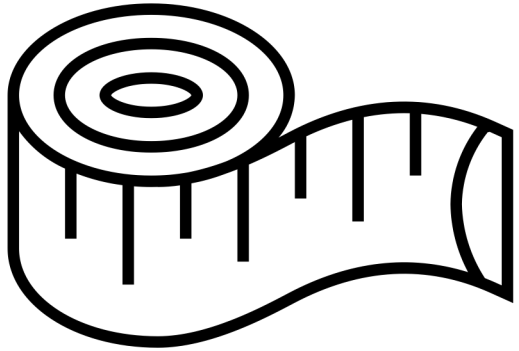
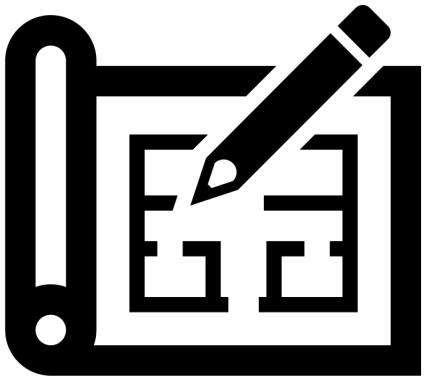
Measures of Occurrence

Epidemiology III



Measurement

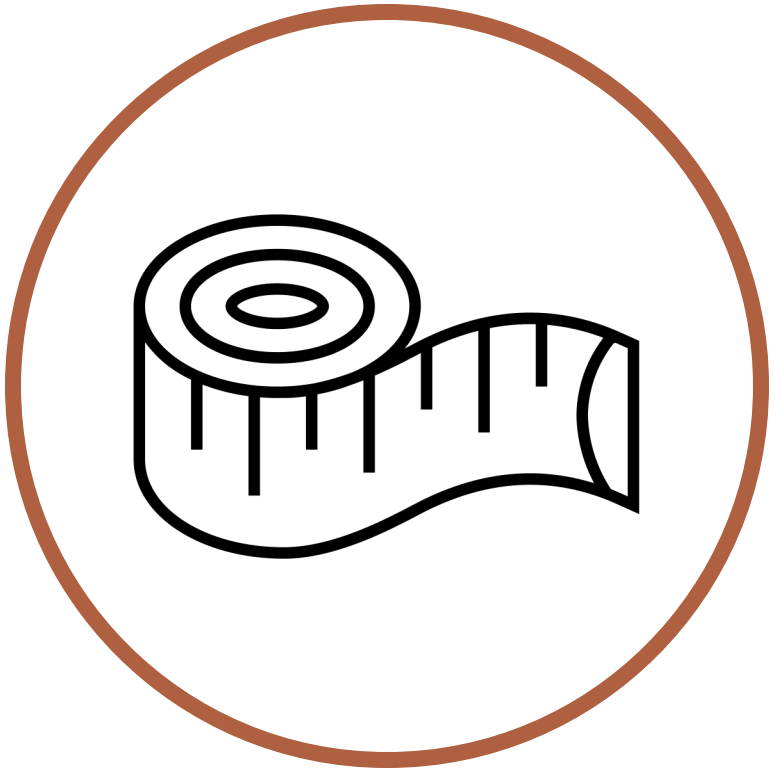
Uncertainty



Study Design

"the study of the occurrence and distribution of health-related states or events in specified populations, including the study of the determinants influencing such states, and the application of this knowledge to control the health problems."

Source: Porta M, ed. *A Dictionary of Epidemiology*. Oxford University Press; 2008.



Measurement

"the study of the occurrence and distribution of health-related states or events in specified populations, including the study of the determinants influencing such states, and the application of this knowledge to control the health problems."

- Observe and assign values to relevant characteristics.
- Look for patterns among those values.

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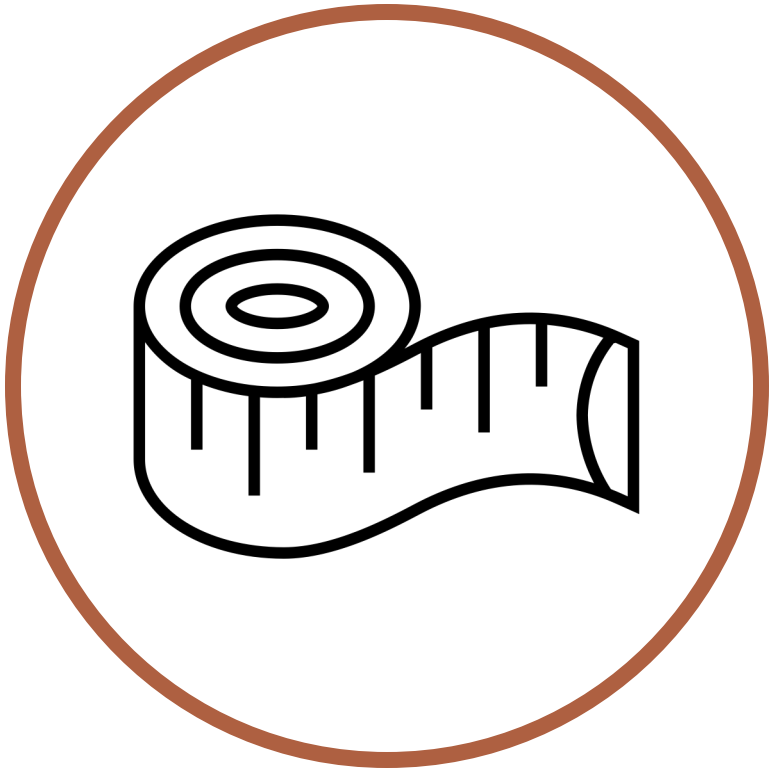
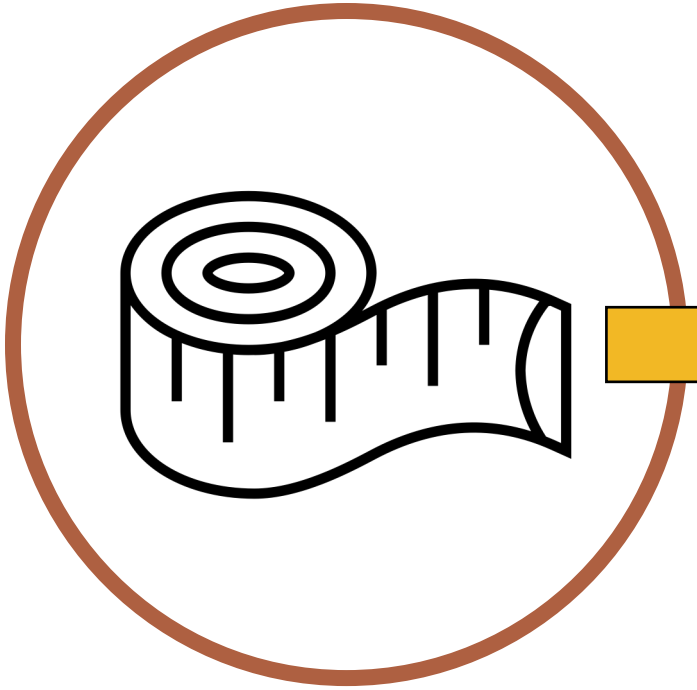


Measurement

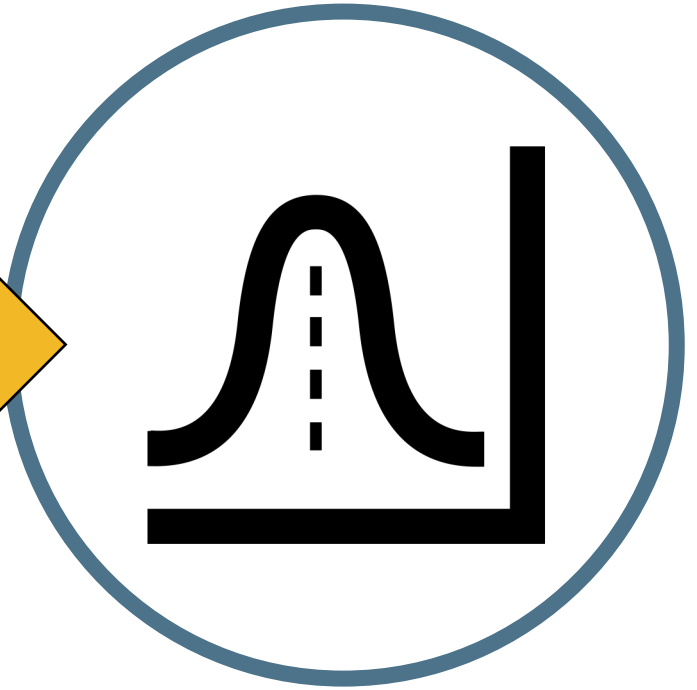
"the study of the occurrence and distribution of health-related states or events in specified populations, including the study of the determinants influencing such states, and the application of this knowledge to control the health problems."

- Observe and assign values to relevant characteristics.

Observe: "To be aware of" or "Have knowledge about"



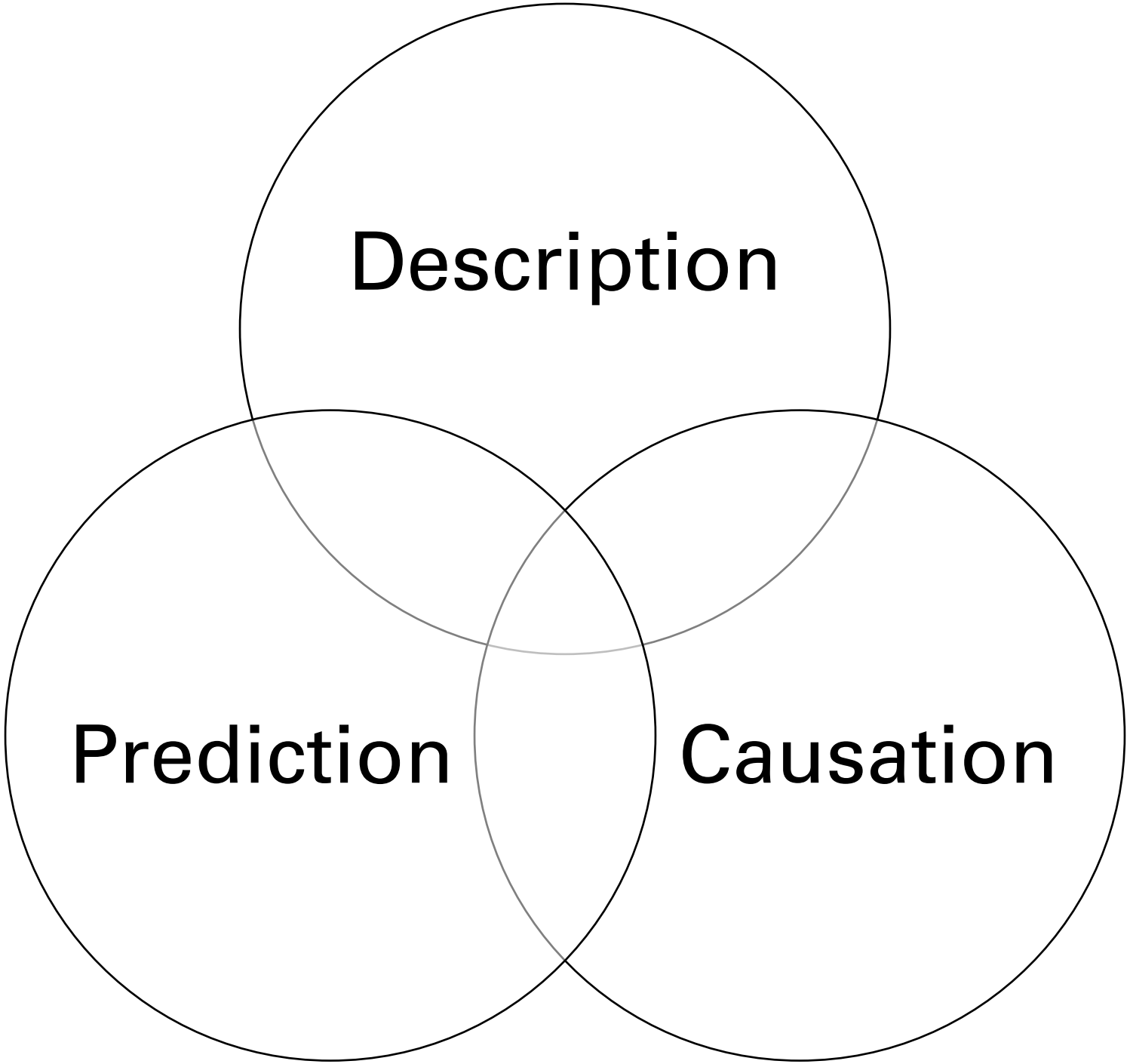
X	Y	Z
1	A	1
2	B	0
3	C	1



Measurement

Data

Statistics


Description
Prediction
Causation

Description

- Not necessarily looking for associations.
- Distributions (i.e., middle, spread, shape, proportion of people in each category) of single variables.
- Resource management and planning.
- Examples:
  - How many ventilators are available in Texas?
  - What is the average age of people living in Florida?
  - How much time elapses, on average, between exposure to a pathogen and occurrence of disease symptoms.

Description

- But, sometimes looking for associations.
- Comparing distributions of single variables within levels of another variable.
- Examples:
  - Are there more ventilators available in Texas or New York?
  - Are people older, on average, in Florida or Pennsylvania?
  - Is symptom onset quicker, on average, for Cholera or E. coli?

Description

- Measures of occurrence.
  - Counts
  - Incidence
  - Prevalence
  - Odds
- Can be useful on their own.
- Can be useful for hypothesis generation.

1. Few checklists

1. Few checklists

2. Statistical uncertainty

Uncertainty

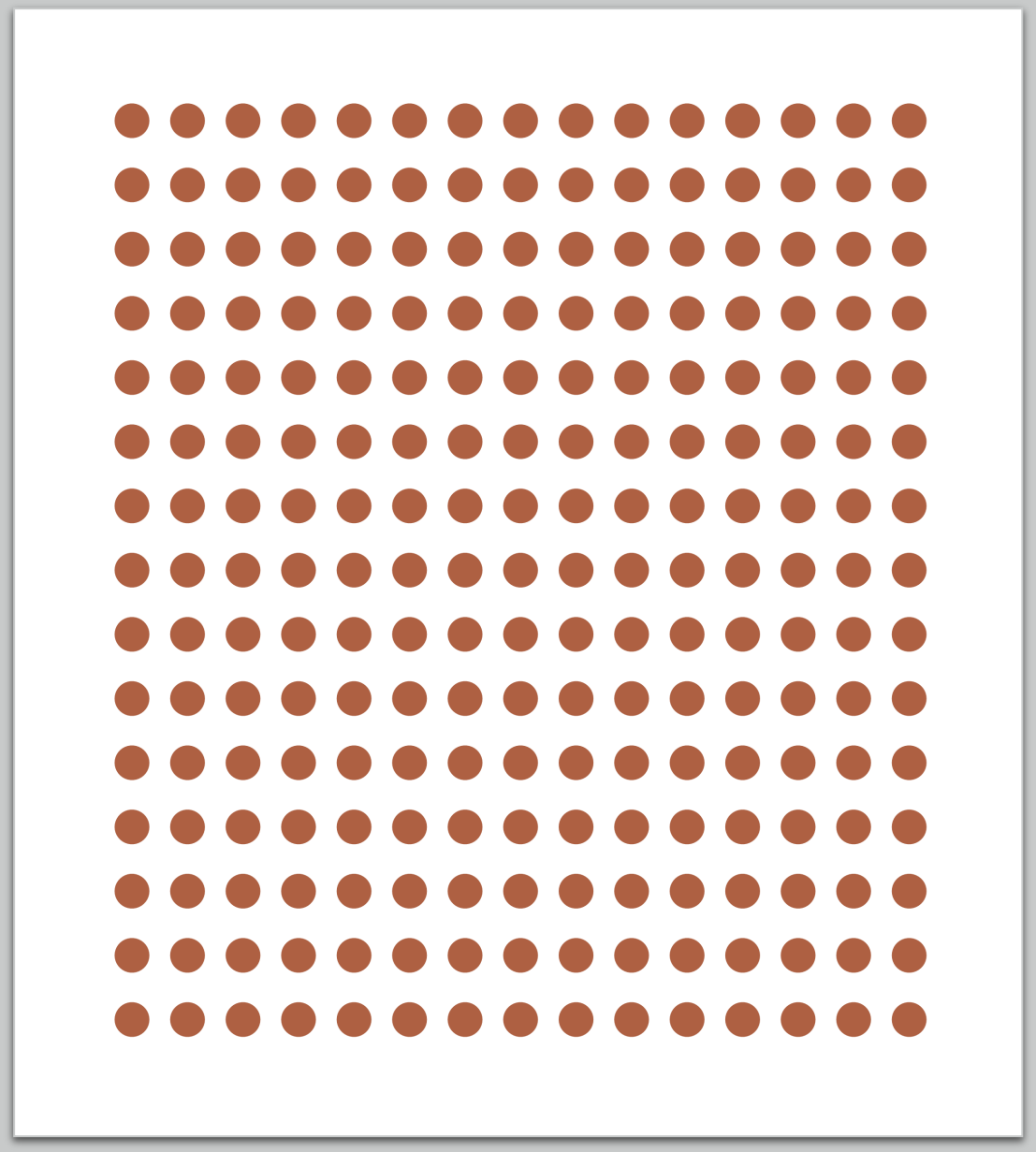
1. Few checklists
2. Statistical uncertainty
3. Causal uncertainty

Uncertainty

"the study of the occurrence and distribution of health-related states or events in specified populations, including the study of the determinants influencing such states, and the application of this knowledge to control the health problems."

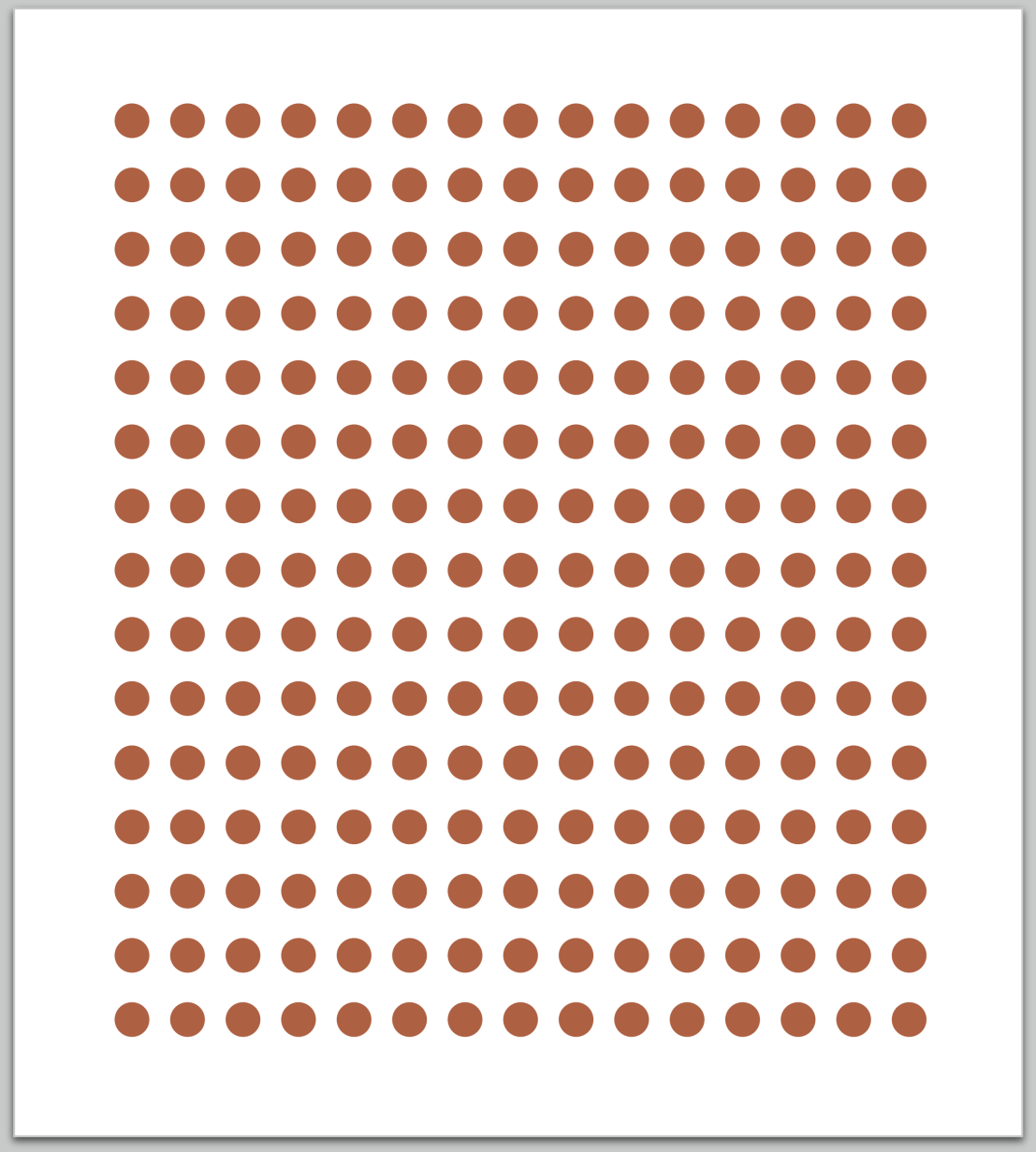
Source: Porta M, ed. *A Dictionary of Epidemiology*. Oxford University Press; 2008.

"The simplest definition of a population is a group of people who share characteristics or meet criteria that define membership in the population."



Source: Lash TL, VanderWeel TJ, Haneuse S, Rothman KJ. *Modern Epidemiology*. fourth. Wolters Kluwer; 2021.

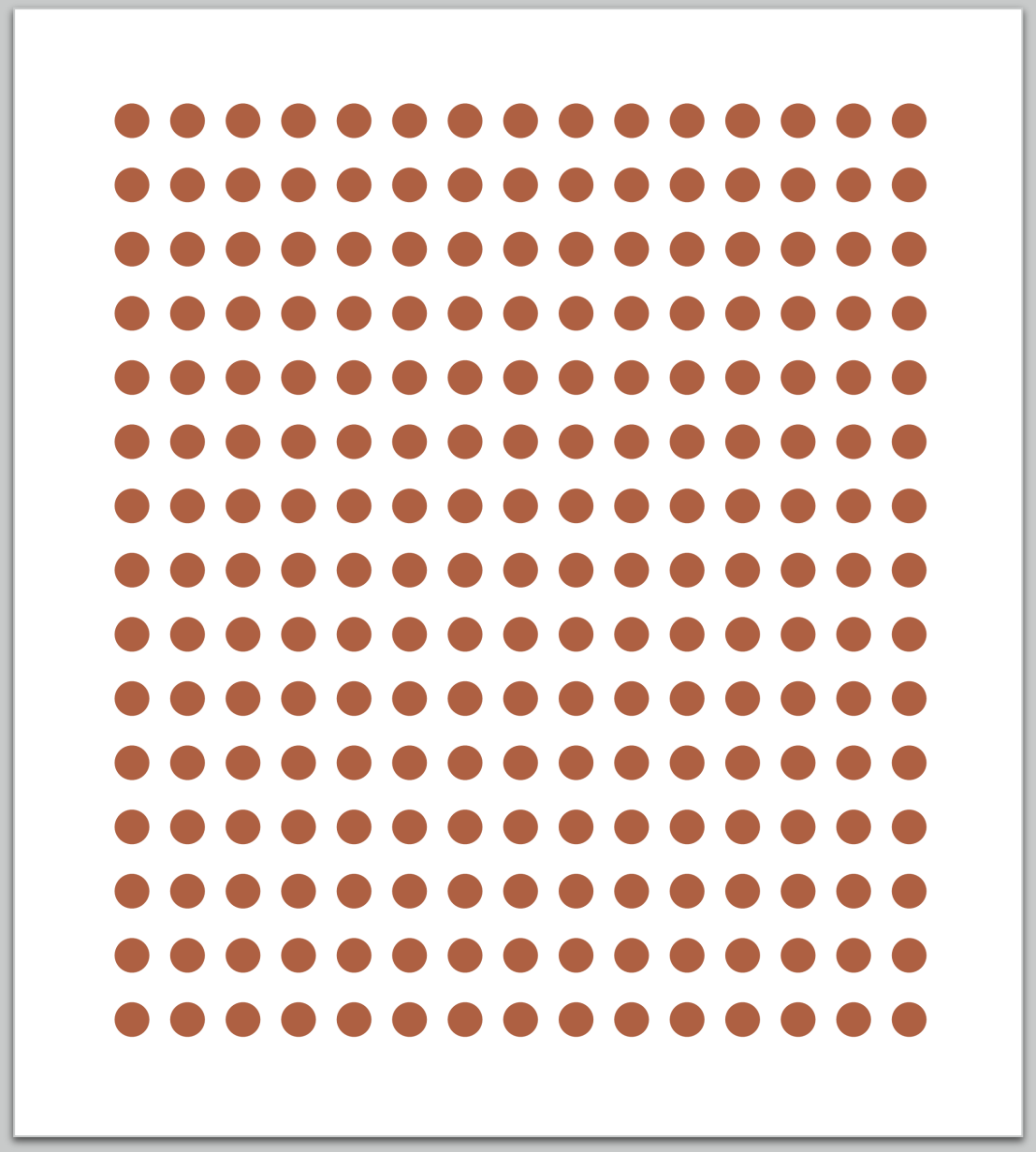
"The simplest definition of a population is a group of people [during a defined time period] who share characteristics or meet criteria that define membership in the population."



Source: Lash TL, VanderWeel TJ, Haneuse S, Rothman KJ. *Modern Epidemiology*. fourth. Wolters Kluwer; 2021.

- Closed population
  - After the population is defined…
  - Doesn’t add any new members over time.
  - Loses members only to death.

- Open population
  - May gain members over time through birth or as new people meet the definition.
  - Loses members over time as people stop meeting the criteria or die.



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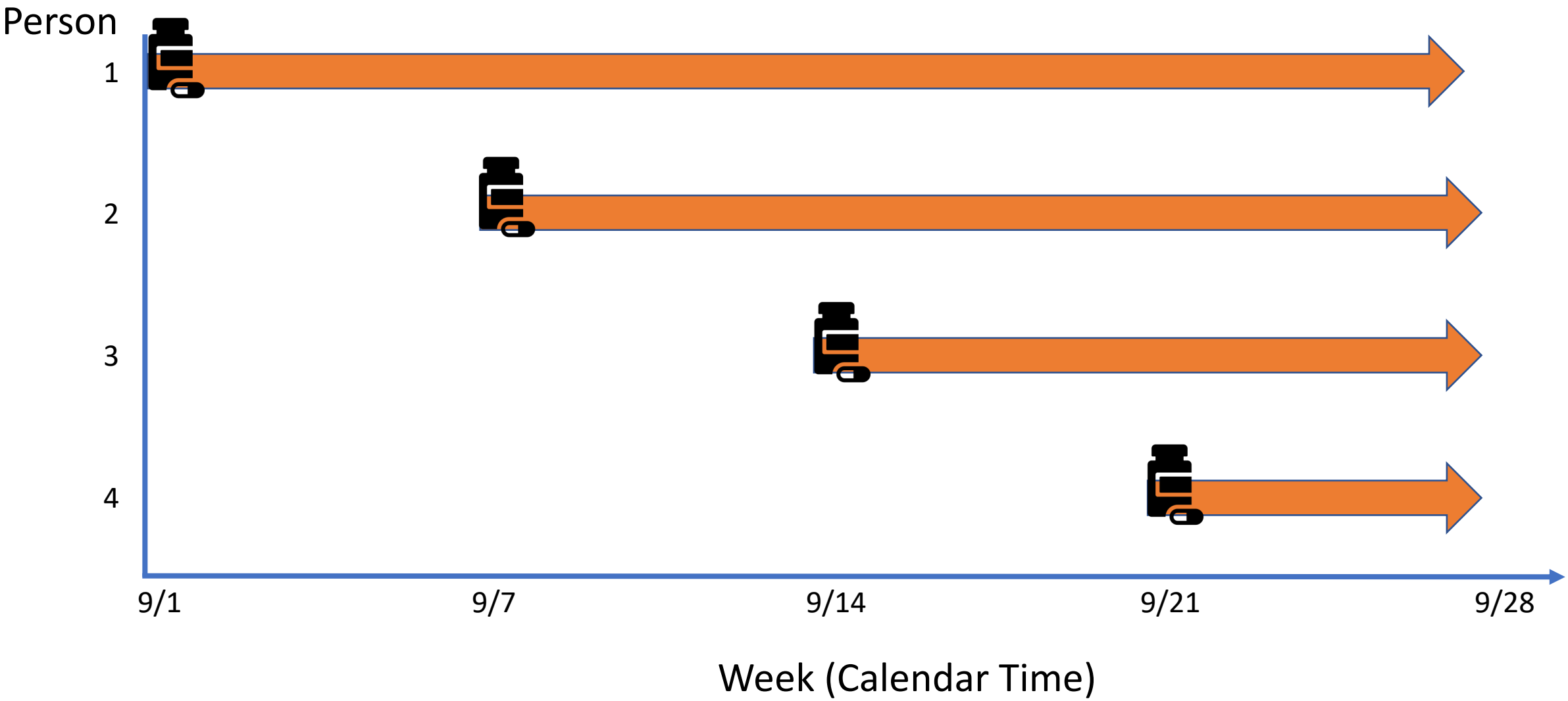
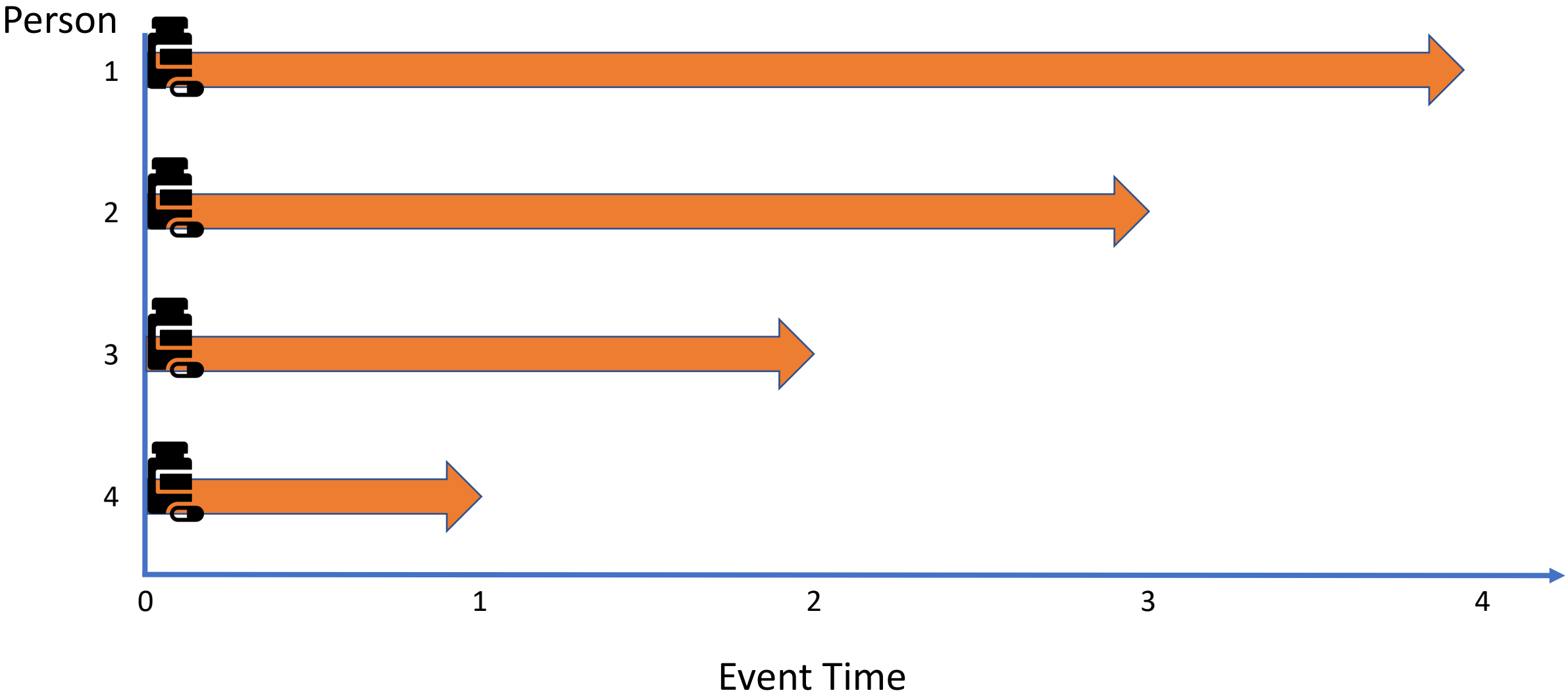
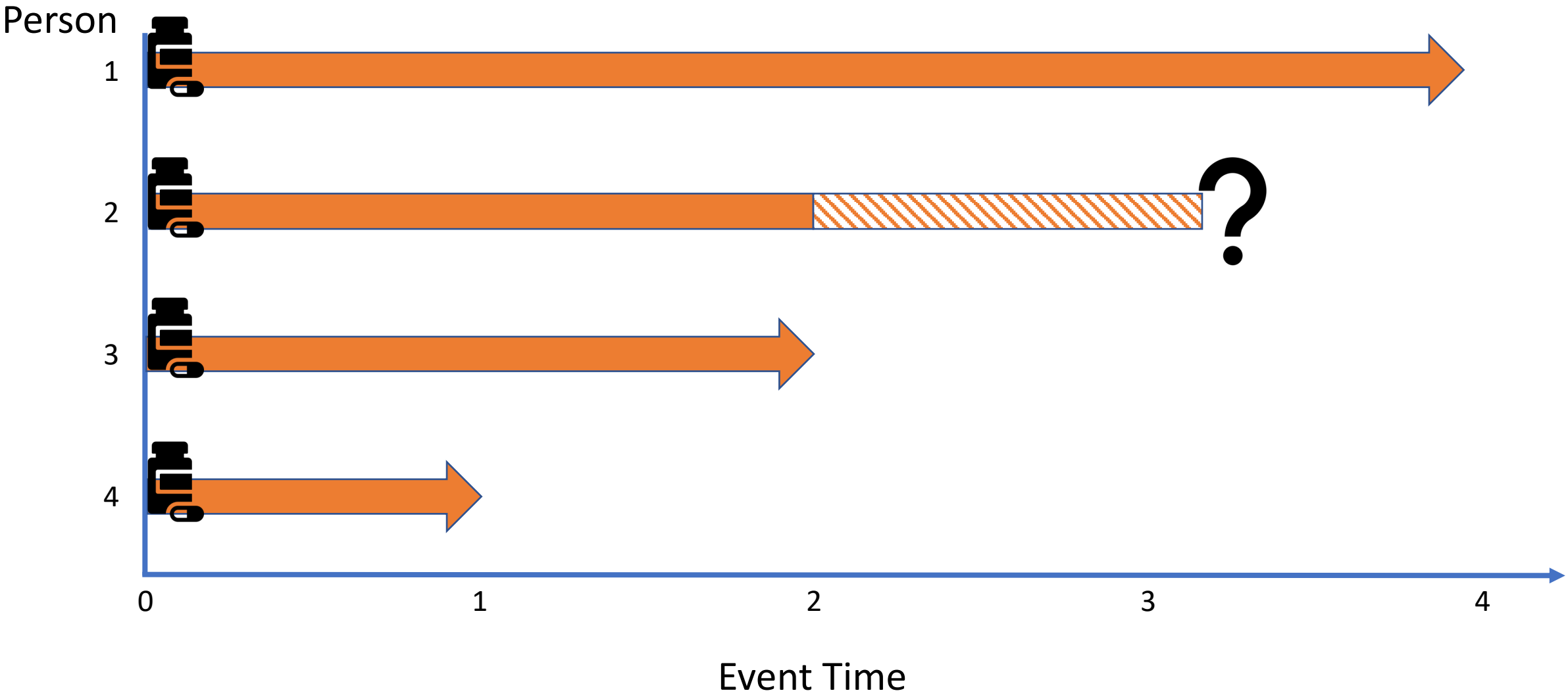
Closed vs. Open Populations



Closed vs. Open Populations



Closed vs. Open Populations



Examples

- Currently enrolled in Epi 3: Open population
- Ever enrolled in Epi 3 as of today: Closed population
- Resident of Texas: Open population
- People aged 65+ as of today: Closed population
- People aged 20 to 30 as of today: Open population

Populations

- **Source population**: The source population is the population from which persons will be sampled and included in a measurement of disease frequency.
  - For example, the source population of the original Framingham Heart Study included men and women between the ages of 30 and 62 years who were residents of the town of Framingham, Massachusetts, in 1948.
- **Target population**: The target population is the group of people about which our scientific or public-health question asks, and comprises the persons for whom information gleaned by the measurement of disease frequency will be relevant [we hope].
  - Information about risk factors for cardiac disease from the Framingham Heart Study has contributed to a nearly 75% decline in mortality related to cardiovascular disease in most industrialized societies.

Source: Lash TL, VanderWeel TJ, Haneuse S, Rothman KJ. *Modern Epidemiology*. fourth. Wolters Kluwer; 2021. Westreich D. *Epidemiology by Design*. Oxford University Press; 2019

Sample

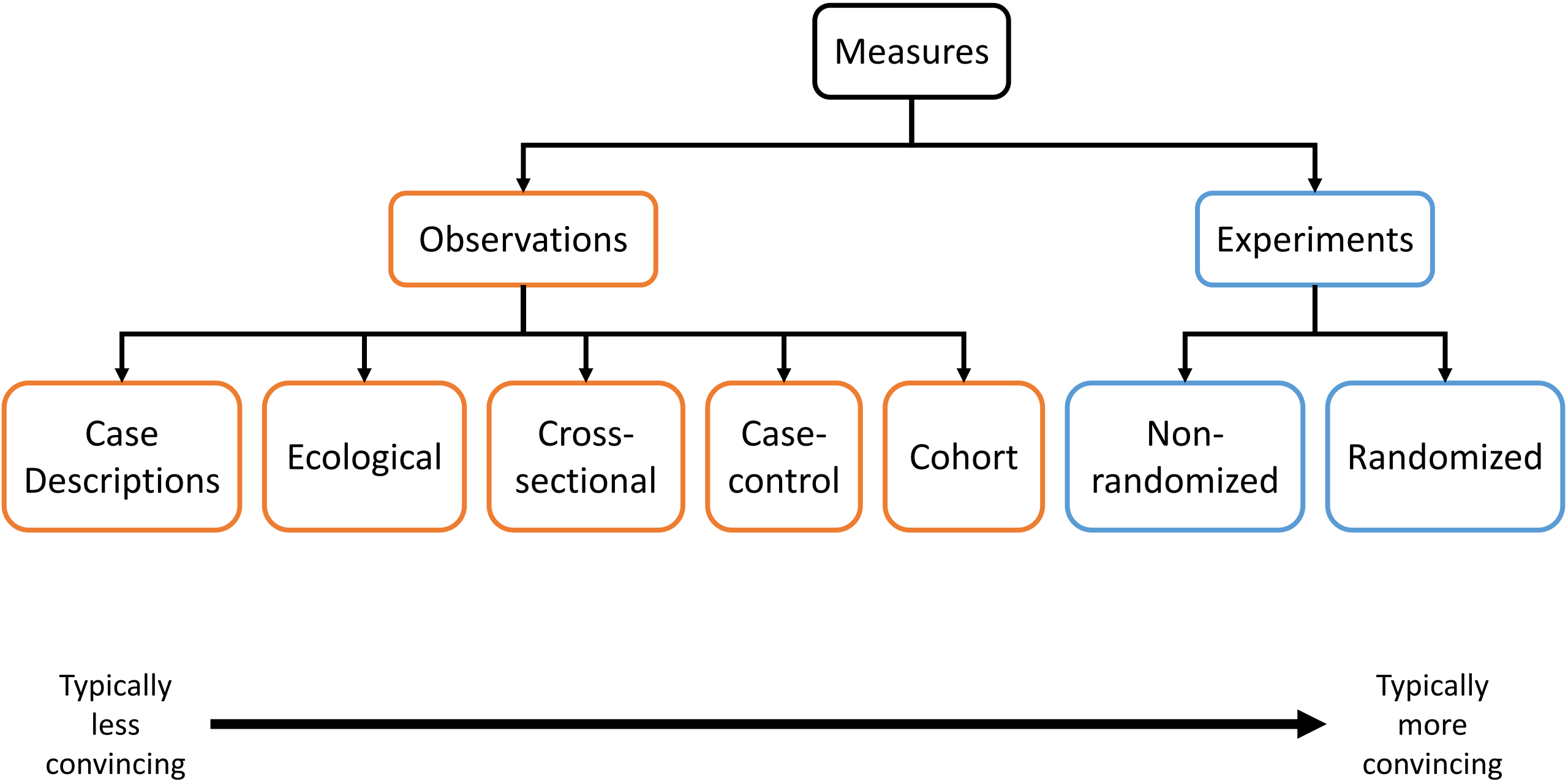
- Study population: The study population is the subset, up to a complete census, of the source population whose experience is included in a measurement of disease frequency.
  - Not all men and women who were eligible to join the Framingham Heart Study were invited to participate, and not all who were invited to participate agreed to participate. Those who were invited, agreed, and were free of prevalent cardiovascular disease constituted the study population.
- Sample: A selected subset of a population. A sample may be random or nonrandom and may be representative or nonrepresentative.

Source: Lash TL, VanderWeel TJ, Haneuse S, Rothman KJ. *Modern Epidemiology*. fourth. Wolters Kluwer; 2021. Porta M, ed. *A Dictionary of Epidemiology*. Oxford University Press; 2008.

Cohorts

- Cohort: a group of persons for whom membership is defined in a permanent fashion, or a population in which membership is determined by satisfying a set of defining events and so becomes permanent. Often used as a synonym for “sample” in the context of a cohort study.
- Similar to a population. The key difference is that every member of the cohort is enumerated (i.e., known or listed). That is not necessarily true of a closed population.

Source: Lash TL, VanderWeel TJ, Haneuse S, Rothman KJ. *Modern Epidemiology*. fourth. Wolters Kluwer; 2021.


Measures
Observations
Experiments
Case Descriptions
Ecological
Cross-sectional
Case-control
Cohort
Non-randomized
Randomized
Typically less convincing
Typically more convincing

Terminology Recap

Our Term	Definition	Examples
Population	A group of people [during a defined time period] who share characteristics or meet criteria that define membership in the population.	The population of the United States.
Closed population	Given a particular time frame (after the population is defined), a population that doesn't add any new members over time and loses members only to death.	People who had a flu vaccine in 2022.
Open population	Given a particular time frame, a population that gains members over time through birth or as new people meet the criteria that define the population, and/or a population that loses members over time as people stop meeting the criteria or are lost to follow-up.	People who have the flu.

Terminology Recap

Our Term	Definition	Examples
Source population	The population from which persons will be sampled and included in a measurement of disease frequency.	The source population of the original Framingham Heart Study included men and women between the ages of 30 and 62 years who were residents of the town of Framingham, Massachusetts, in 1948.
Target population	The group of people about which our scientific or public-health question asks and comprises the persons for whom information gleaned by the measurement of disease frequency will be relevant [we hope].	Information about risk factors for cardiac disease from the Framingham Heart Study has contributed to a nearly 75% decline in mortality related to cardiovascular disease in most industrialized societies.

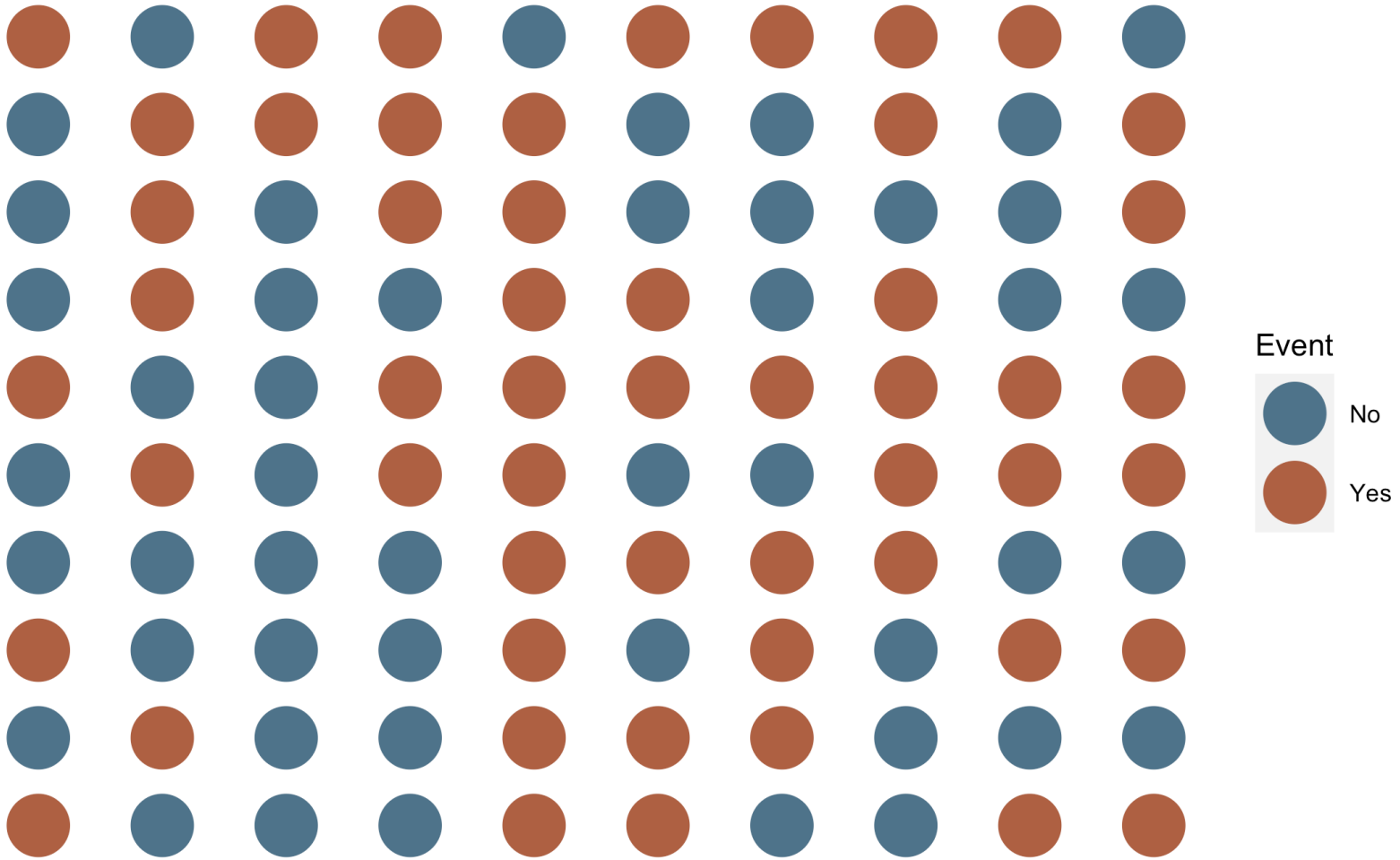
Terminology Recap

Our Term	Definition	Examples
Study population	The subset, up to a complete census, of the source population whose experience is included in a measurement of disease frequency.	Not all men and women who were eligible to join the Framingham Heart Study were invited to participate, and not all who were invited to participate agreed to participate. Those who were invited, agreed, and were free of prevalent cardiovascular disease constituted the study population.
Sample	A selected subset of a population. A sample may be random or nonrandom and may be representative or nonrepresentative.	Another term (probably more common) for study population.

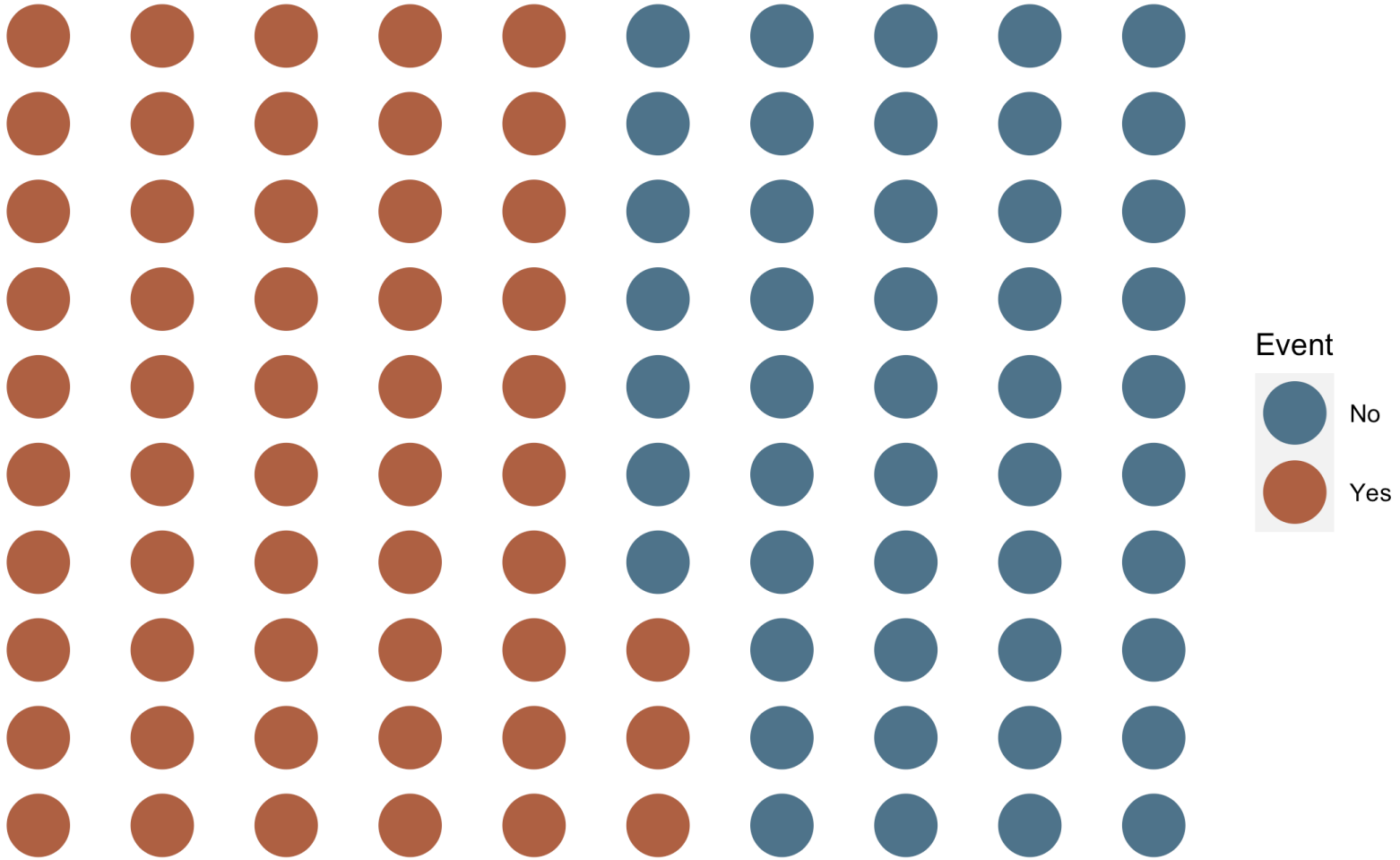
Terminology Recap

Our Term	Definition	Examples
Cohort	A group of persons for whom membership is defined in a permanent fashion, or a population in which membership is determined by satisfying a set of defining events and so becomes permanent. May be open or closed. Often used as a synonym for “sample” in the context of a cohort study.	Similar to a population. The key difference is that every member of the cohort is enumerated (i.e., known or listed).

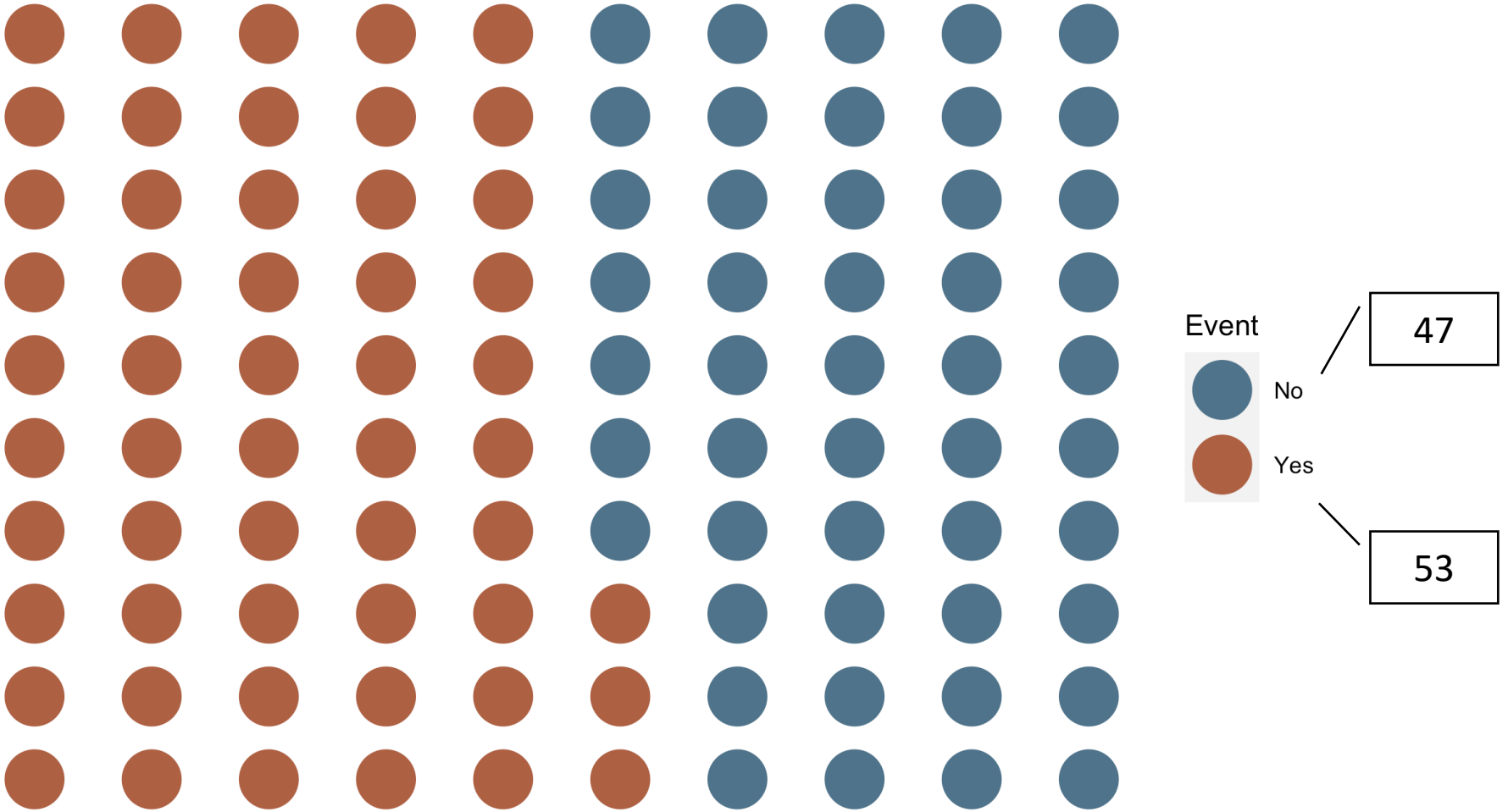
Counts (n)



Counts (n)



Counts (n)



Prevalence

- Prevalence provides information about the presence or absence of a condition of interest (e.g., disease, exposure, or characteristic) in a population.
- It describes the extent to which that condition is present in a population, *in a given time frame.*
- For example, we might ask about the prevalence of diabetes in a population: what we are asking about is the number (or more likely proportion) of people currently living in that population who have diabetes.

Source: Westreich D. *Epidemiology by Design*. Oxford University Press; 2019

Prevalence Count

- A count of the number of people in a population with the condition of interest in a given time frame.
- As few as 0 people, and as many as all people, can be living with the condition of interest
  - Range 0 to infinity.

Source: Westreich D. *Epidemiology by Design*. Oxford University Press; 2019

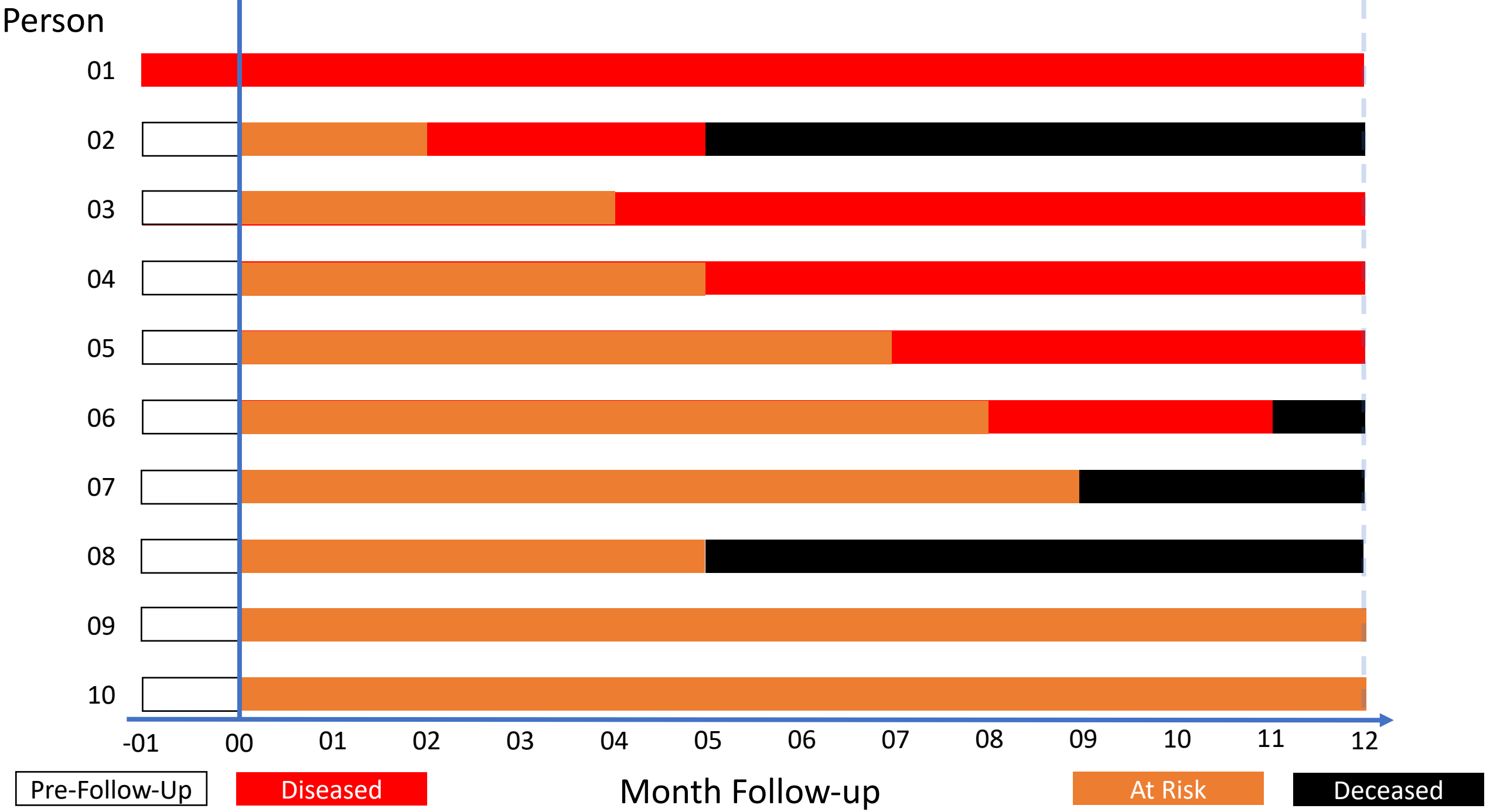
Prevalence Proportion

- The proportion (or percentage) of the population that presently has the condition of interest or who presently has a history of the condition of interest of a specified duration in the past (e.g., “history of caner in the past 10 years”).
- Since at fewest none and at most all of the members of a population can have a condition or a history of that condition, the prevalence proportion ranges from 0 to 1, much like a probability.

Source: Westreich D. *Epidemiology by Design*. Oxford University Press; 2019

Prevalence Proportion

$$\frac{Count\ of\ condition}{Living\ members\ of\ the\ population}$$



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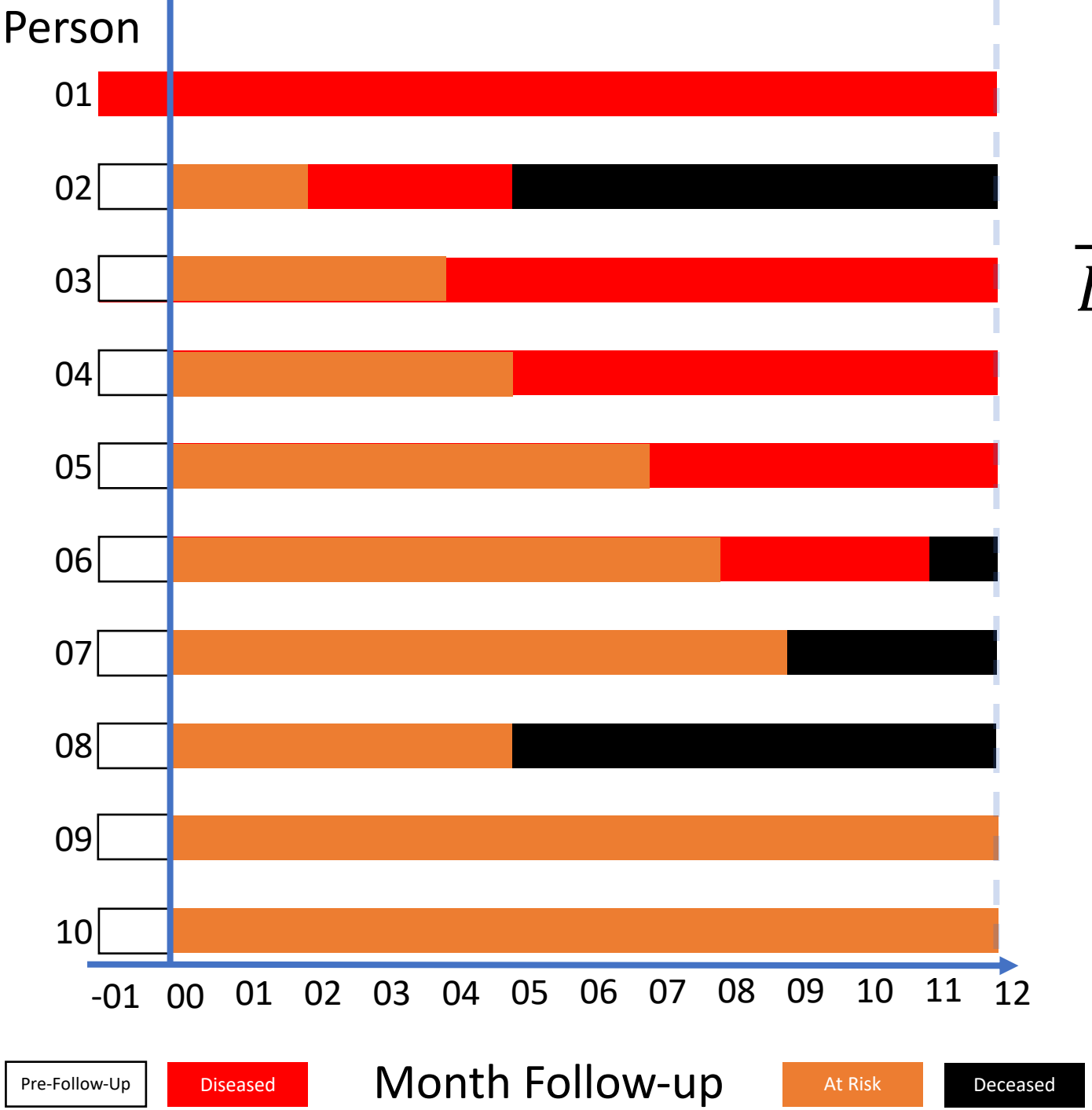


Prevalence Proportion

$$\frac{Count\ of\ condition}{Living\ members\ of\ the\ sample}$$

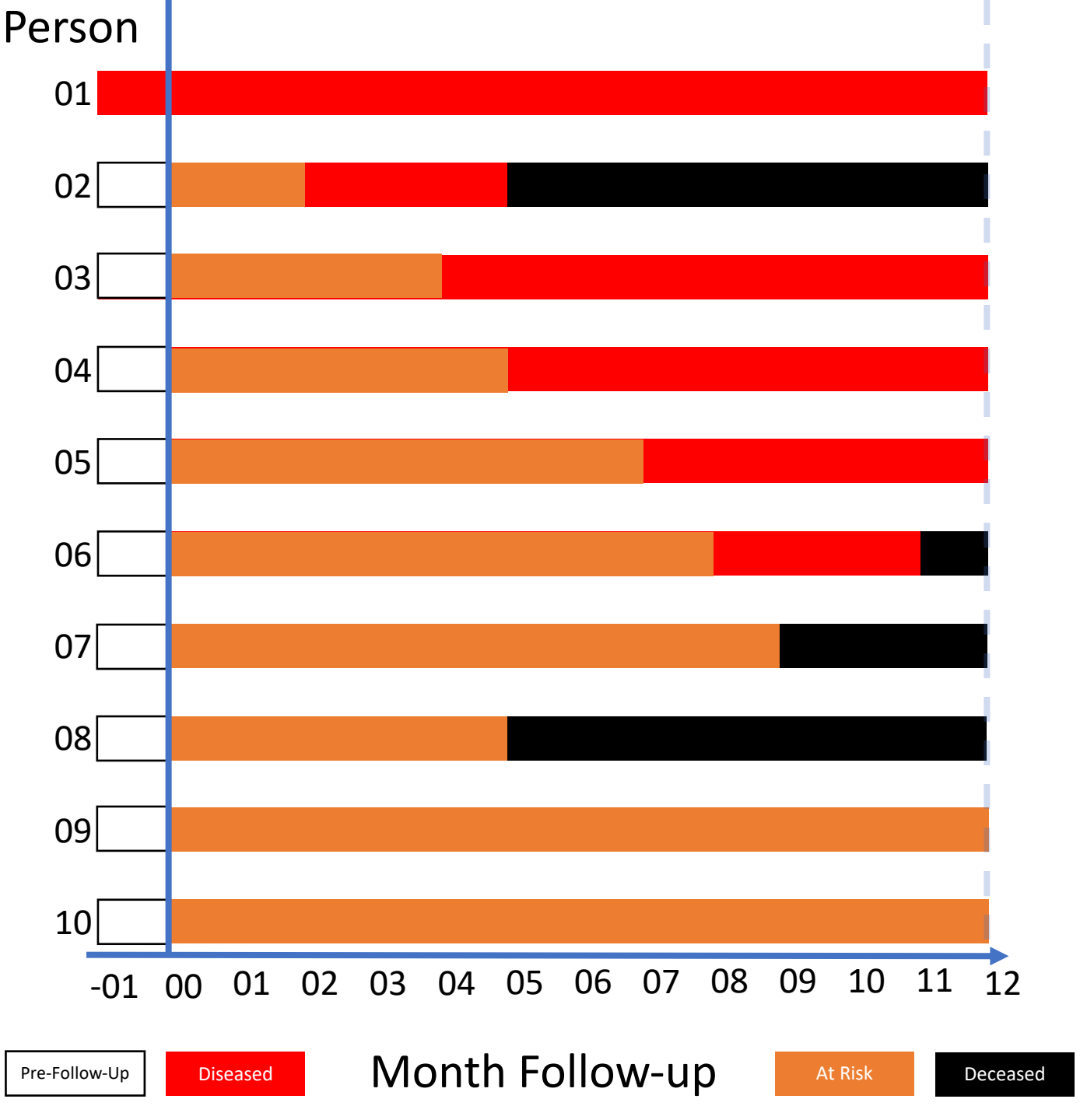
=

$$\frac{2}{10}$$

=

$$0.2\ or\ 20\%$$

Prevalence Proportion



Among the members of our population, the prevalence of disease in month two was 0.2. Said another way, 20% of our population had disease in month two.

Source: https://www.r-project.org/logo/

Point prevalence and period prevalence

- **Point prevalence:** is the prevalence of a condition of interest at a single point in time.
- **Period prevalence:** is the prevalence of a condition of interest over a period of time.
- As the duration of the period shrinks, period prevalence will converge to point prevalence.
- There is no hard and fast rule about what window of time is sufficiently short to count a point prevalence.

Source: Westreich D. *Epidemiology by Design*. Oxford University Press; 2019

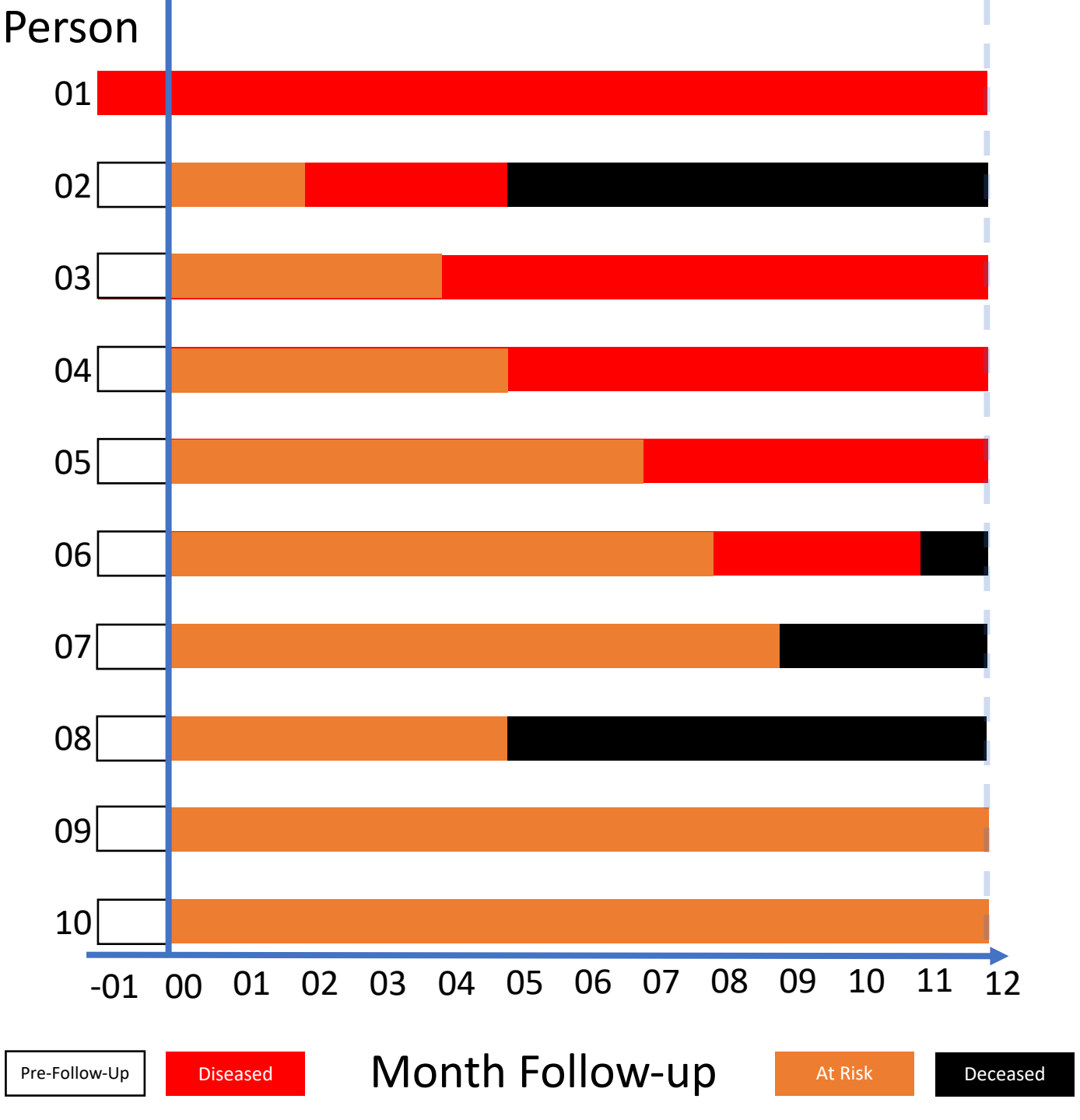
Prevalence Odds

- A prevalence odds is a simple function of the prevalence proportion, just as the odds in general is a simple function of probability, and are typically reported out of convenience or for their desirable statistical properties.
- The prevalence odds, then, is simply the prevalence proportion divided by 1 minus the prevalence proportion.
- Range 0 to infinity.

Source: Westreich D. *Epidemiology by Design*. Oxford University Press; 2019

Prevalence Odds

$$\frac{Prevalence\ proportion}{1\ -\ Prevalence\ proportion}$$



Prevalence Odds

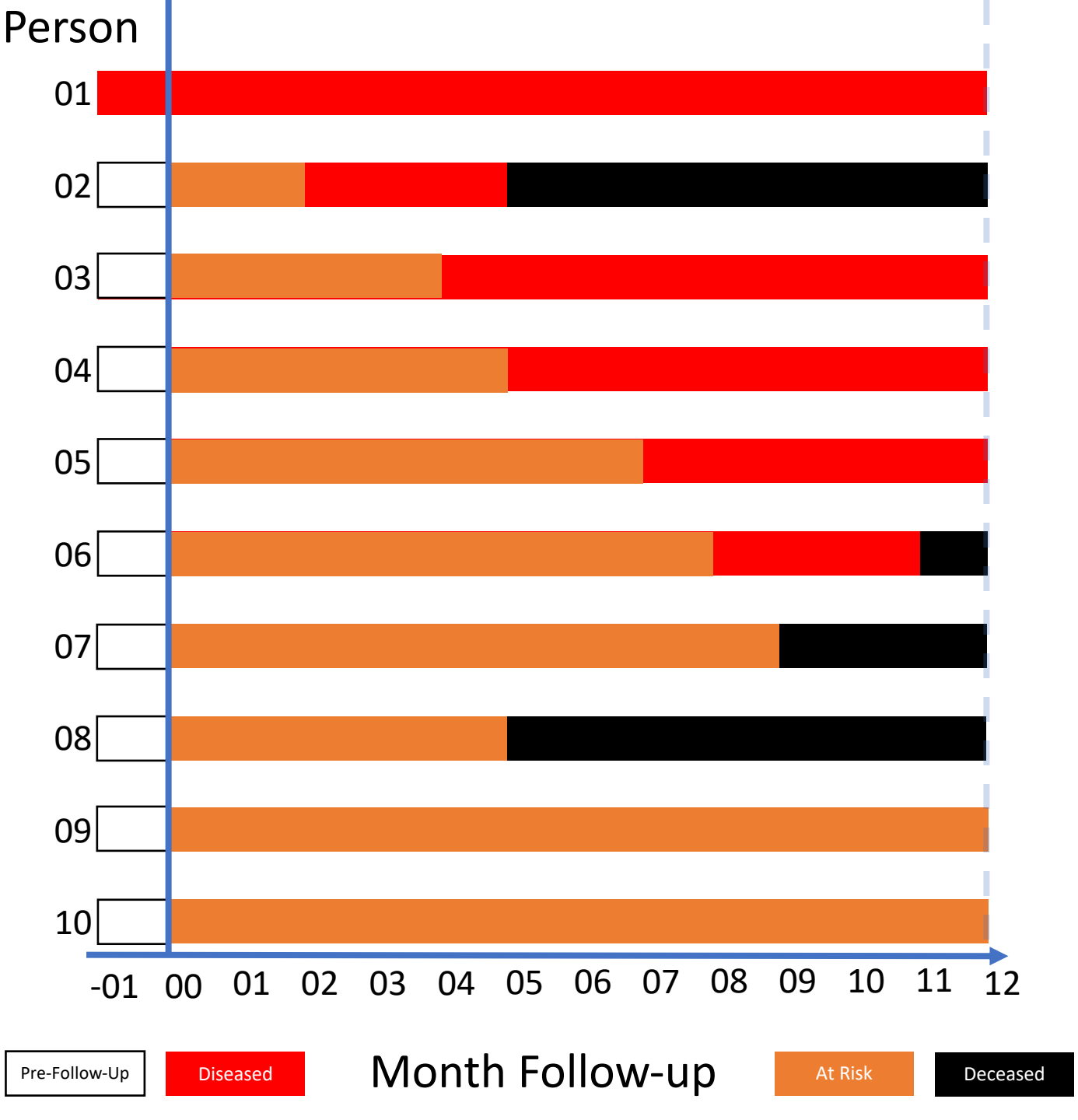
$$\frac{Prevalence\ proportion}{1\ -Prevalence\ proportion}$$

=

$$\frac{0.2}{1\ -0.2}$$

=

$$0.25$$



Prevalence Odds

Among the members of our population, the odds of disease in month two were 0.25.

Among the members of our population, for every person who had disease at month two there were four people who did not.

Source: https://www.r-project.org/logo/

Incidence

- Where prevalence is a measure of how many cases of disease or condition are present at a given moment or over a period, incidence is a measure of how many *new cases* of a disease arise *over a specified period of time*.
- A critical difference between prevalence and incidence is that, unlike prevalence, incidence is a measure of occurrences, or events: incidence counts the number of transitions from a condition being absent in an individual to that condition being present *over a specified period of time*.

Source: Westreich D. *Epidemiology by Design*. Oxford University Press; 2019

Incidence

- Incidence proportion and “risk” are sometimes used interchangeably in epidemiology.
- Risk can be ambiguous. Incidence proportion is less so.

Source: Westreich D. *Epidemiology by Design*. Oxford University Press; 2019

Incidence Count

- A count of the number of new occurrences of some condition in a population at risk for the occurrence in a given time frame.
- Range: 0 to infinity

Source: Westreich D. *Epidemiology by Design*. Oxford University Press; 2019

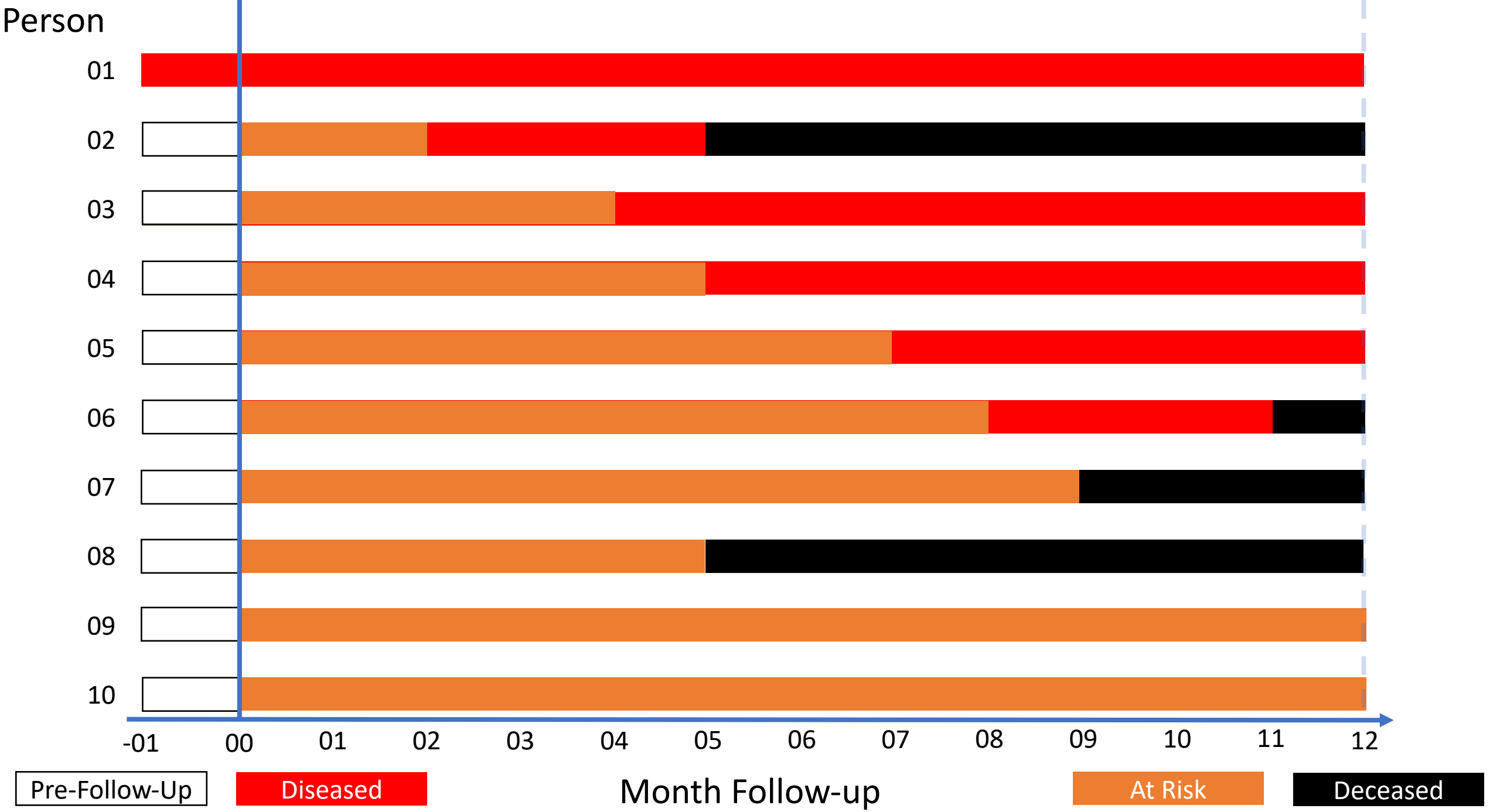
Incidence Proportion

- The proportion of the population who experiences a new occurrence of the condition of interest among those in the population who are at risk of experiencing a new occurrence the condition of interest during a given time frame.
- Like all proportions, falls between 0 and 1.

Source: Westreich D. *Epidemiology by Design*. Oxford University Press; 2019

Incidence Proportion

$$\frac{Count\ of\ new\ occurences}{Population\ at\ risk}$$



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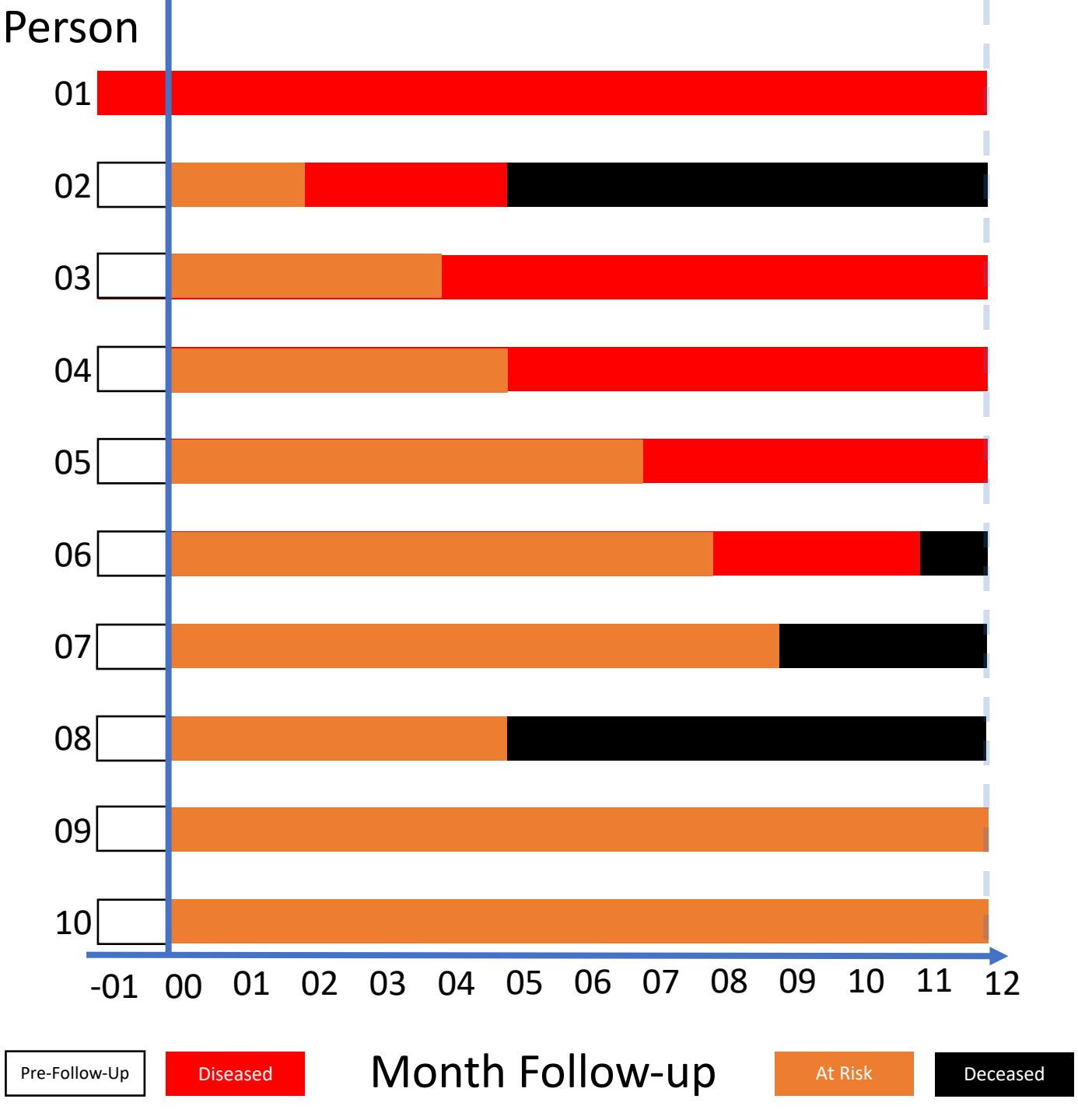


Incidence Proportion

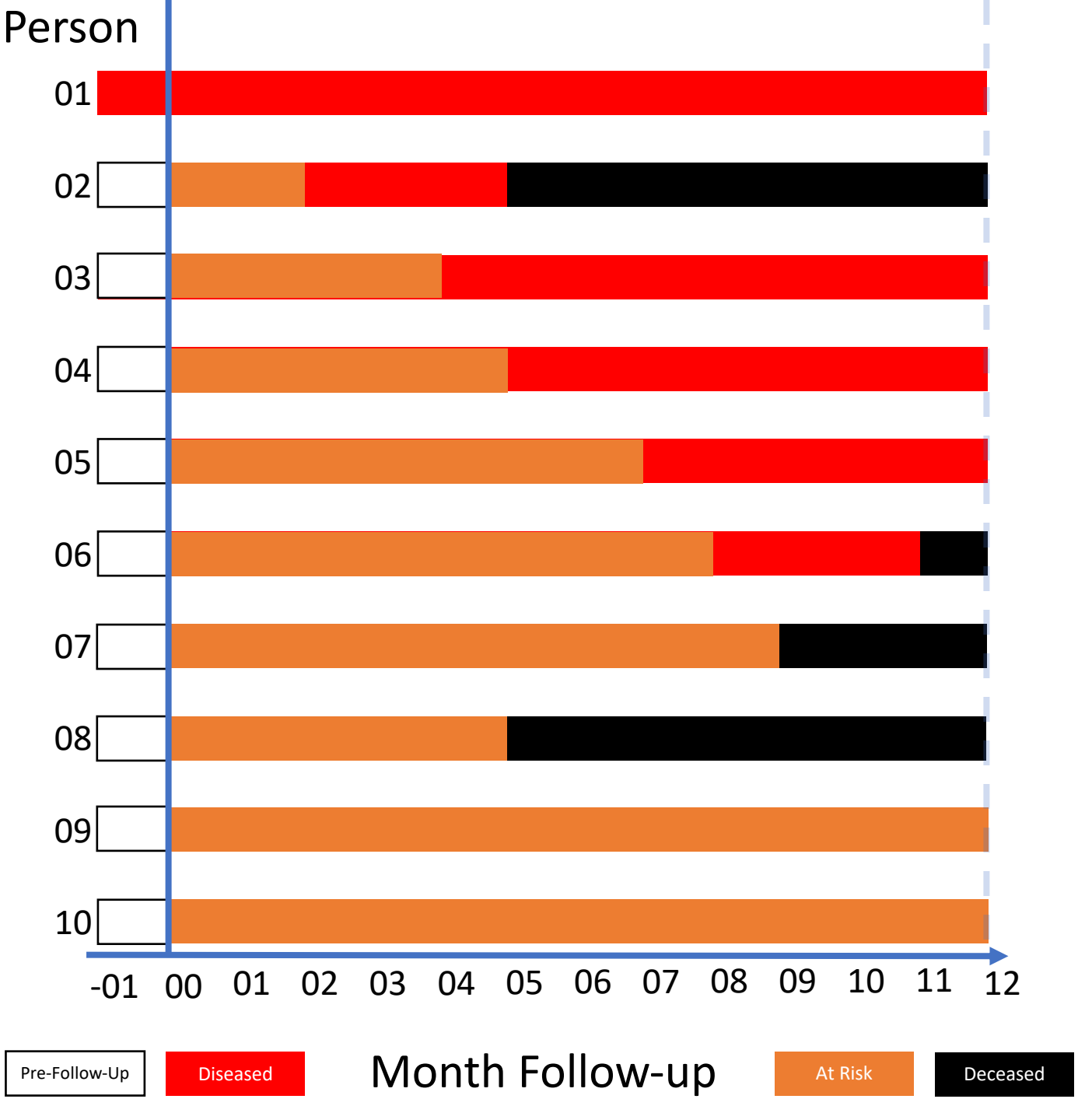
$$\frac{Count\ of\ new\ occurences}{Population\ at\ risk}$$

=

$$\frac{5}{9}$$

=

$$0.56\ or\ 56\%$$



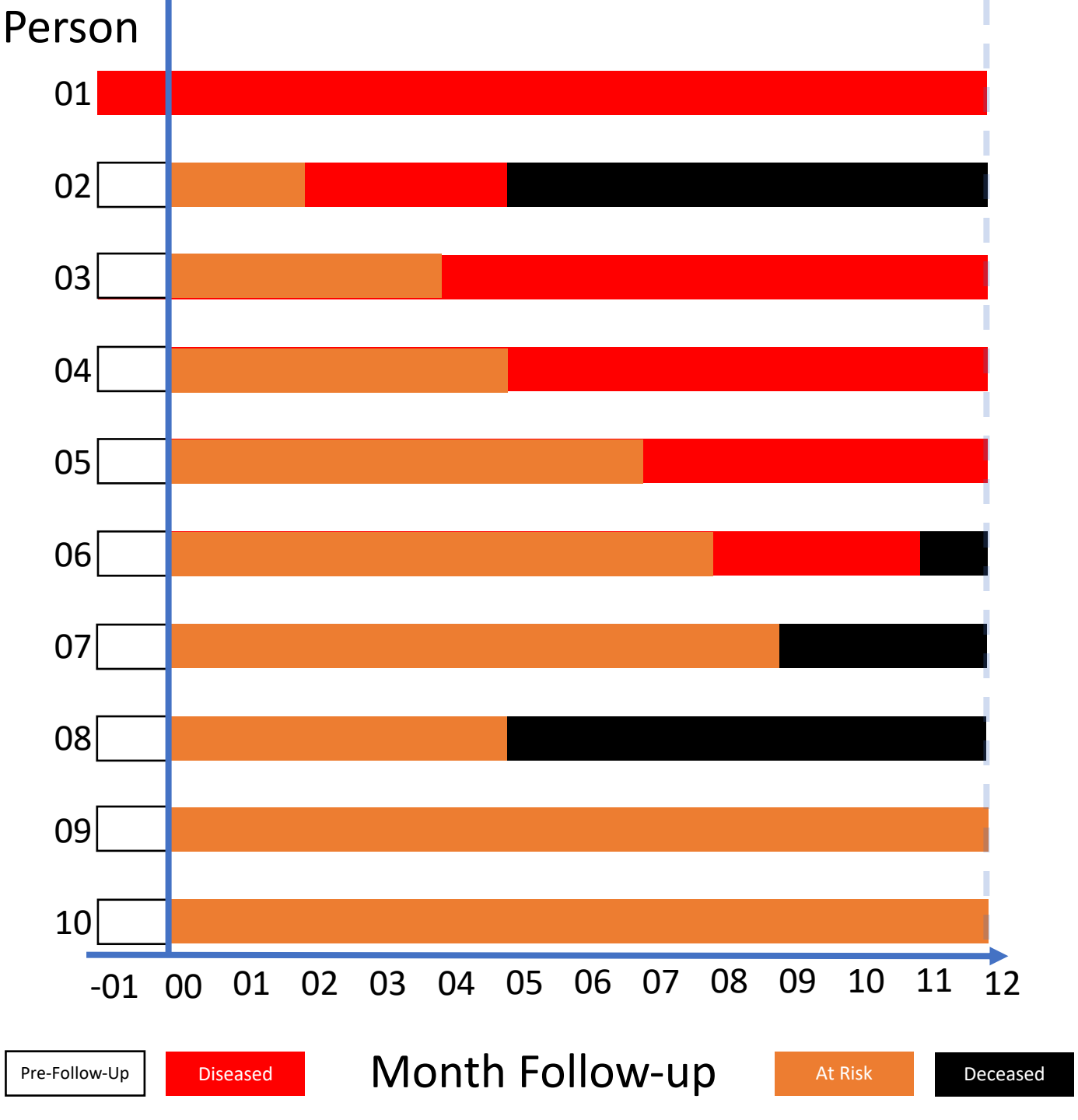
Incidence Proportion

Among the members of our population, the incidence of disease over 12 months of follow-up was 0.56.

Fifty six percent of the members of our population developed disease over 12 months of follow-up .

Incidence Odds

$$\frac{Incidence\ proportion}{1 - Incidence\ proportion}$$



Incidence Odds

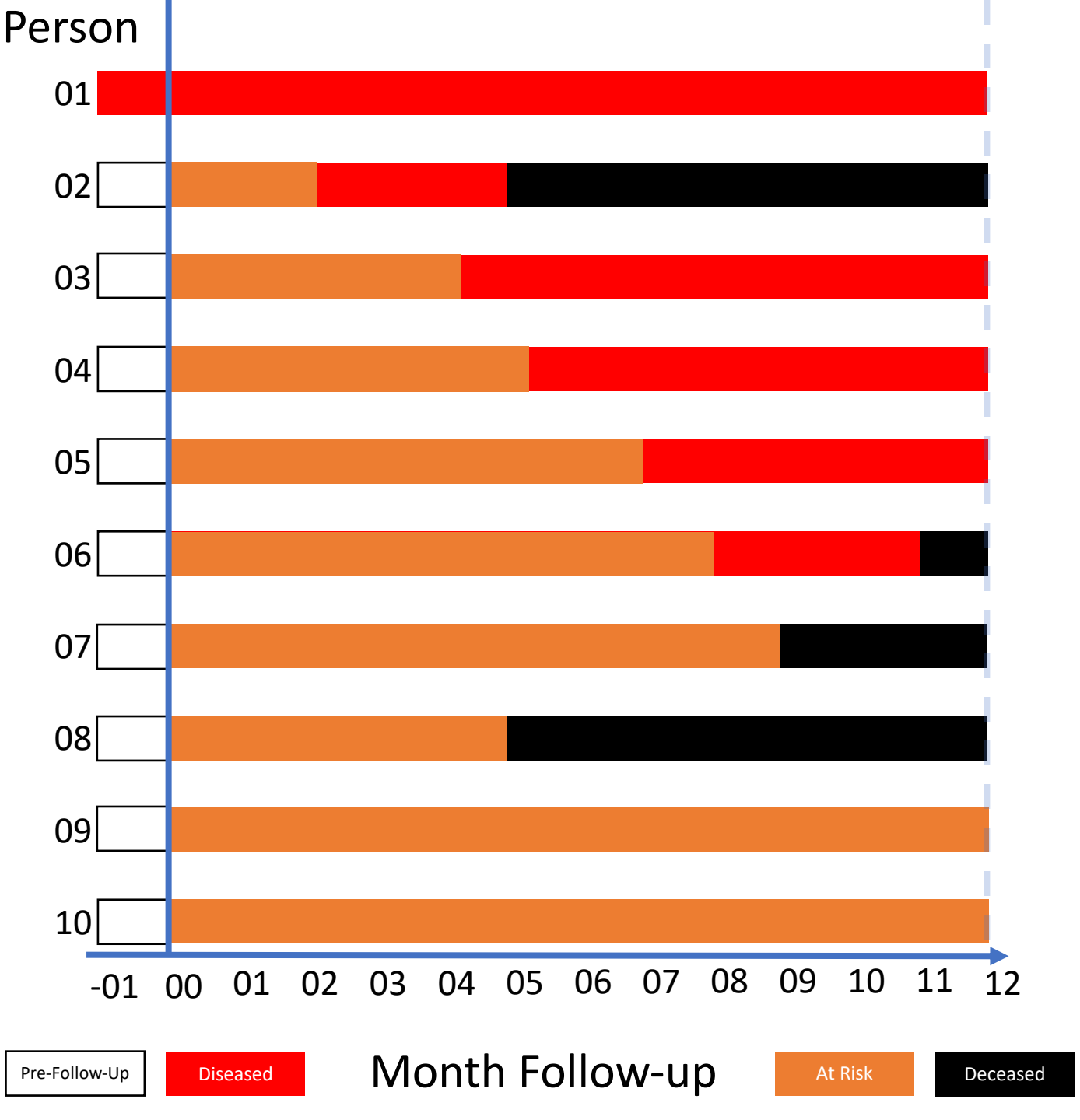
$$\frac{Incidence\ proportion}{1\ -Incidence\ proportion}$$

=

$$\frac{0.56}{1\ -0.56}$$

=

$$1.27$$



Incidence Odds

Among the members of our population, the odds of incident disease over 12 months of follow-up were 1.27.

Among the members of our population, for every 127 people develop incident disease over 12 months of follow-up there were 100 people who did not.

Incidence Rate

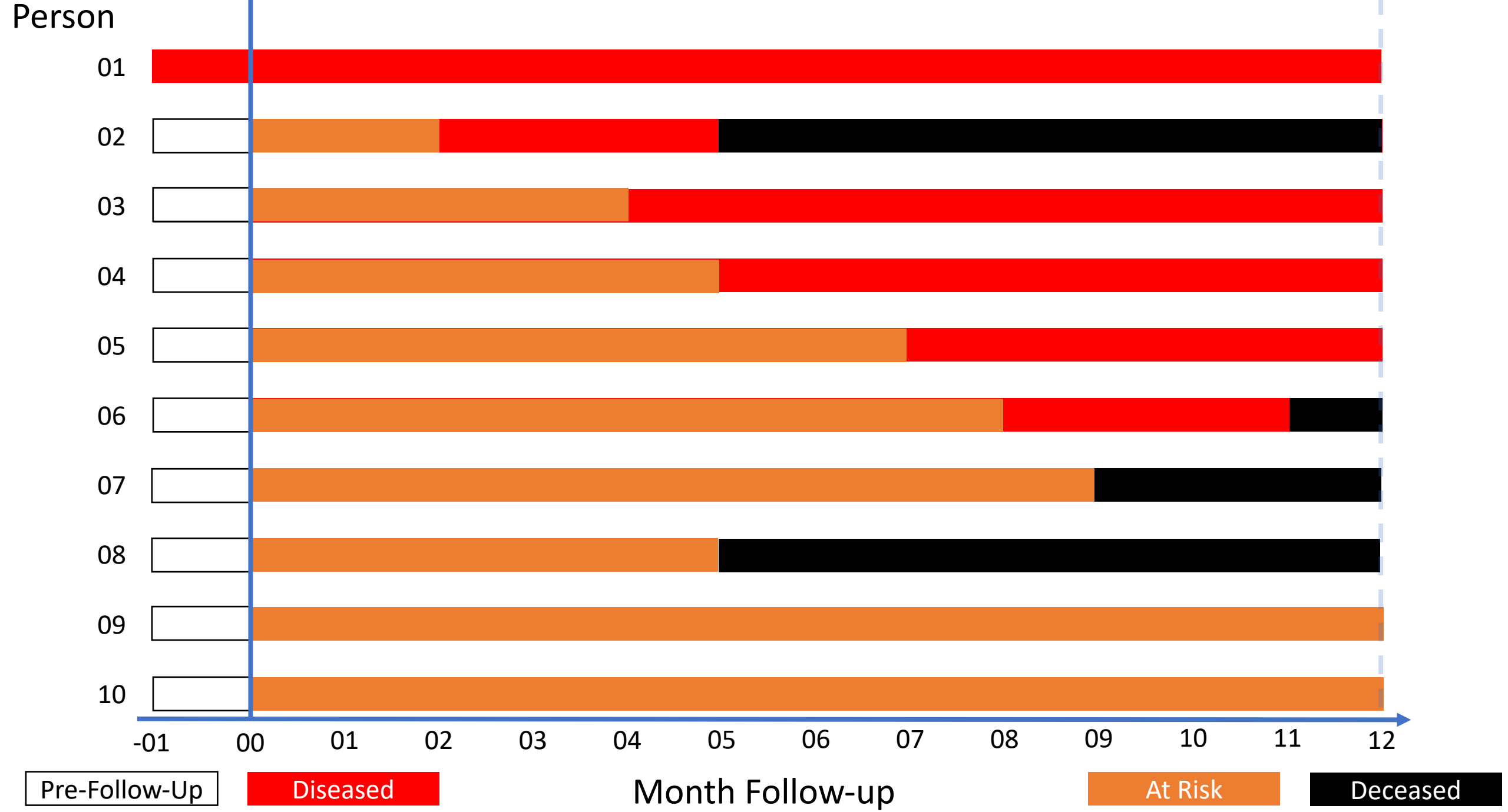
- A measure of the average intensity at which an event occurs in the experience of people over time, and, for a population followed from baseline, it is calculated as the number of cases in that population divided by the amount of person-time at risk accumulated by that population.
- Range: 0 to infinity
- NOT a proportion
- The denominator is reciprocal time (usually person-time)
- The numeric value of an incidence rate in itself has no interpretability because it depends on the selection of the time unit.

Source: Westreich D. *Epidemiology by Design*. Oxford University Press; 2019

Person-time

- Person-time is the amount of time observed for all people under study while at risk of experiencing an incident outcome.

Source: Westreich D. *Epidemiology by Design*. Oxford University Press; 2019



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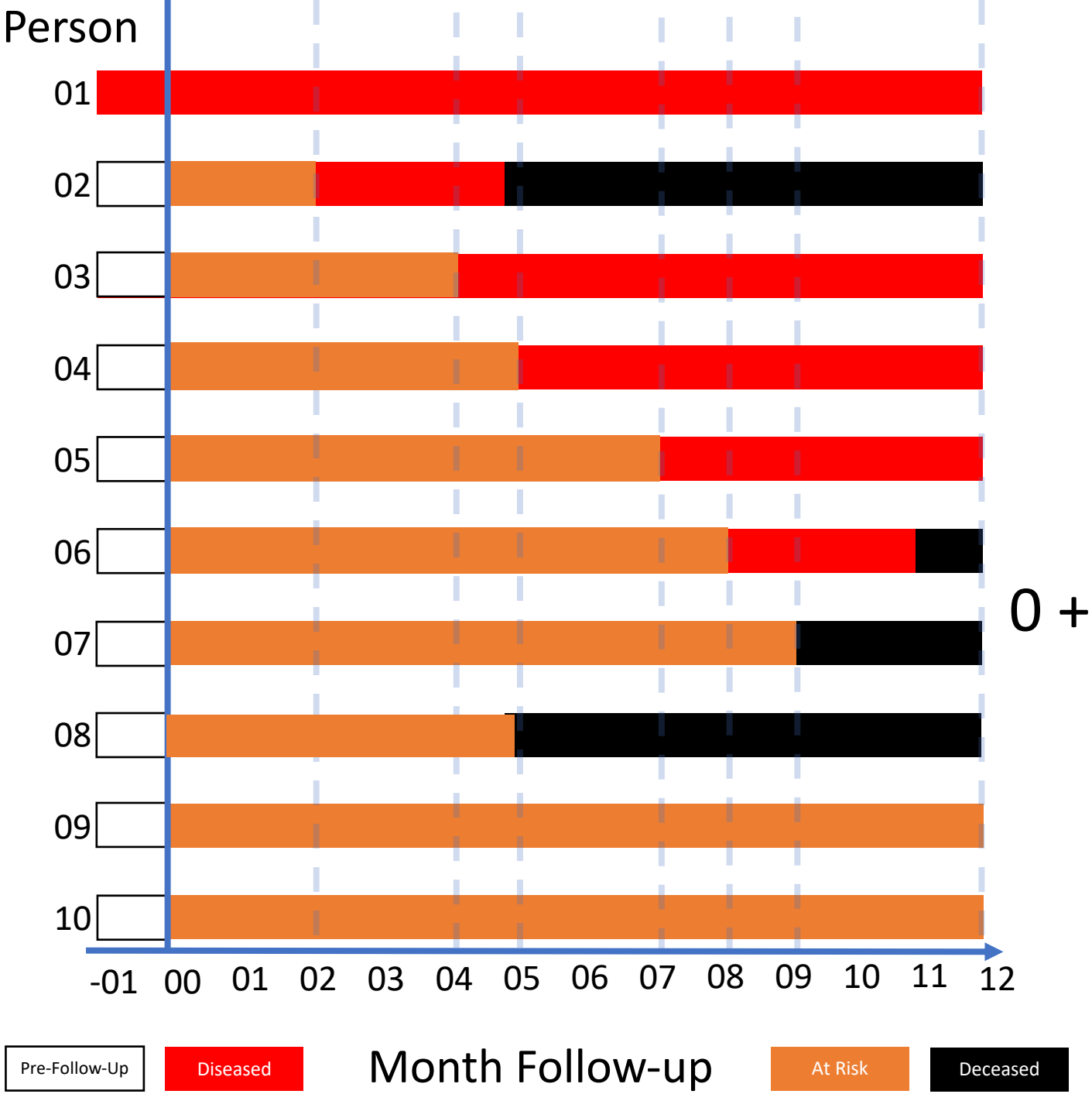


Person-time

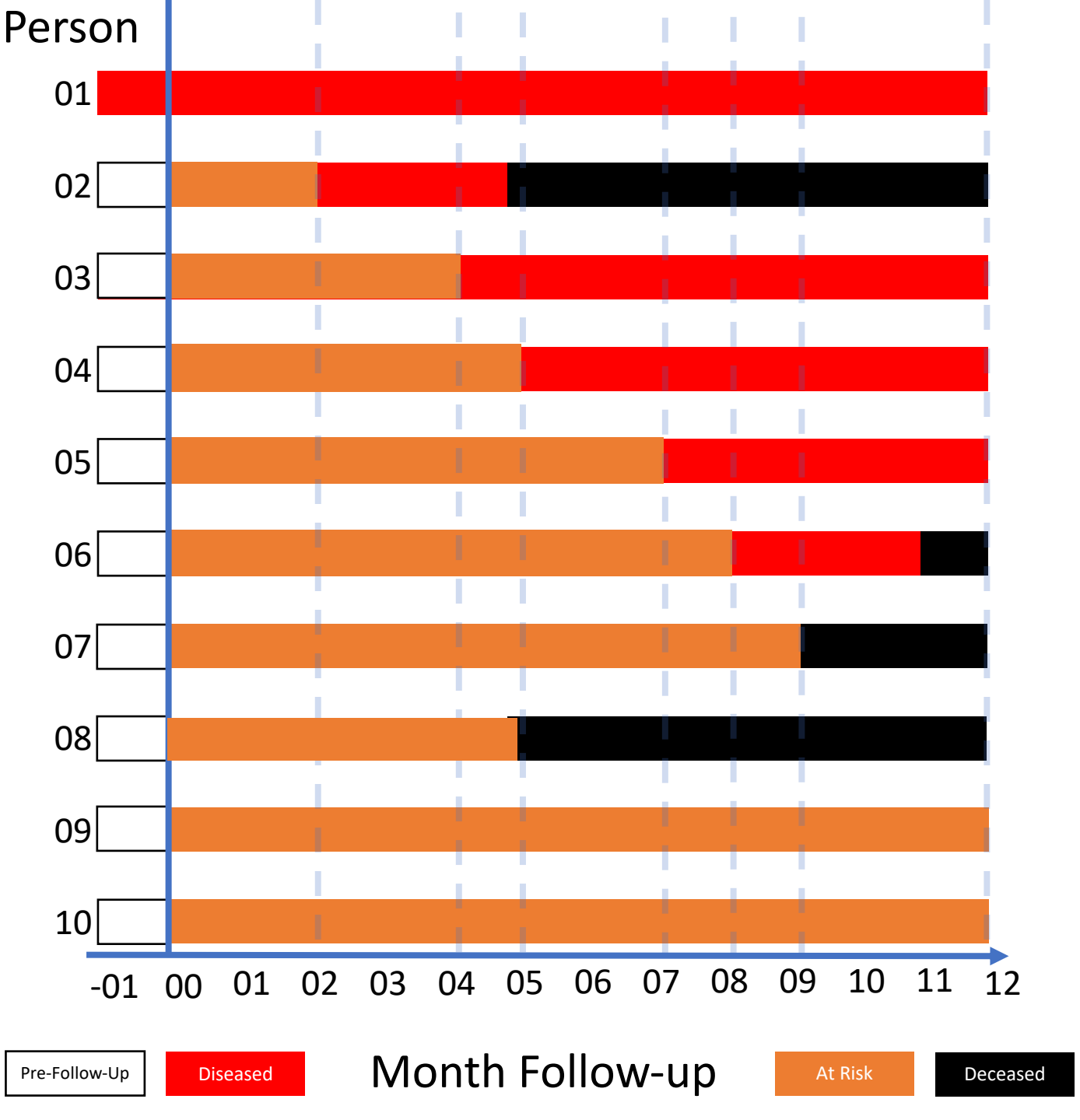
$$\sum_{people} Time\ spent\ at\ risk$$

=

0 + 2 + 4 + 5 + 7 + 8 + 9 + 5 +12 + 12

=

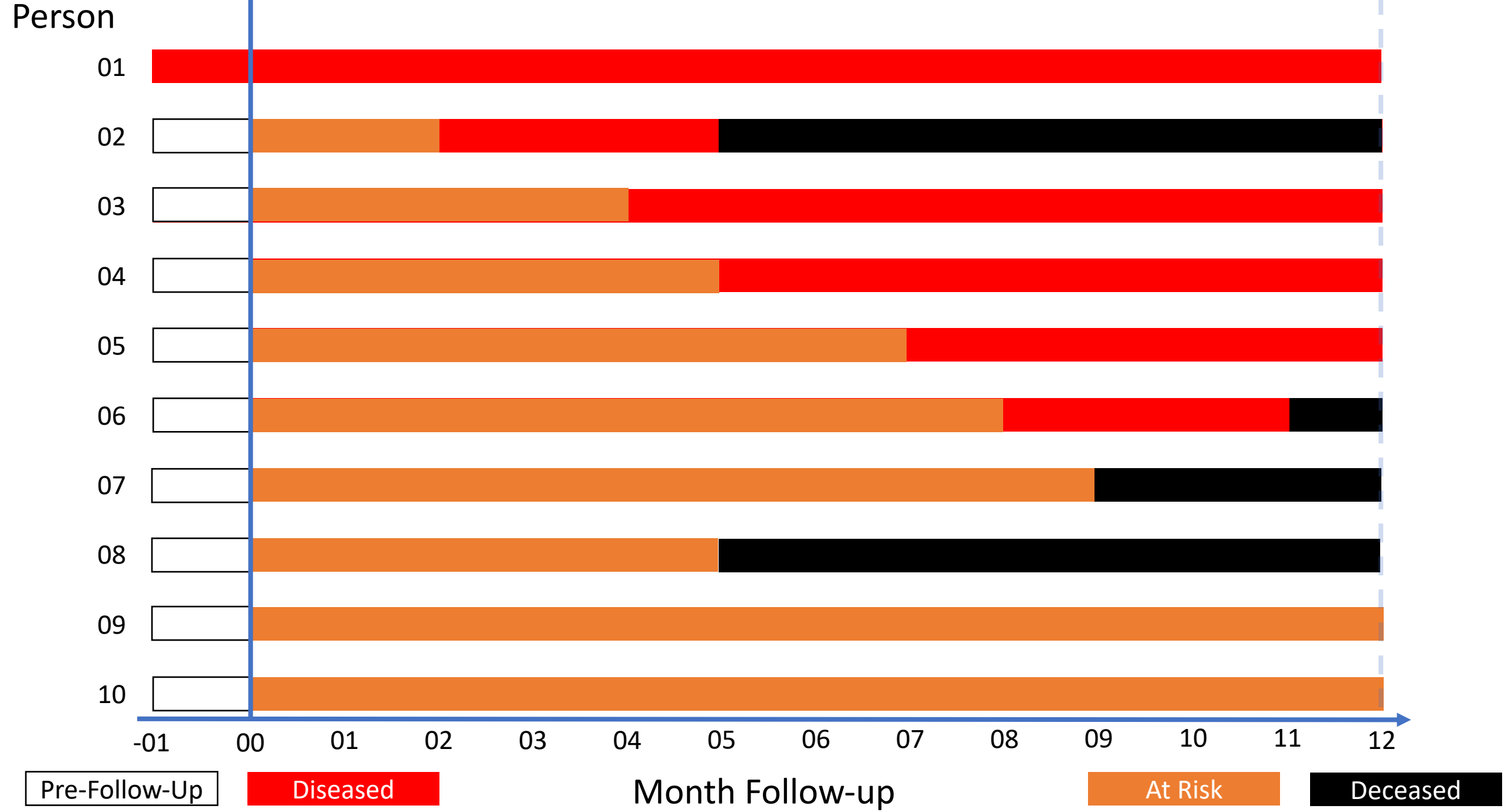
64



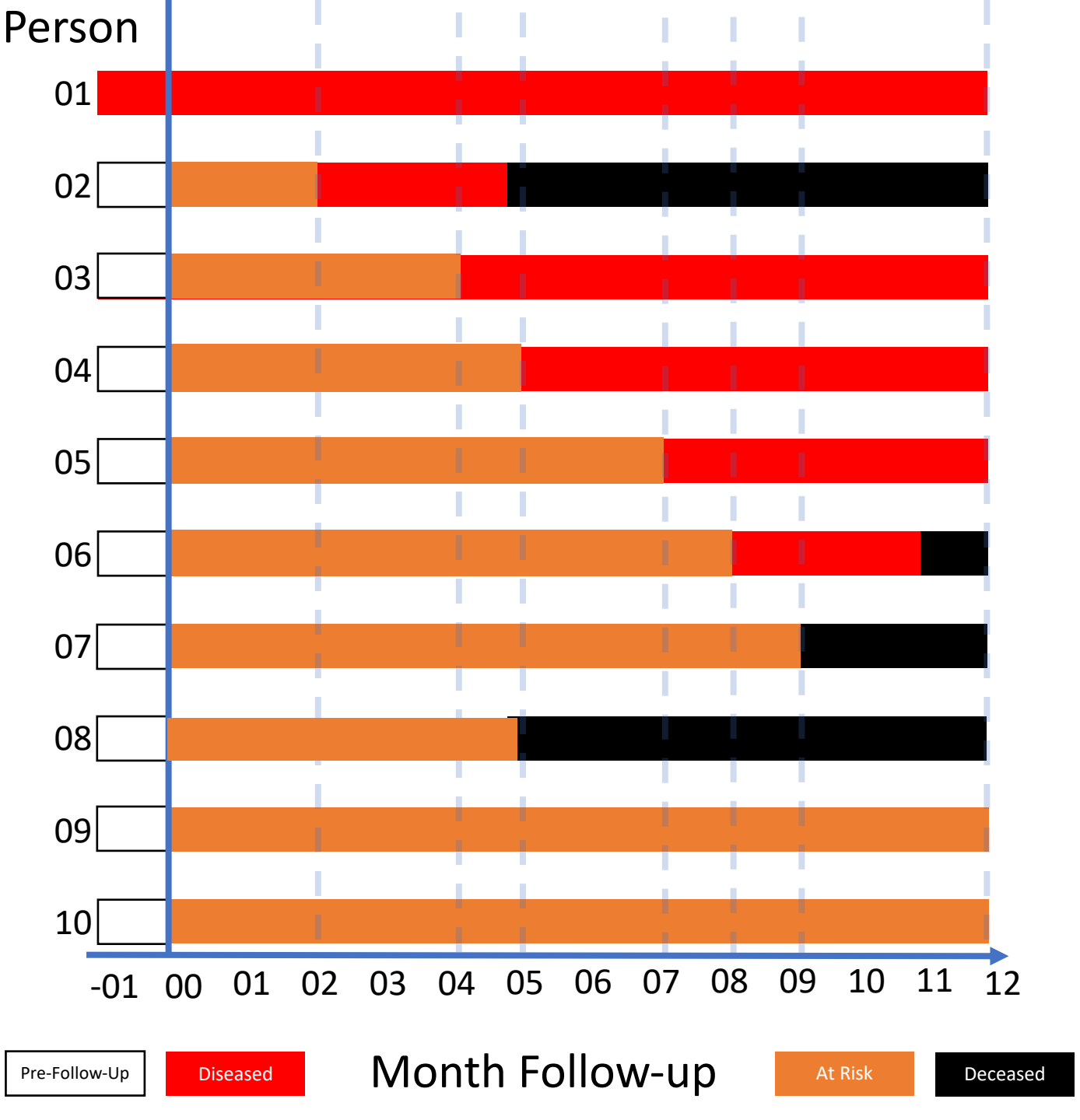
Person-time

The members of our population accumulated 64 person-months at risk during 12 months of follow-up.

The members of our population accumulated 5.33 person-years at risk during 12 months of follow-up.



Source: Lash TL, VanderWeel TJ, Haneuse S, Rothman KJ. *Modern Epidemiology*. fourth. Wolters Kluwer; 2021.



Incidence Rate

$$\frac{Count\ of\ new\ occurences}{Person-time\ at\ risk}$$

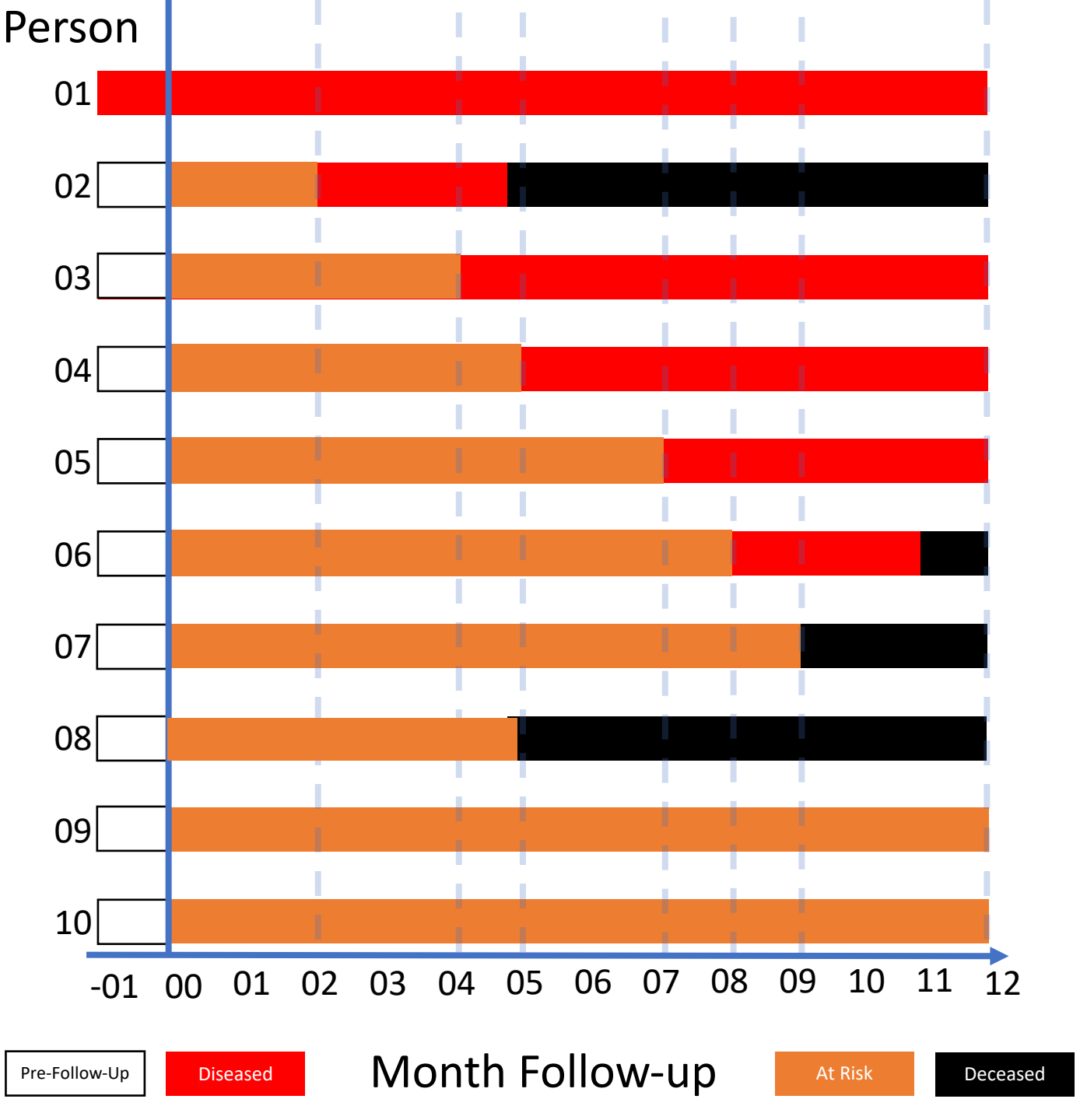
$$=$$

$$\frac{5}{64\ person-months}$$

or

$$8\ per\ 100\ pm$$

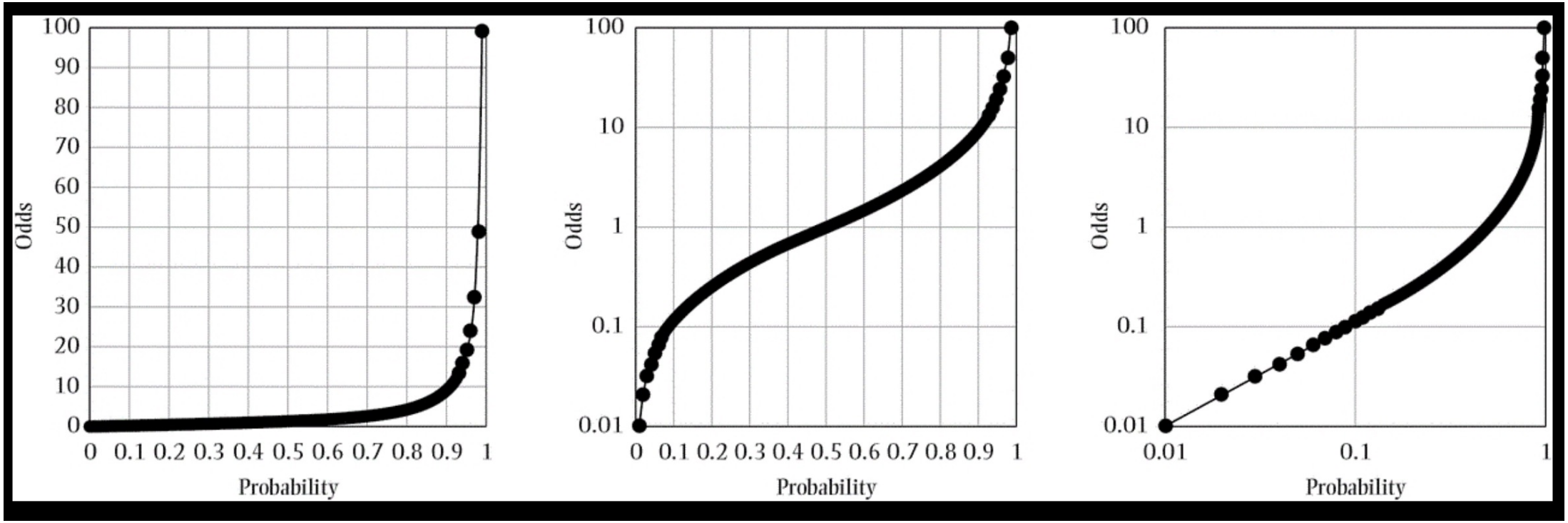
Incidence Rate



The incidence rate of disease among the members of our population was 5 cases per 64 person-months during 12 months of follow-up.

The incidence rate of disease among the members of our population was 7.8 cases per 100 person-months during 12 months of follow-up.

Odds and proportions



Source: Westreich D. *Epidemiology by Design*. Oxford University Press; 2019