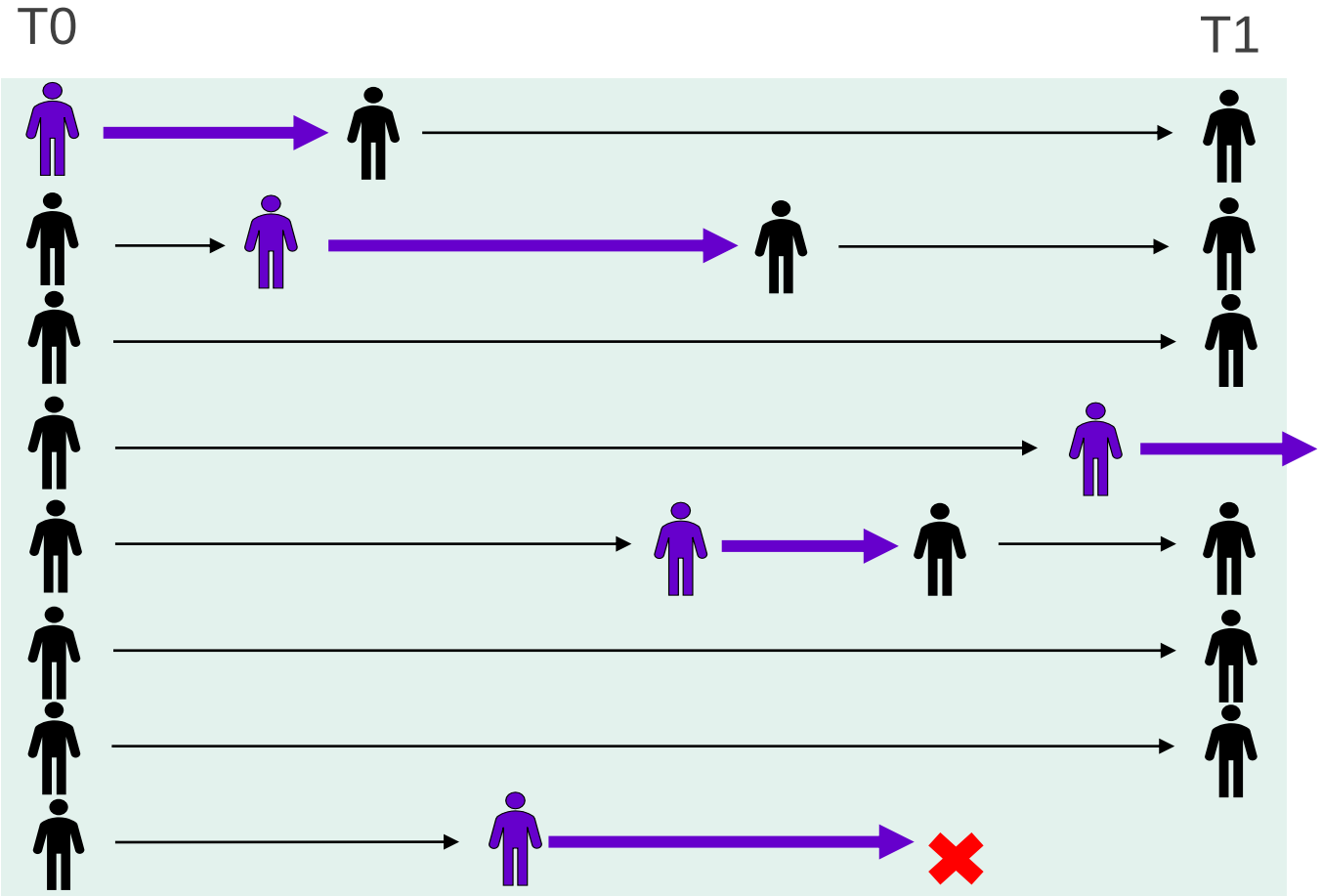
INCIDENCE PROPORTION

Problems

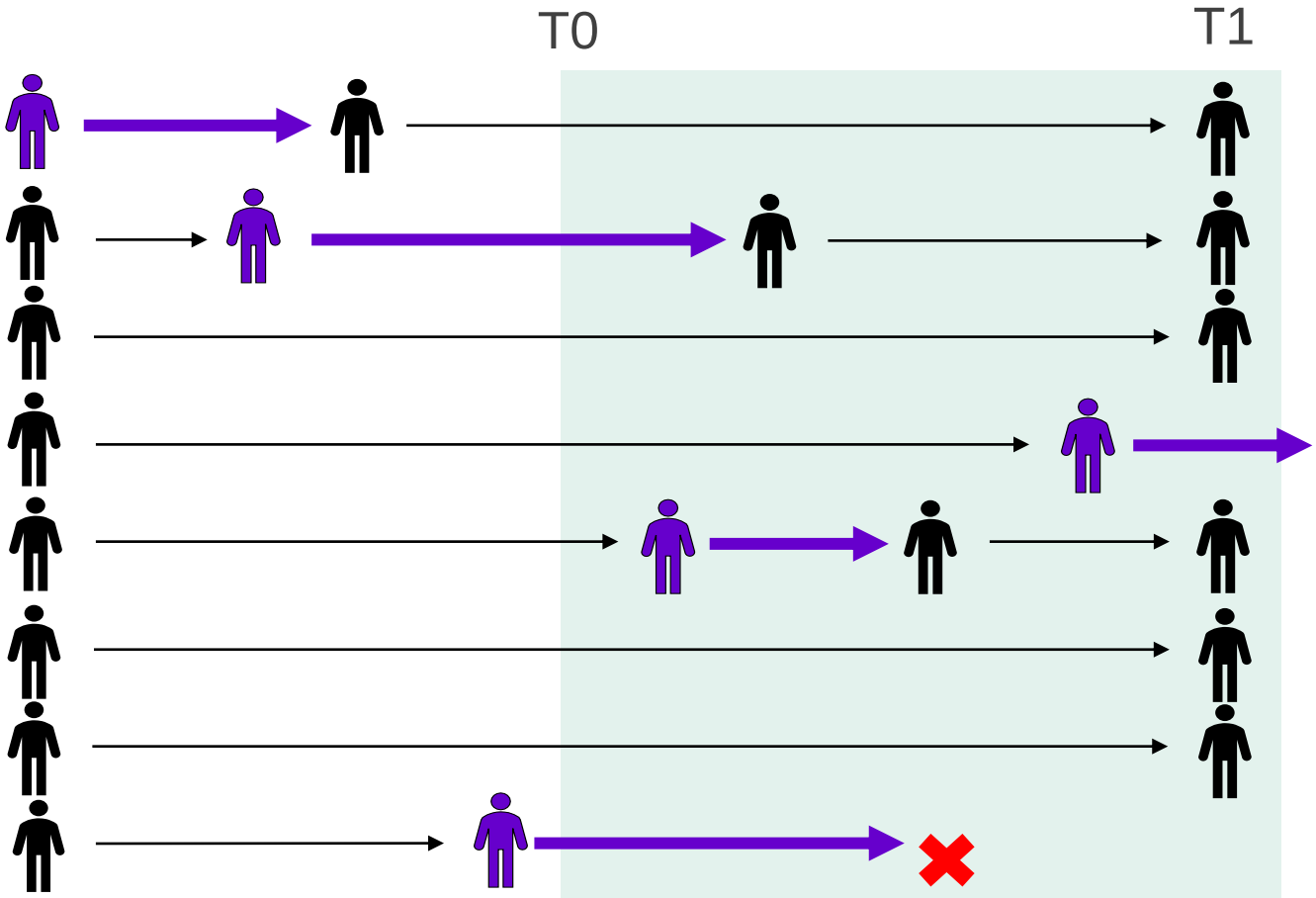
- Loss to follow up
- New subject entering
- Competing risk

Incidence proportion is not well defined!

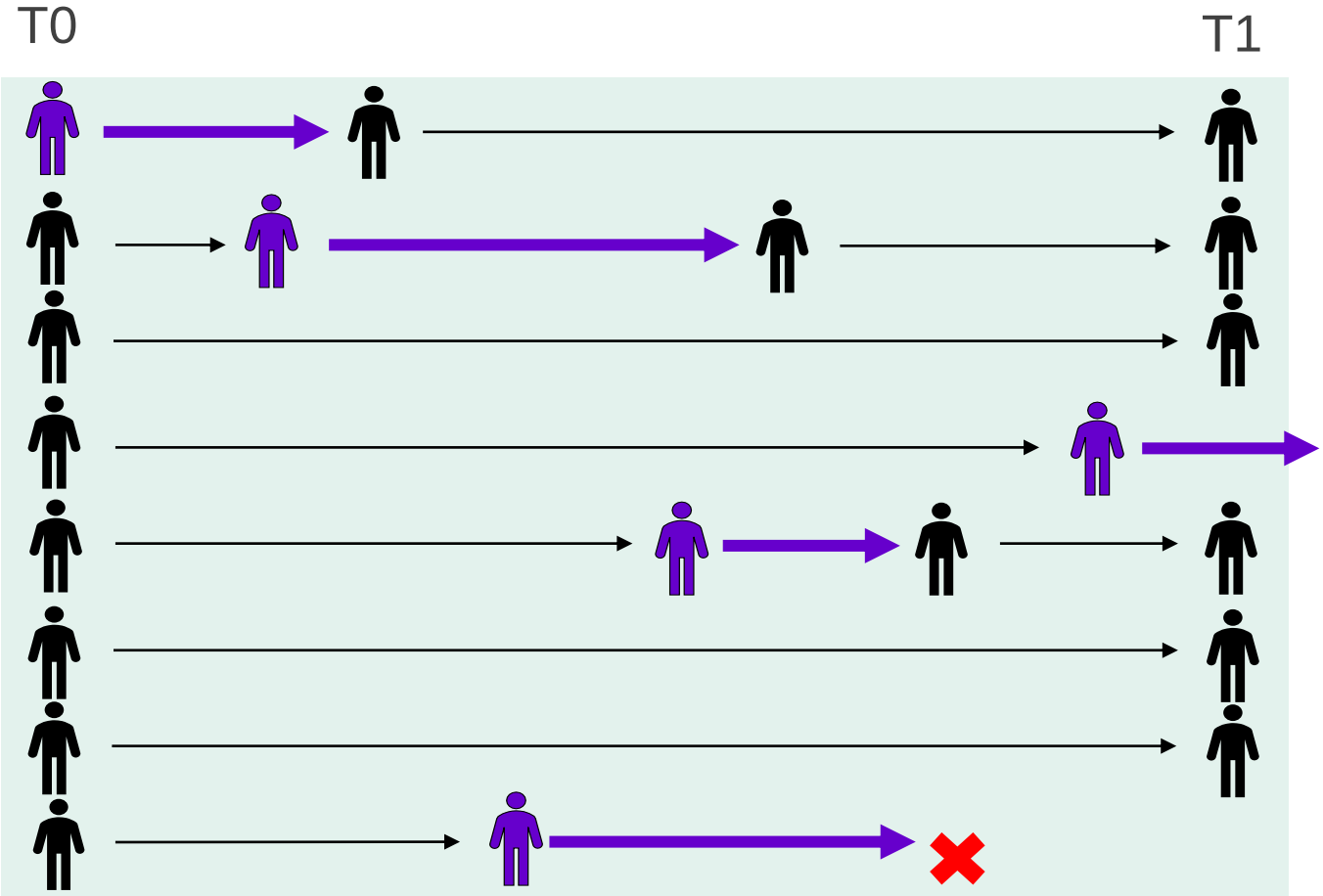
Count denominator for incidence



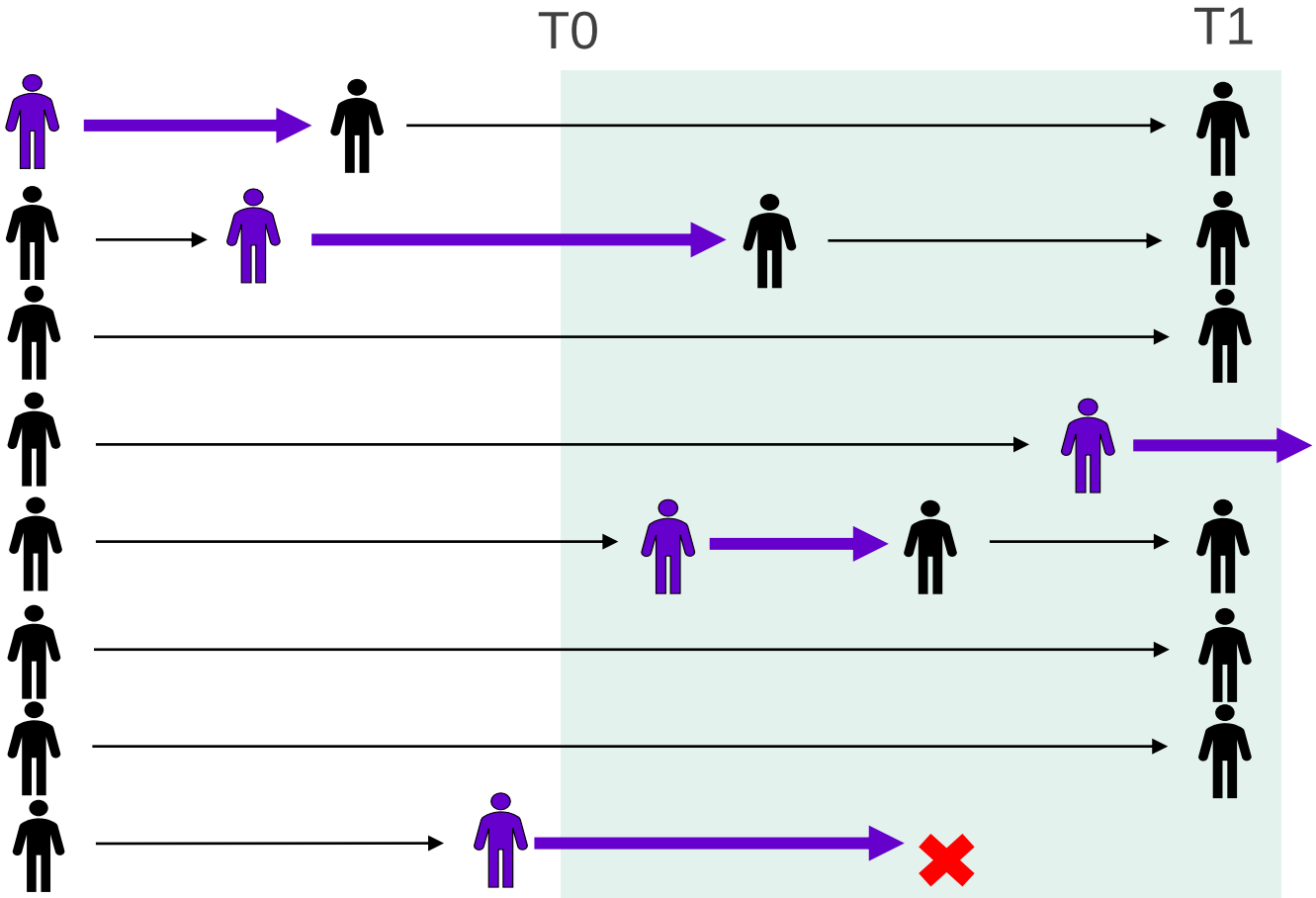
Count denominator for incidence



What is the incidence proportion



What is the incidence proportion



INTERPRETATION OF INCIDENCE PROPORTION

- The only way to interpret incidence proportion, or “risk”, is to know **the length of the time period** over which the risk applies
- This time period may be short or long, but without identifying it, risk values are not meaningful
- Over a very short time period, the risk of any particular disease is usually extremely low.

INCIDENCE RATE

Person-time

Time participant spend in the study

- Each individual has their own person-time
- Has several units

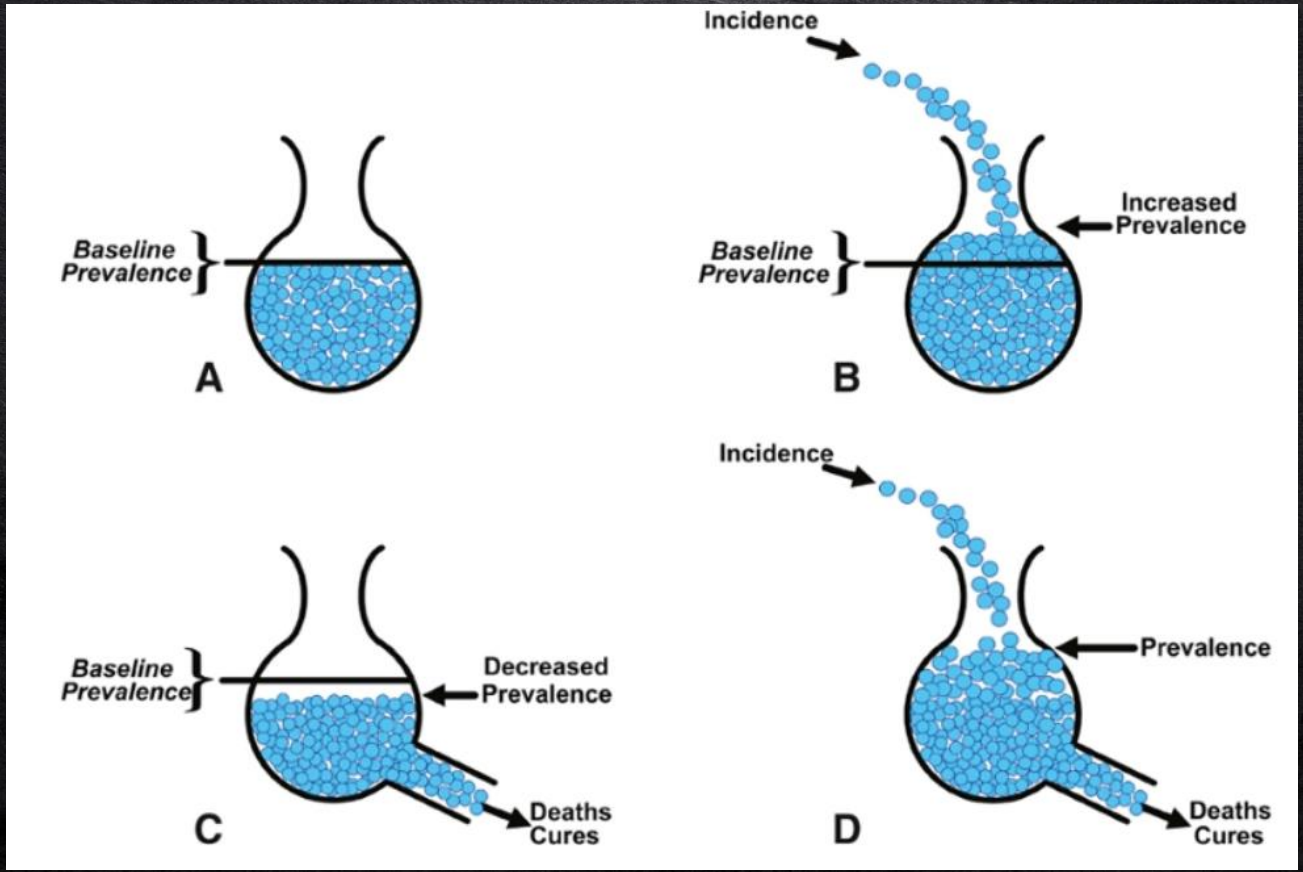
INCIDENCE RATE

Cumulative incidence is **number of new cases per unit of time**

$$\textbf{Incidence Rate} = \frac{\text{Number of new cases during a given time period}}{\text{Total person-time of population at risk (disease free)}}$$

Do not forget person-time unit!

TAKE HOME POINT



TAKE HOME POINT

	Incidence	Prevalence
Numerator	Number of **new cases** of disease during a specified period of time	Number of existing cases of disease at a given point of time
Denominator	Population at risk	Population at risk
Focus	• Dynamic concept, i.e. “follow-up” • Focuses on time of onset of the disease • Unaffected by cure or death	• Static concept, i.e. “snapshot” • Focuses on presence or absence of a disease; time period is arbitrary • Affected by cure or death
Uses	• Expresses the risk or speed of becoming ill • The main measure of acute diseases or conditions, but also used for chronic diseases • More useful for studies of causation	• Estimates the probability of the population being ill at the period of time being studied • Inappropriate for diseases with short duration • Useful in the study of the burden of chronic diseases and implication for health services

TAKE HOME POINT

Incidence Proportion	Incidence Rate
Simple proportion with no units	Rate expressed per person-time unit
Range from 0-1	Range from 0 - Infinity
Measures average risk of disease development	Measures speed of disease development
Appropriate with **fixed** populations or closed cohort where follow-up times are uniform	Appropriate with **dynamic** populations or open cohort where follow-up times vary
Assume no deaths due to competing risks or loss to follow up	Account for deaths due to competing risks or loss to follow up
Easily interpreted	Not easily interpreted

FACTORS AFFECTING PREVALENCE

PREVALENCE

-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 susceptible people
-Improved diagnosis facilities (better reporting)

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

INCIDENCE AND PREVALENCE

Assuming steady-state condition…
the population is closed (no immigration, no death from other causes, and no loss follow up)
Duration and incidence are unchanging

$$\frac{P}{1-P} = IxD$$

$D =$ **Average disease duration**
$P =$ **Point Prevalence**
$I =$ **Incidence Rate**

If P is small
e.g. < 10-20%

$$P \approx IxD$$

INCIDENCE AND PREVALENCE

Prevalence = Incidence x Duration of Disease

- Small incidence e.g. Incident proportion < 10-20%
- Incidence rate remains constant over the time period

MEASURE OF FREQUENCY

OTHERS

ATTACK RATE

Proportion of cases among population at risk

= **incidence proportion**

$$\frac{\text{Number of incident cases during an epidemic period}}{\text{Population at risk at the beginning of the epidemic period}}$$

The number of people who were exposed to the factor

ATTACK RATE

- **Overall attack rate**: Attack rate among total population at risk
- **Specific Attack rate**: Attack rate among subpopulation
  - Age-specific attack rate
  - Gender-specific attack rate
  - Food-specific attack rate

Differences among specific attack rates are important for generating hypotheses!

EXAMPLE: ATTACK RATE

A large food festival outbreak

2,000 visitors attended the festival
400 became sick
(assume no one got sick before)

What is the overall attack rate?

= 400/2,000 = 20%

EXAMPLE: SPECIFIC ATTACK RATE

Food shop	#Visitors eating	#visitors getting sick	Specific attack rate
A	700	200	
B	1200	250	
C	500	300	

EXAMPLE: SPECIFIC ATTACK RATE

Food shop	#Visitors eating	#visitors getting sick	Specific attack rate
A	700	200	29%
B	1200	250	21%
C	500	300	60%

SECONDARY ATTACK RATE

Disease' infectiousness

The attack rate among susceptible people who come into direct contact with primary cases

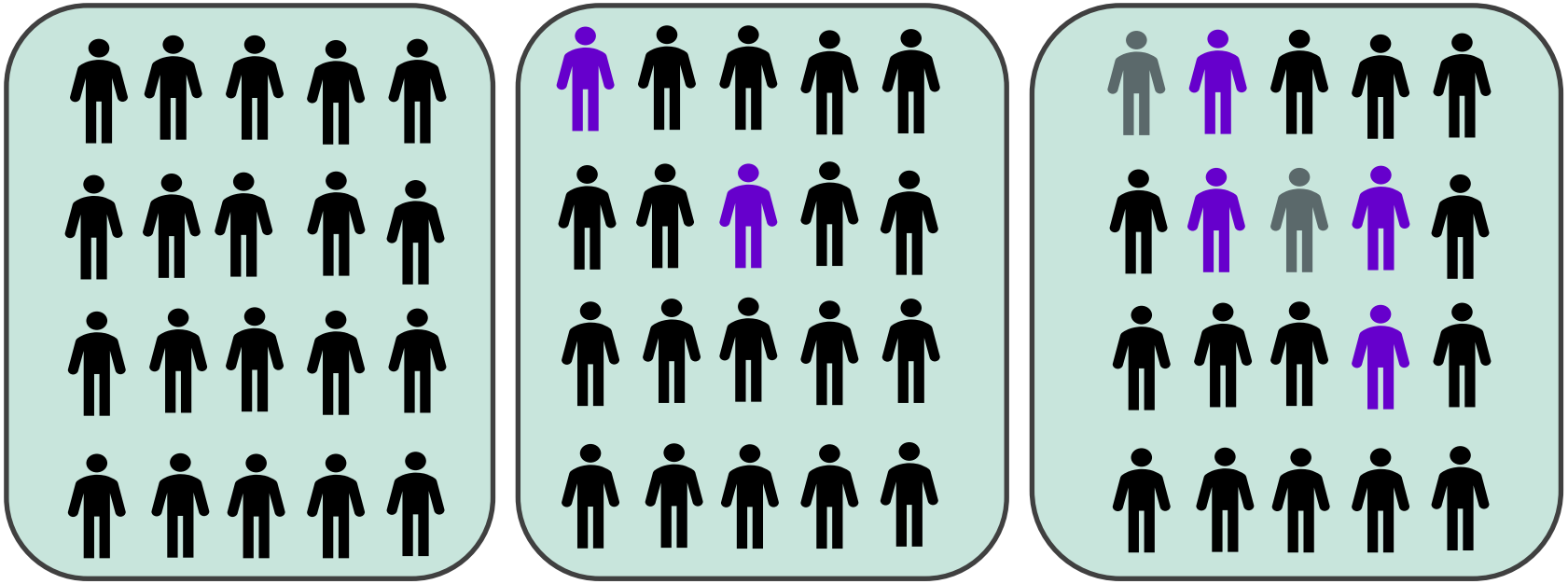
$$\frac{\text{Number of new cases among contacts of primary cases during the epidemic period}}{\text{Total number of contacts}}$$

USE OF SECONDARY ATTACK RATE

Disease' infectiousness

- Measure the intensity of spread of infection or risk among the susceptible contacts after exposure to an infective case
- Evaluate the effectiveness of control measures such as isolation and immunization
- Document the difference between community transmission of illness versus transmission of illness in a household, barracks, or other closed population

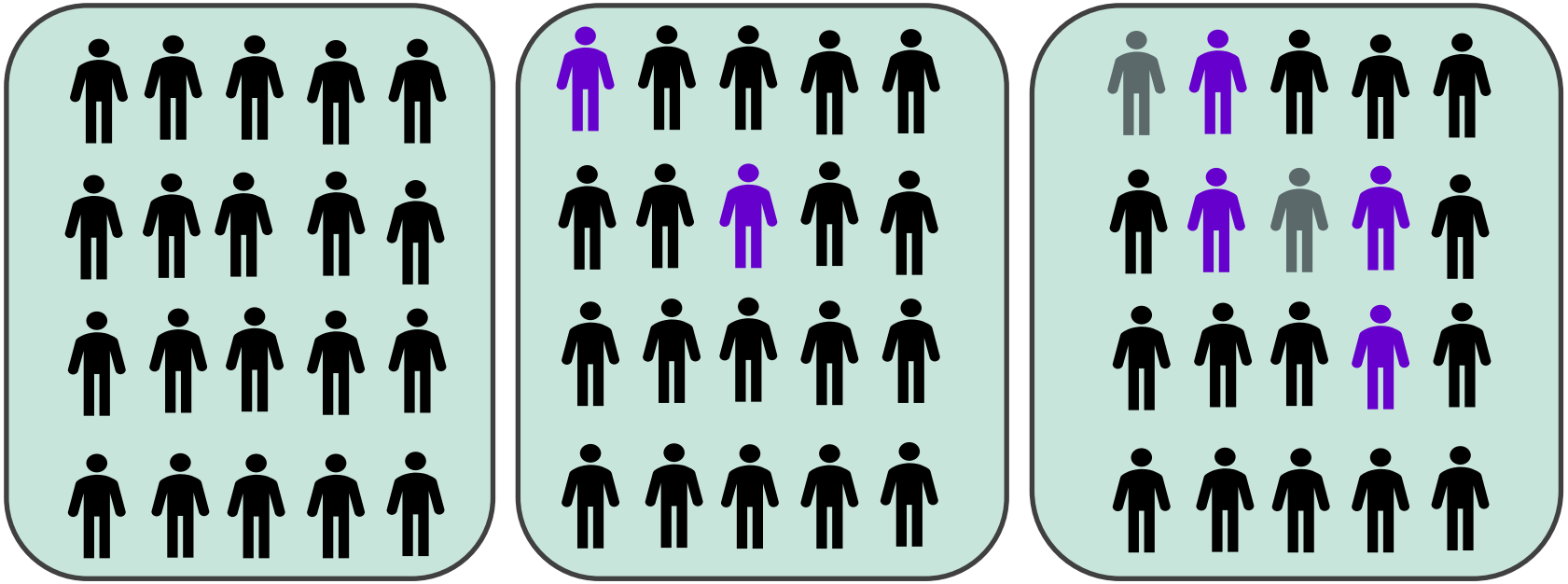
EXAMPLE: SECONDARY ATTACK RATE



Overall attack rate (T0-T2)

6/20 = 30%

EXAMPLE: SECONDARY ATTACK RATE



Secondary attack rate (T1-T2)

4/(20-2) = 4/18
= 22.2%

Crude mortality rate

- It is a proportion of total deaths by all causes among total population in a given period

$$\frac{\text{Total number of deaths from all causes during calendar year}}{\text{Total mid-year population}}$$

Case-fatality rate

- It is a proportion of deaths by a specific disease among all deaths in a given period

$$\frac{\text{Total number of deaths due to specific disease during calendar year}}{\text{Total deaths due to all causes during calendar year}}$$

THANKS!