Applying epidemiological estimates

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Objectives

- Definitions
- Type of epidemiological estimates
- Measures of public health impact
  - PAF
  - Burden of disease
- Exercise
  - Causal inference
  - Real world example of use of PAF to estimate burden of disease

Definitions

Disease

A disease is a particular abnormal condition that negatively affects the structure or function of part or all of an organism, and that is not due to any external injury

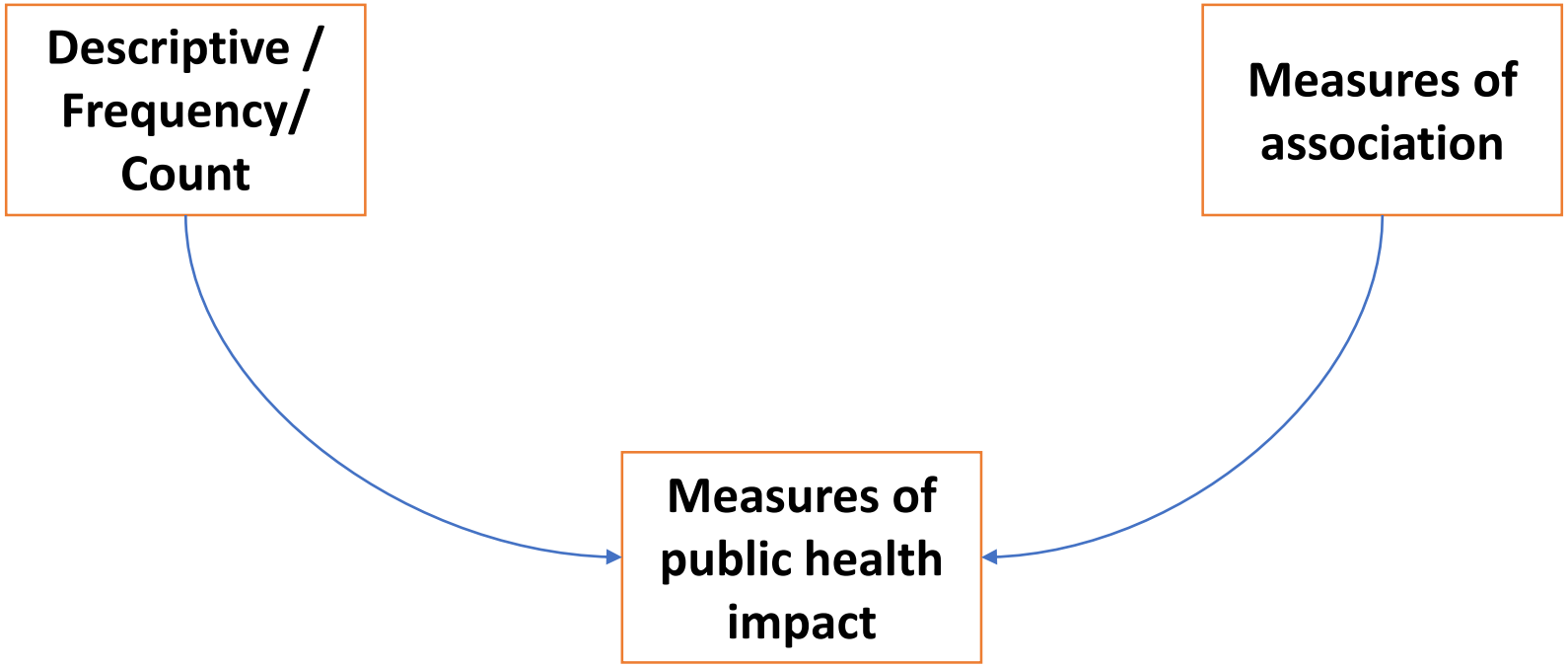
Risk factor

A risk factor is any attribute, characteristic or exposure of an individual that increases the likelihood of developing a disease or injury.

Causal inference

Inferring the cause of something has been described as:
- "...reason[ing] to the conclusion that something is, or is likely to be, the cause of something else".
- "Identification of the cause or causes of a phenomenon, by establishing covariation of cause and effect, a time-order relationship with the cause preceding the effect, and the elimination of plausible alternative causes."

Types of epidemiological estimates / measures of risk



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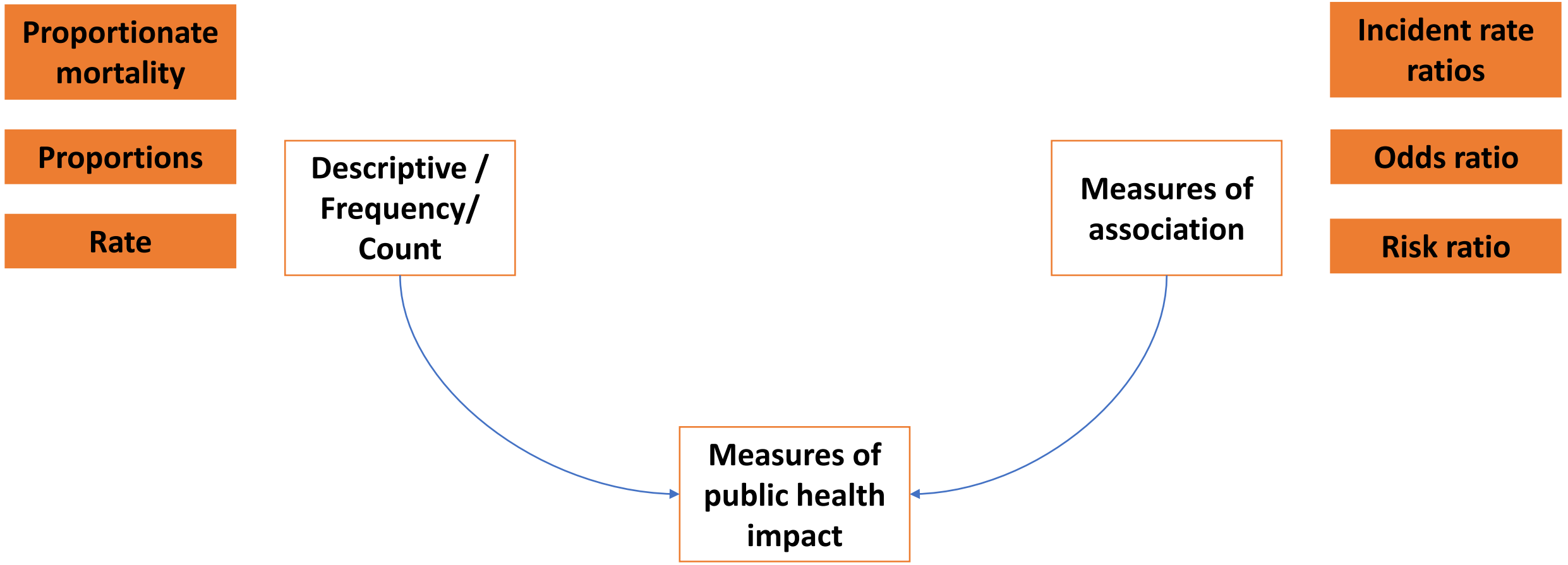
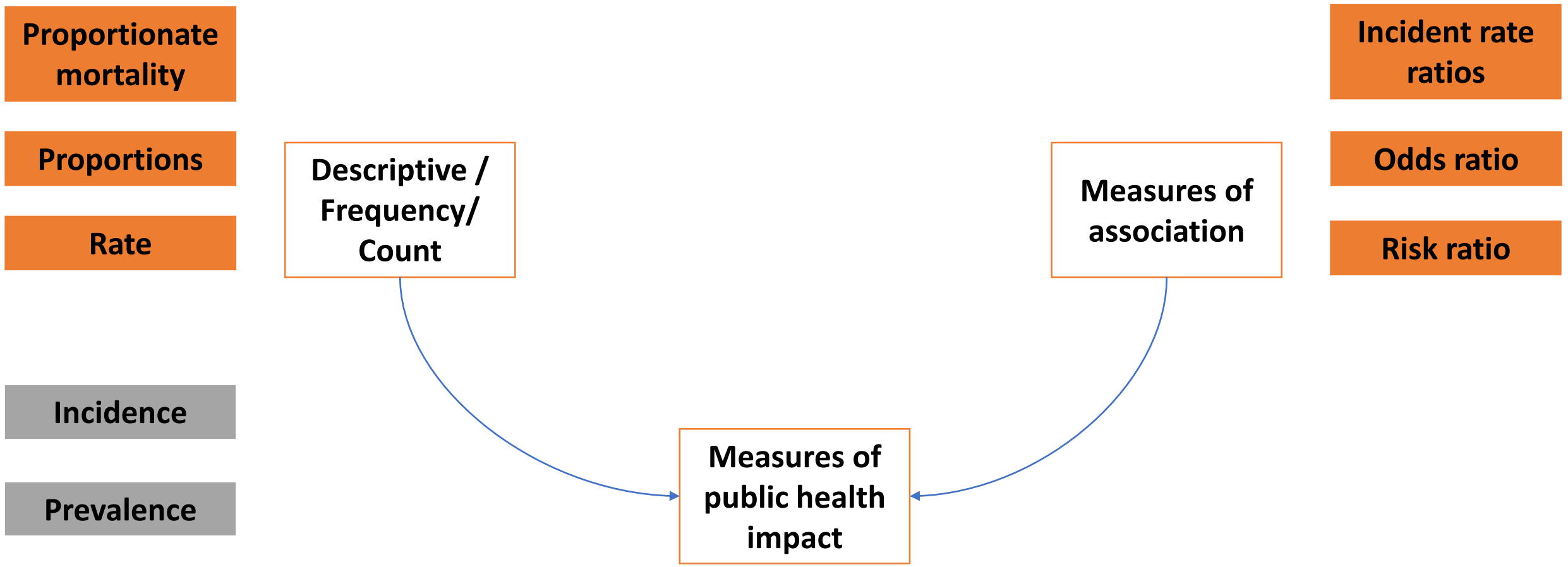
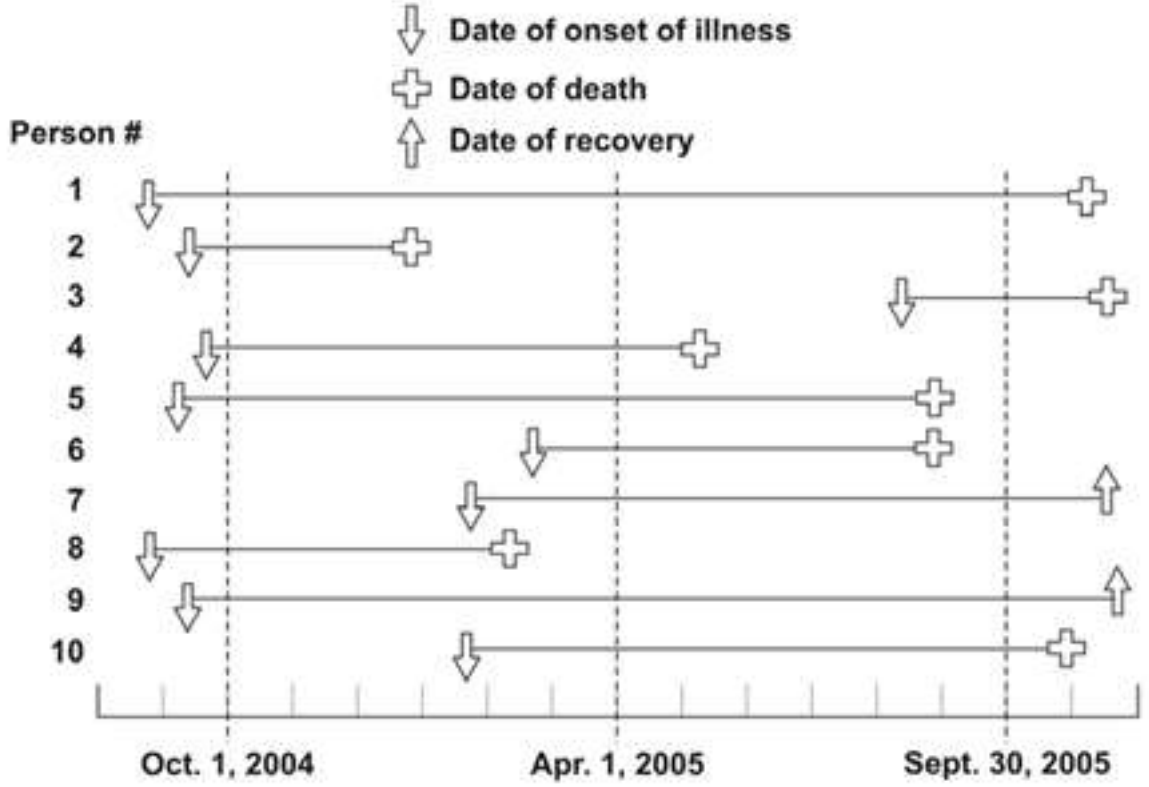


Types of epidemiological estimates



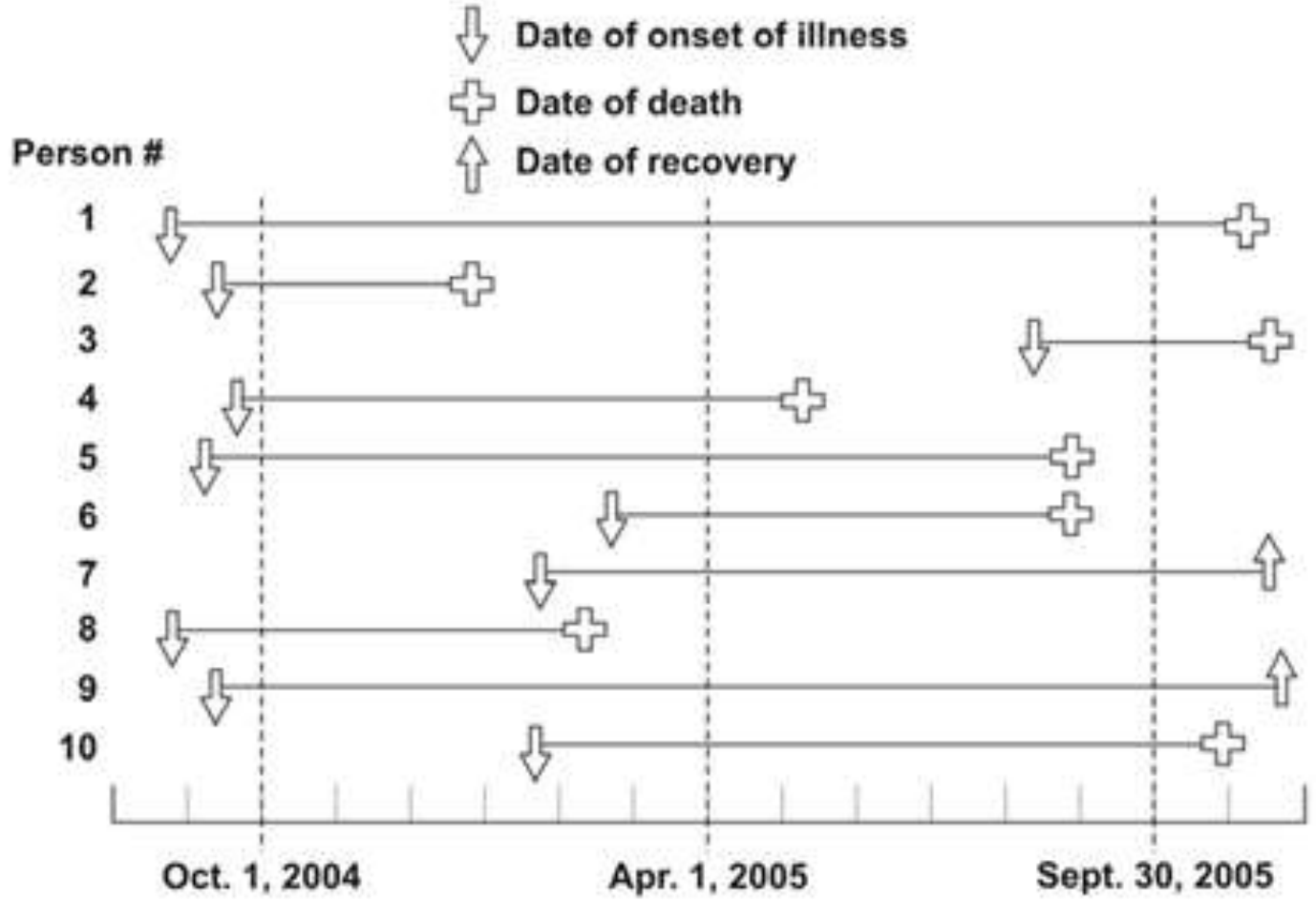
Incidence and prevalence

Figure 3.1 represents 10 new cases of illness over about 15 months in a population of 20 persons. Each horizontal line represents one person. The down arrow indicates the date of onset of illness. The solid line represents the duration of illness. The up arrow and the cross represent the date of recovery and date of death, respectively.



Examples from https://www.cdc.gov/ophss/csels/dsepd/ss1978/lesson3/section1.html

Calculate the incidence rate from October 1, 2004, to September 30, 2005, using the midpoint population (population alive on April 1, 2005) as the denominator. Express the rate per 100 population.



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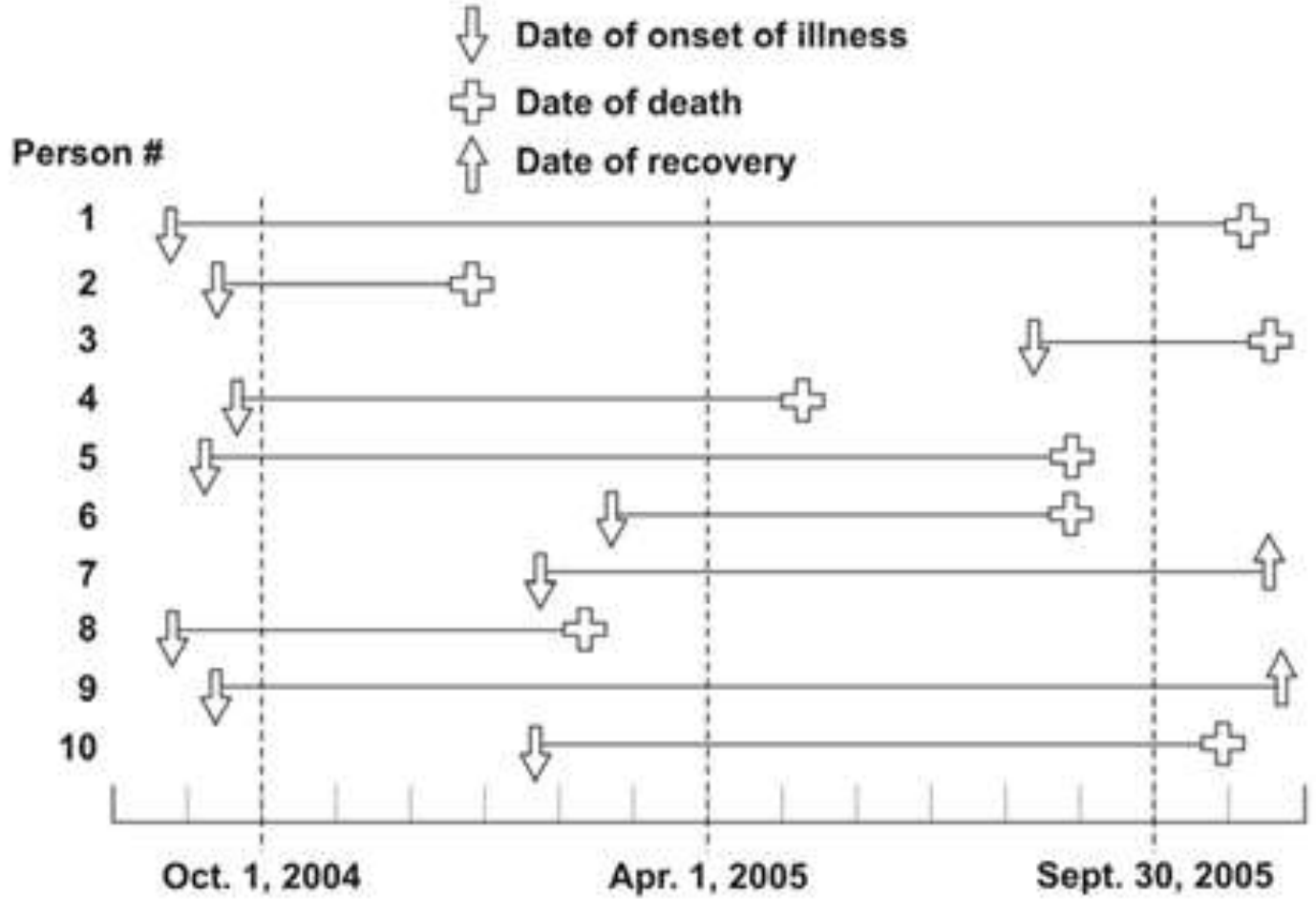
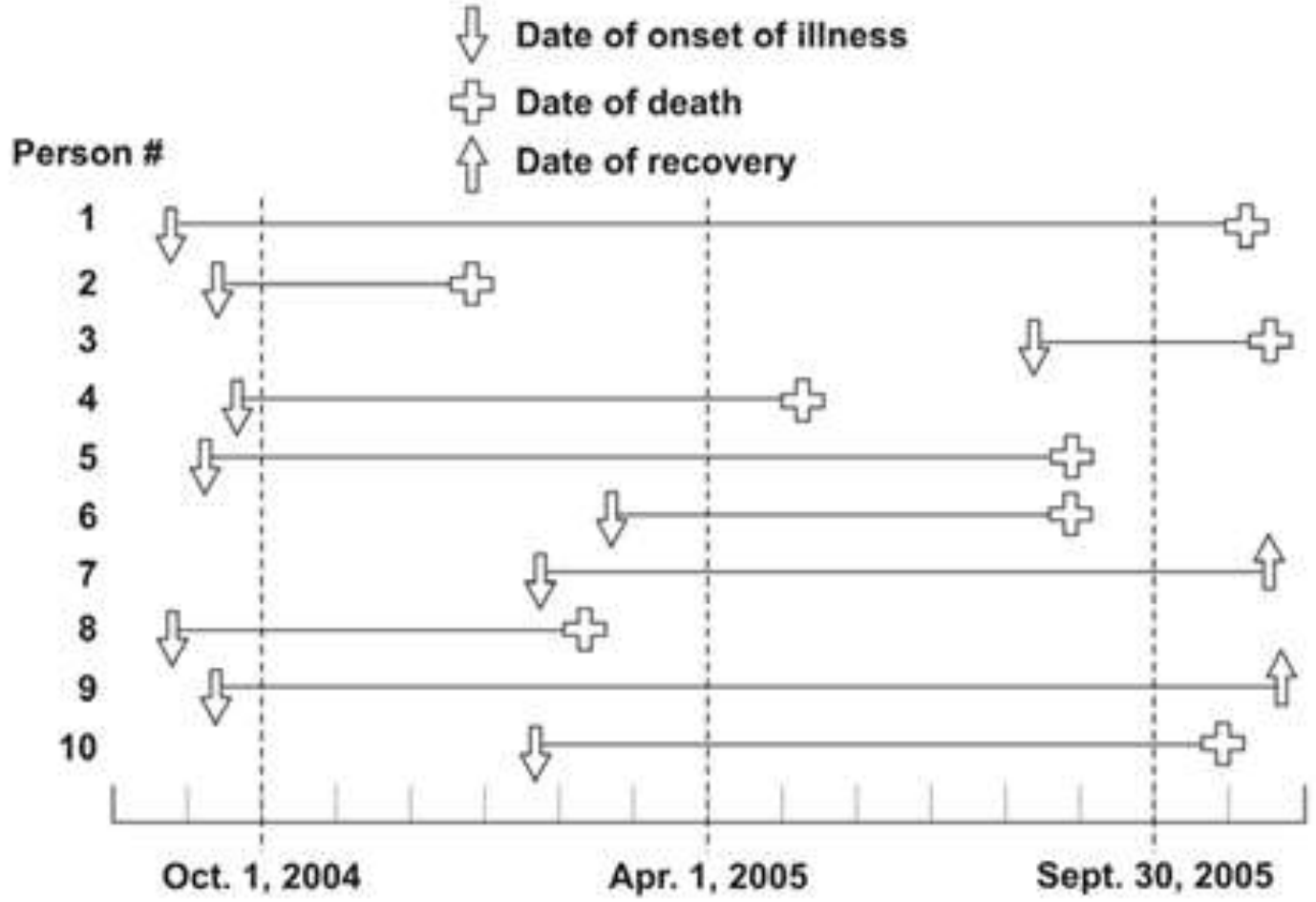
Calculate the point prevalence on April 1, 2005. Point prevalence is the number of persons ill on the date divided by the population on that date.



Examples from https://www.cdc.gov/ophss/csels/dsepd/ss1978/lesson3/section1.html

Calculate the period prevalence from October 1, 2004, to September 30, 2005. The numerator of period prevalence includes anyone who was ill any time during the period.



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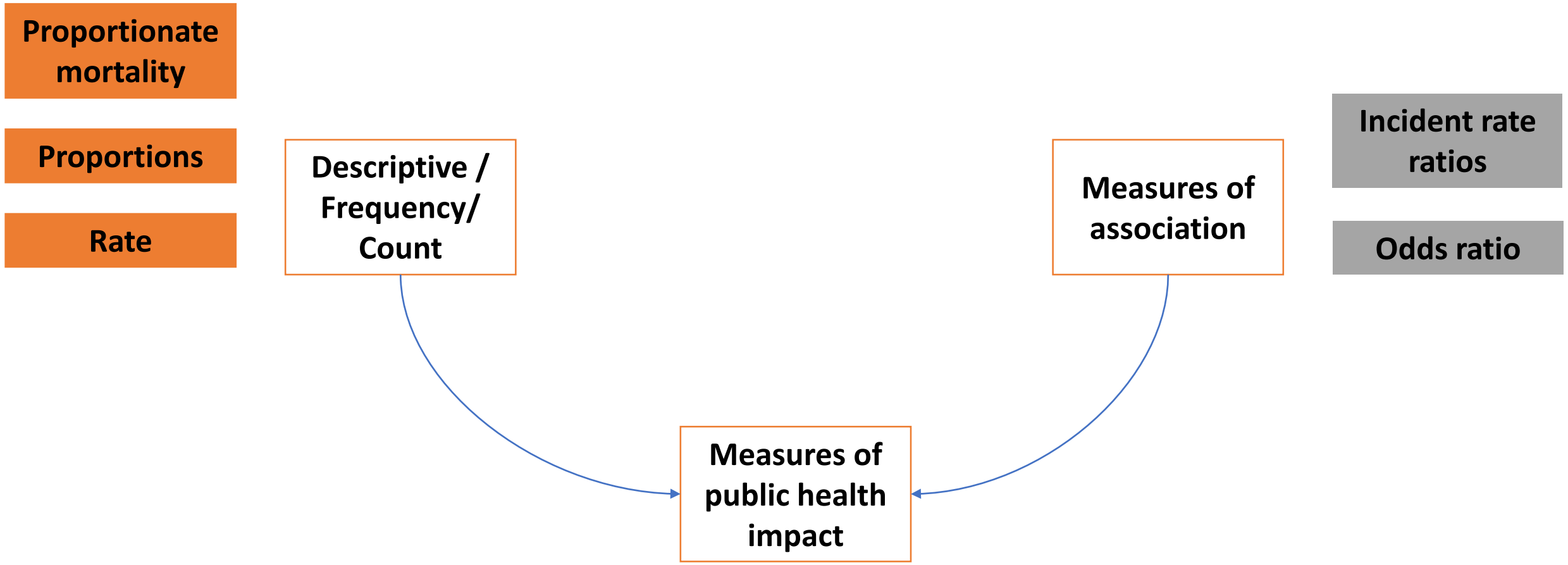
Types of epidemiological estimates



Incidence risk ratios

In an outbreak of tuberculosis among prison inmates in South Carolina in 1999, 28 of 157 inmates residing on the East wing of the dormitory developed tuberculosis, compared with 4 of 137 inmates residing on the West wing. These data are summarized in the two-by-two table so called because it has two rows for the exposure and two columns for the outcome. Here is the general format and notation.

		Disease	
	Yes	**No**	**Total**
East Wing	28	129	**157**
West Wing	4	133	**137**
Total	**32**	**262**	**294**

Incidence risk ratios

Are inmates in the east wing more likely to get TB and if so by how much

		Disease	
	Yes	**No**	**Total**
East Wing	28	129	**157**
West Wing	4	133	**137**
Total	**32**	**262**	**294**

Odds ratio

Are inmates in the east wing more likely to get TB and if so by how much – so what is the odds ratio?

		Disease	
	Yes	**No**	**Total**
East Wing	28	129	**157**
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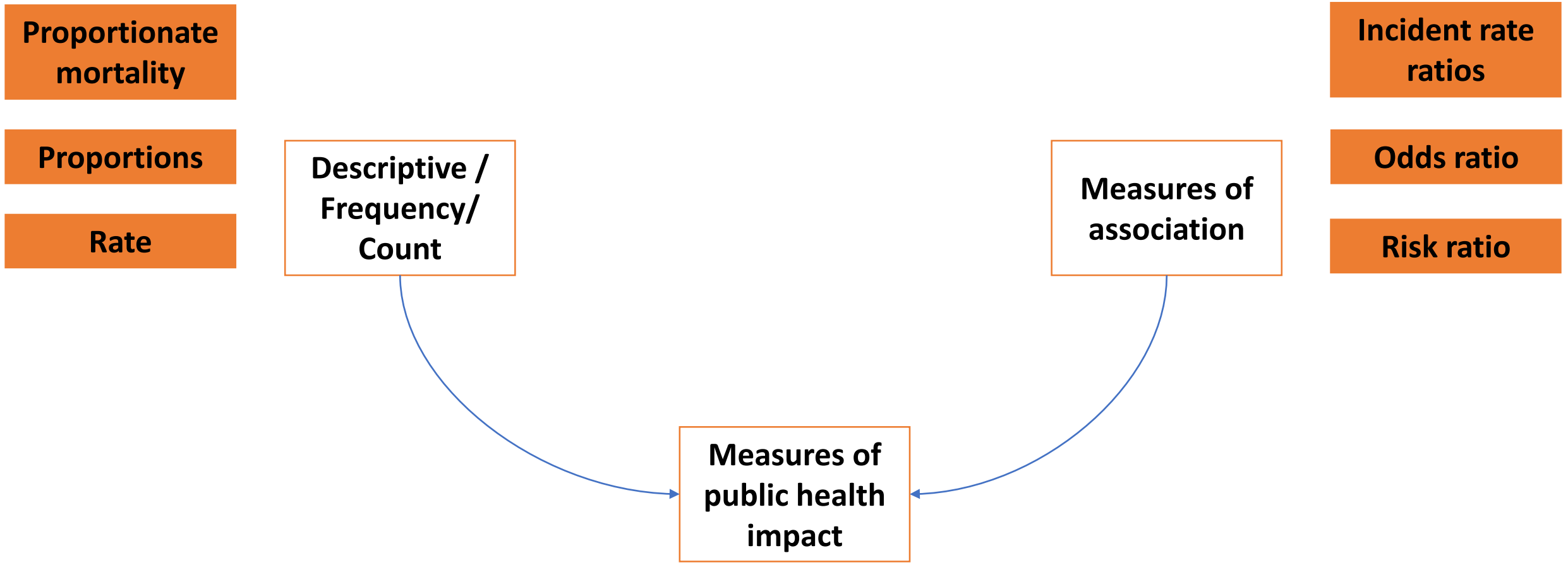
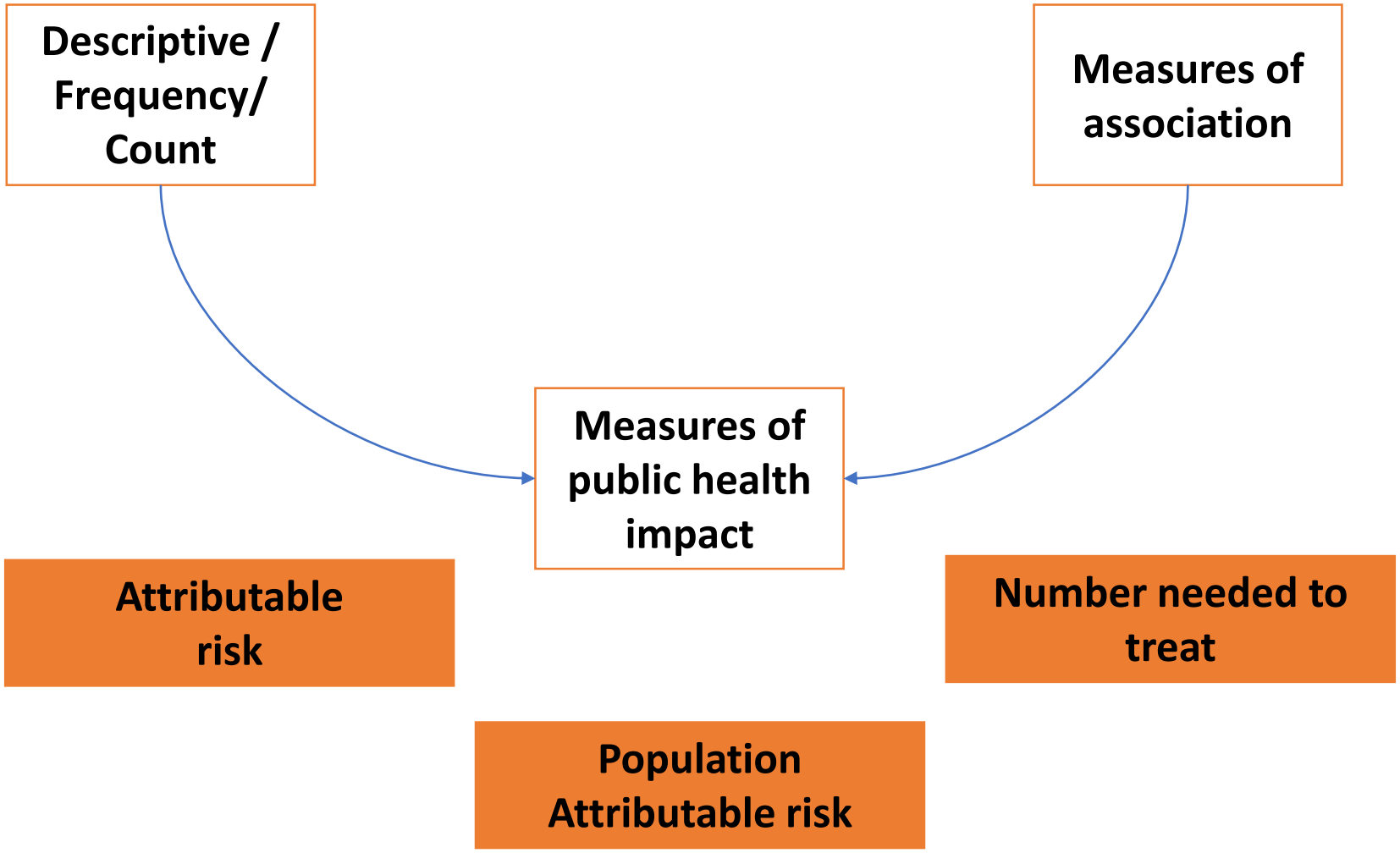
Types of epidemiological estimates / measures of risk



Public health impact



Attributable risk

In another study of smoking and lung cancer, the lung cancer mortality rate among nonsmokers was 0.07 per 1,000 persons per year. The lung cancer mortality rate among persons who smoked 1–14 cigarettes per day was 0.57 lung cancer deaths per 1,000 persons per year. Calculate the attributable proportion.

Calculate the risk ratio?

Calculate the attributable proportion?

Remember the attributable proportion is the risk difference / risk in the exposed group x 100

Attributable risk

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Calculate the risk ratio?

Calculate the attributable proportion?

Alternative formula

AR = (RR – 1)/ RR

Population Attributable risk

Population Attributable Risk (or Population Attributable Fraction) indicates the number (or proportion) of cases that would not occur in a population if the factor were eliminated

So for this metric we need one additional parameter?

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So for this metric we need one additional parameter?

Prevalence

$$\mathbf{PAR = P_e (RR_e\text{-}1) \ / \ [1 + P_e (RR_e\text{-}1)]}$$

Calculate the hypothetical case where

Prevalence is

0% - 0%

10% - 41%

50% - 78%

80% - 85%

100% - 88%

$$\mathbf{PAR = P_e (RR_e\text{-}1) \ / \ [1 + P_e (RR_e\text{-}1)]}$$

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Calculate the hypothetical PAF where

Prevalence is

0% -

10% -

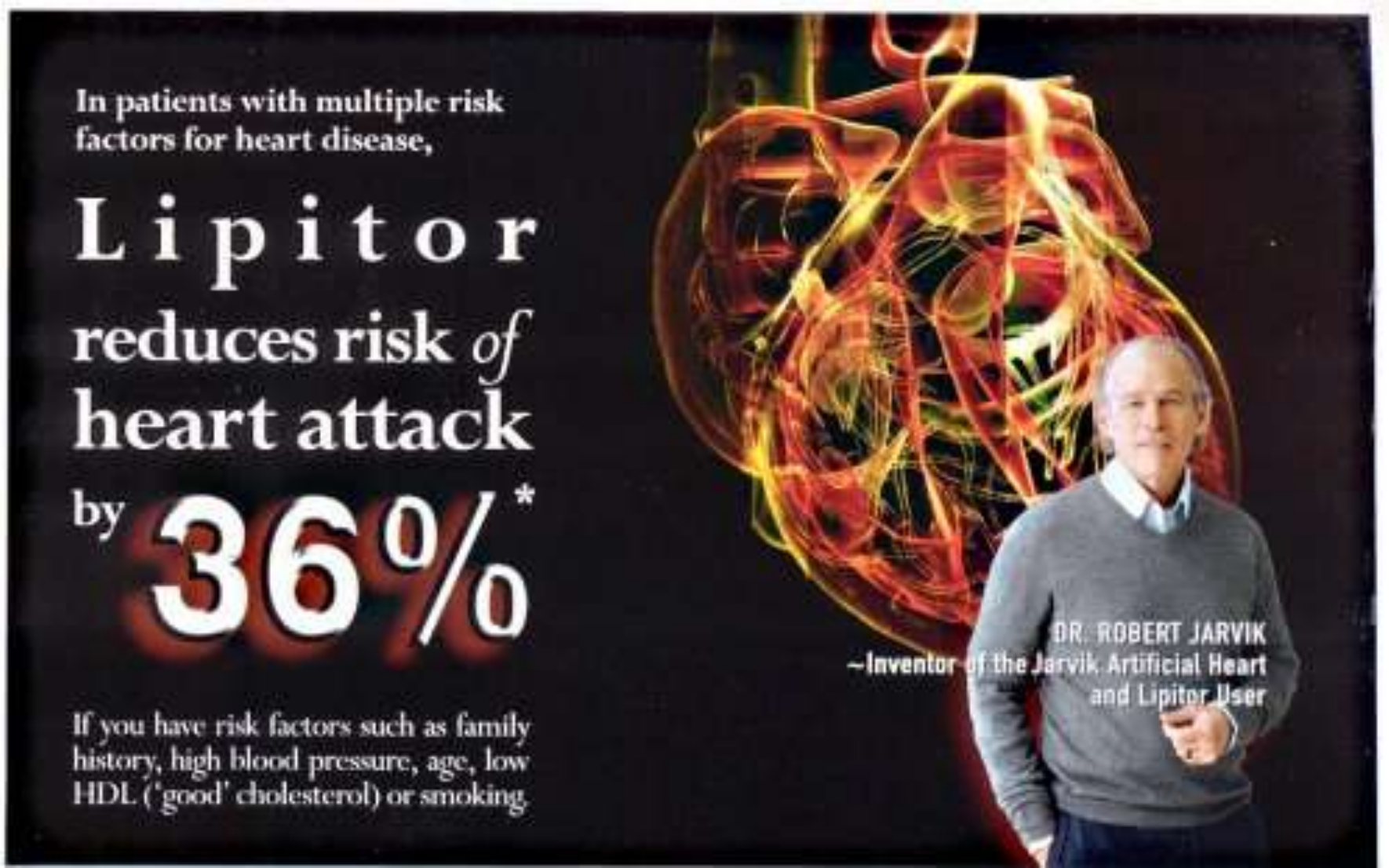
50% -

80% -

100% -

$$\mathbf{PAR = P_e (RR_e\text{-}1) \ / \ [1 + P_e (RR_e\text{-}1)]}$$

RRR, ARR and NNT



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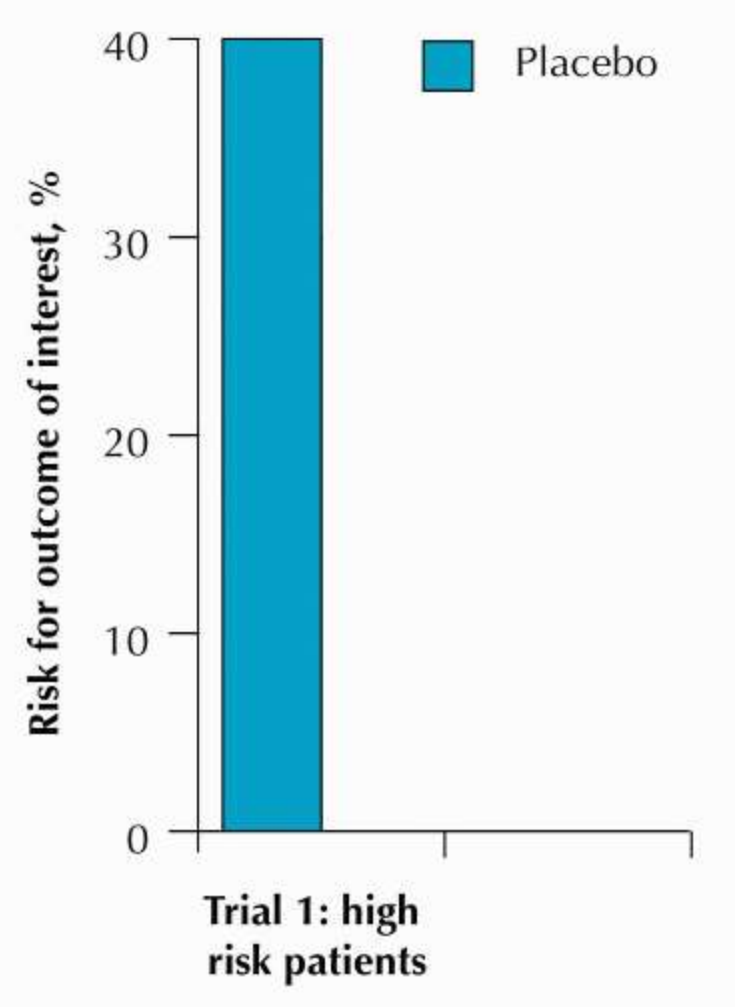
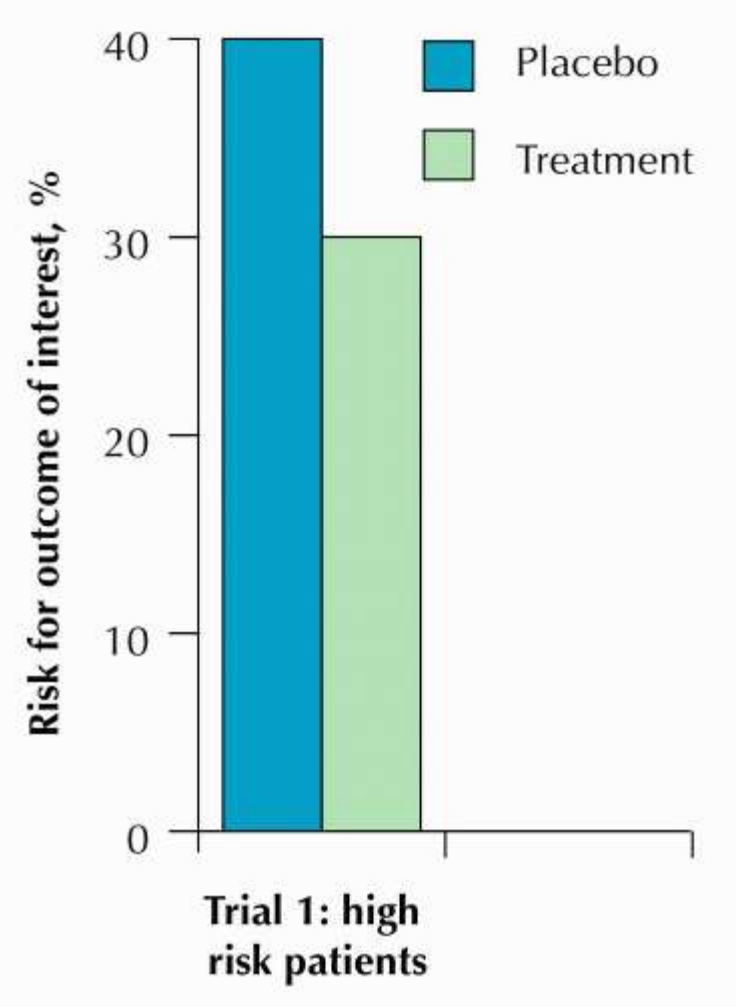


- New drug for acute myocardial infarction to reduce mortality
- First studied in a high risk population:
  - 40% mortality at 30 days among untreated
  - e.g., elderly, heart failure, anterior wall infarction

Ref: http://www.cche.net/usersguides/ebm_tips.asp

RRR, ARR and NNT



- New drug for acute myocardial infarction to reduce mortality
- First studied in a high risk population:
  - 40% mortality at 30 days among untreated
  - e.g., elderly, heart failure, anterior wall infarction
  - 30% mortality among treated
- How would you describe the effect of the new drug?

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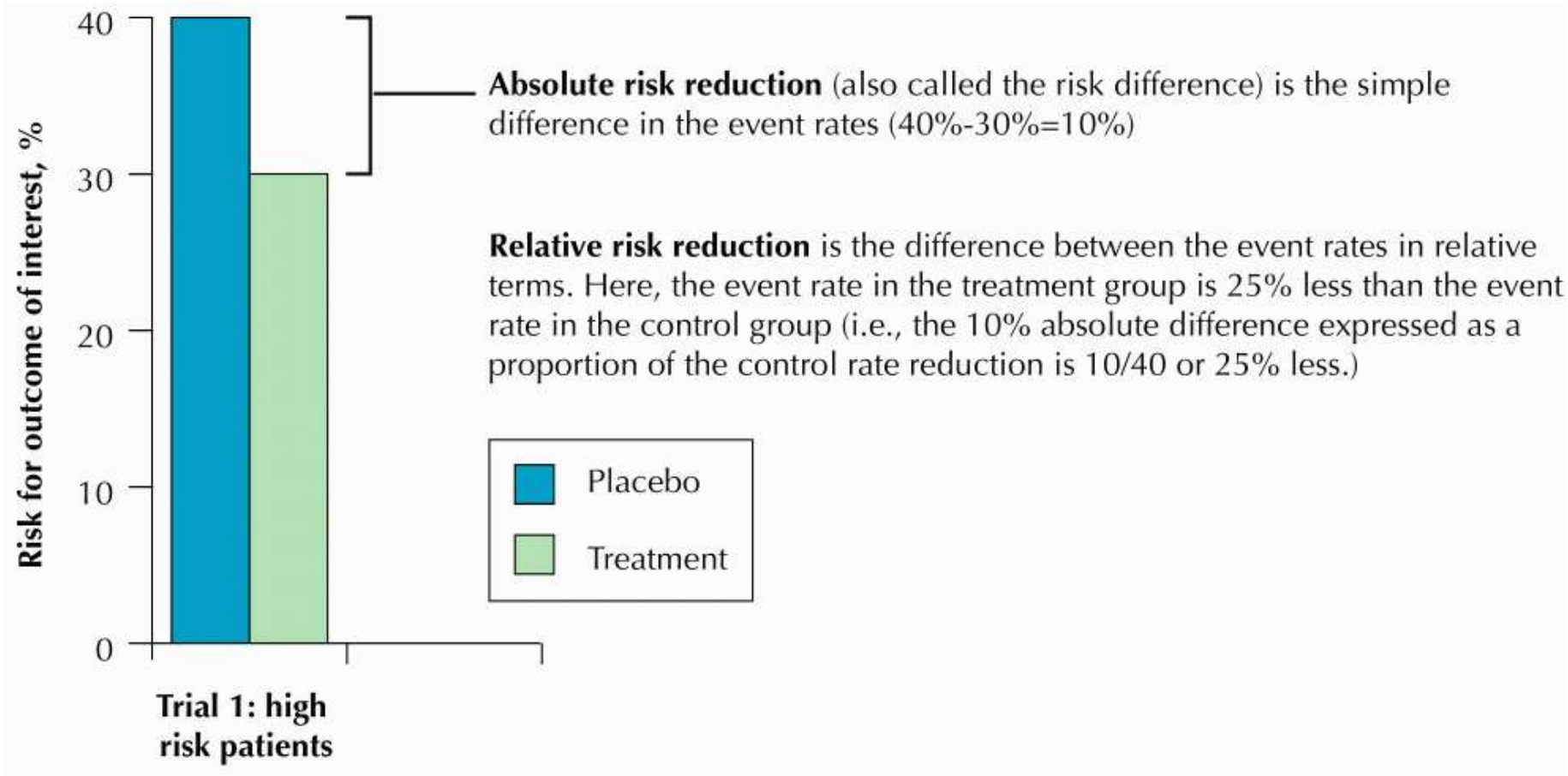
RRR, ARR and NNT



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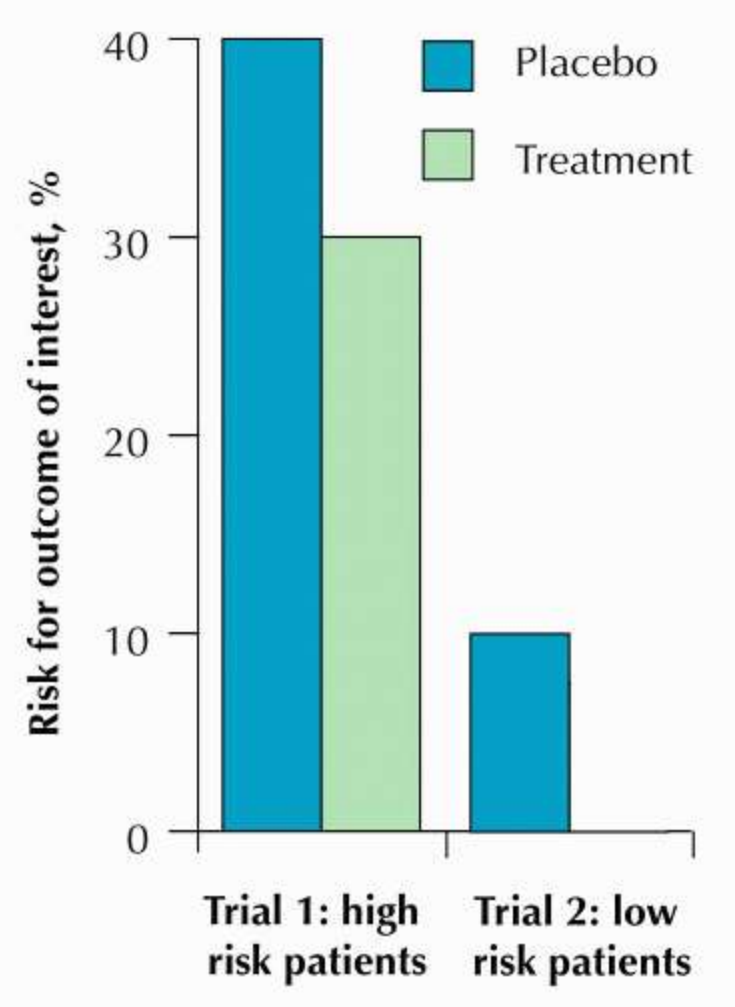

- New drug for acute myocardial infarction to reduce mortality
- Later studied in a lower risk population:
  - 10% mortality at 30 days among untreated
  - e.g., younger, uncomplicated inferior wall infarction

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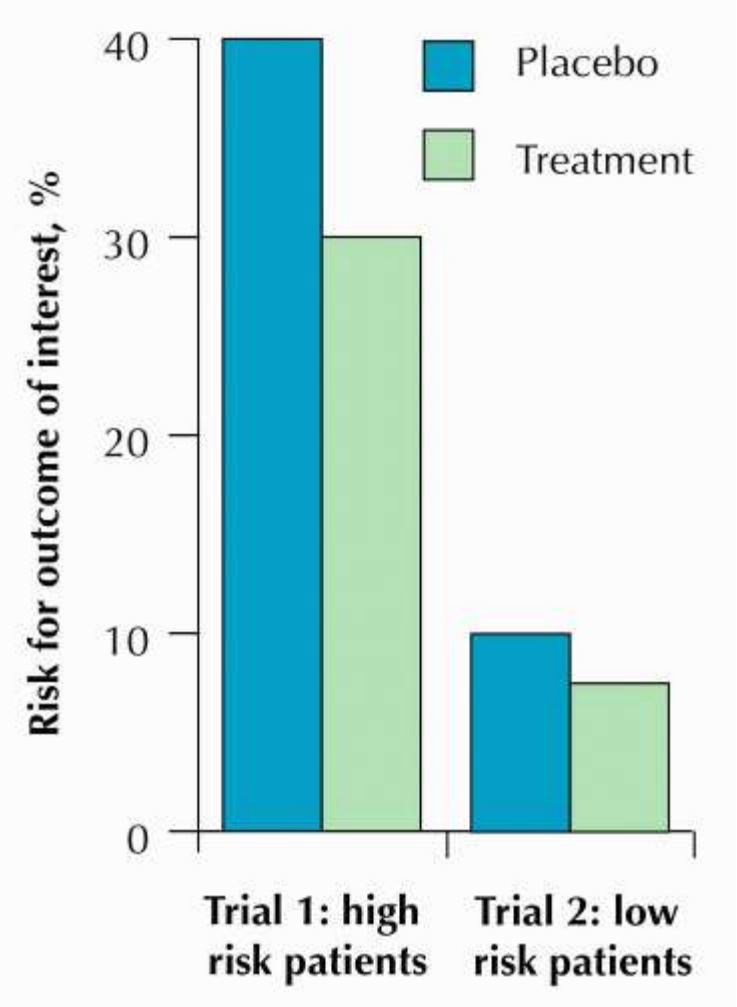
RRR, ARR and NNT



- New drug for acute myocardial infarction to reduce mortality
- Later studied in a lower risk population:
  - 10% mortality at 30 days among untreated
  - e.g., younger, uncomplicated inferior wall infarction
  - 7.5% mortality among treated
- How would you describe the effect of the new drug?

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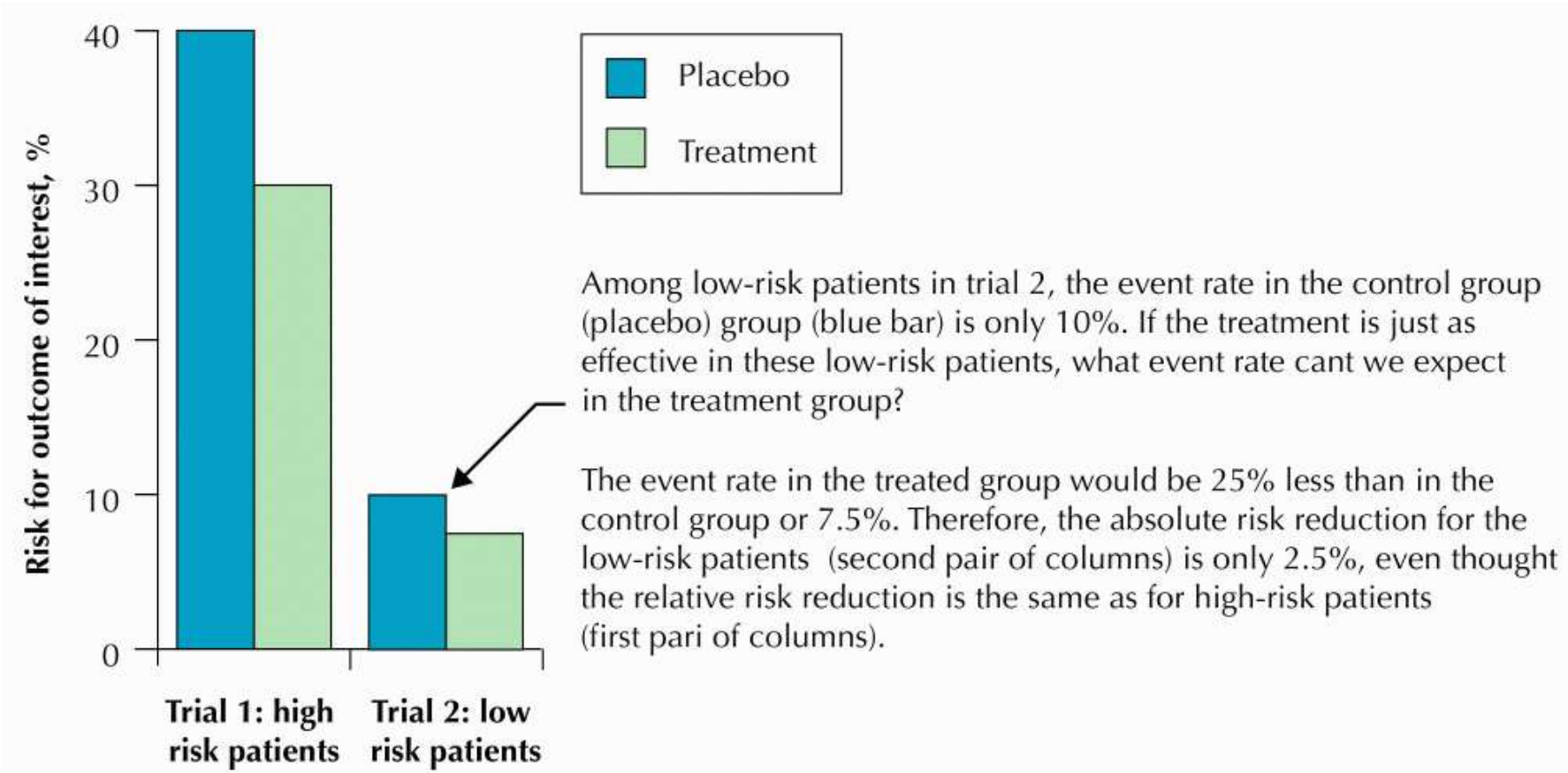
RRR, ARR and NNT



Among low-risk patients in trial 2, the event rate in the control group (placebo) group (blue bar) is only 10%. If the treatment is just as effective in these low-risk patients, what event rate cant we expect in the treatment group?

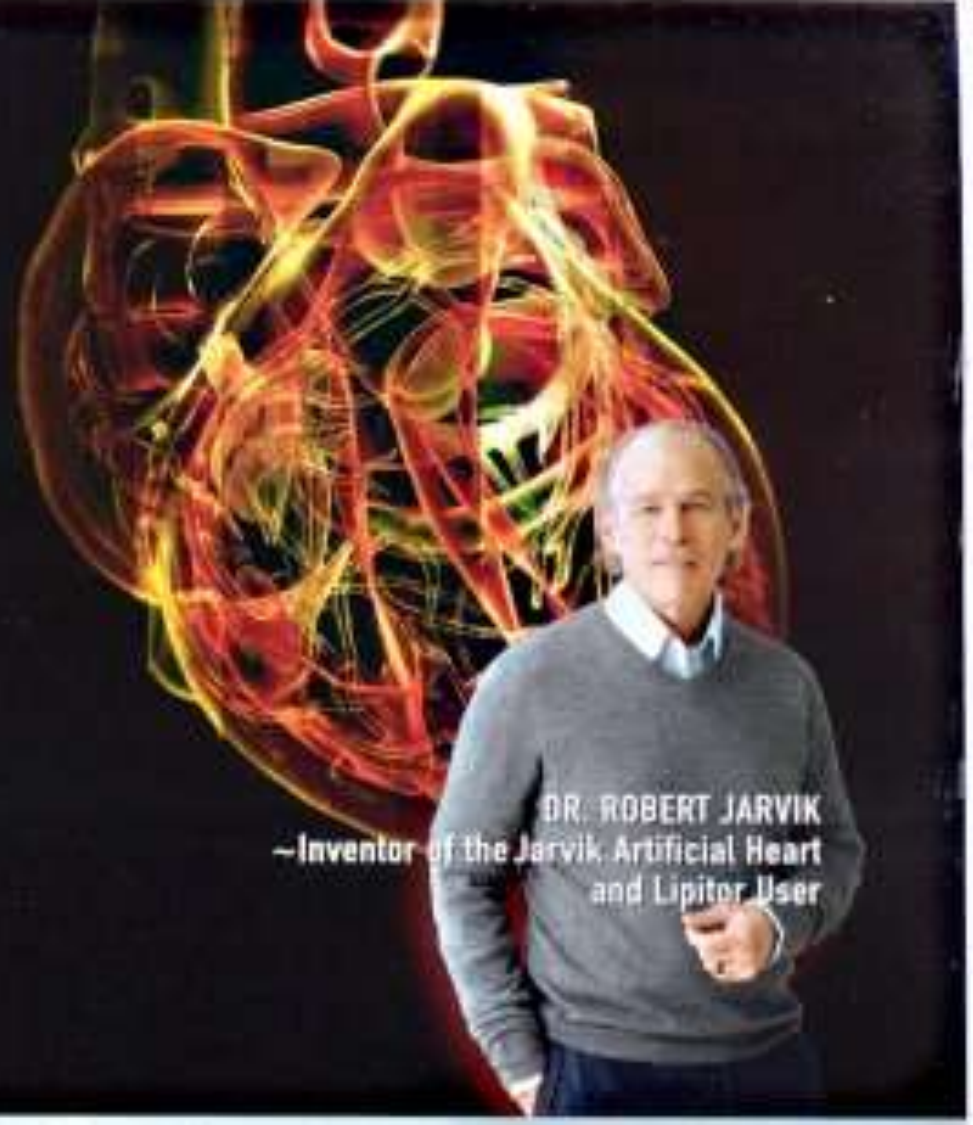
The event rate in the treated group would be 25% less than in the control group or 7.5%. Therefore, the absolute risk reduction for the low-risk patients (second pair of columns) is only 2.5%, even thought the relative risk reduction is the same as for high-risk patients (first pari of columns).

Ref: http://www.cche.net/usersguides/ebm_tips.asp

In patients with multiple risk factors for heart disease,

Lipitor reduces risk *of* heart attack by 36%*

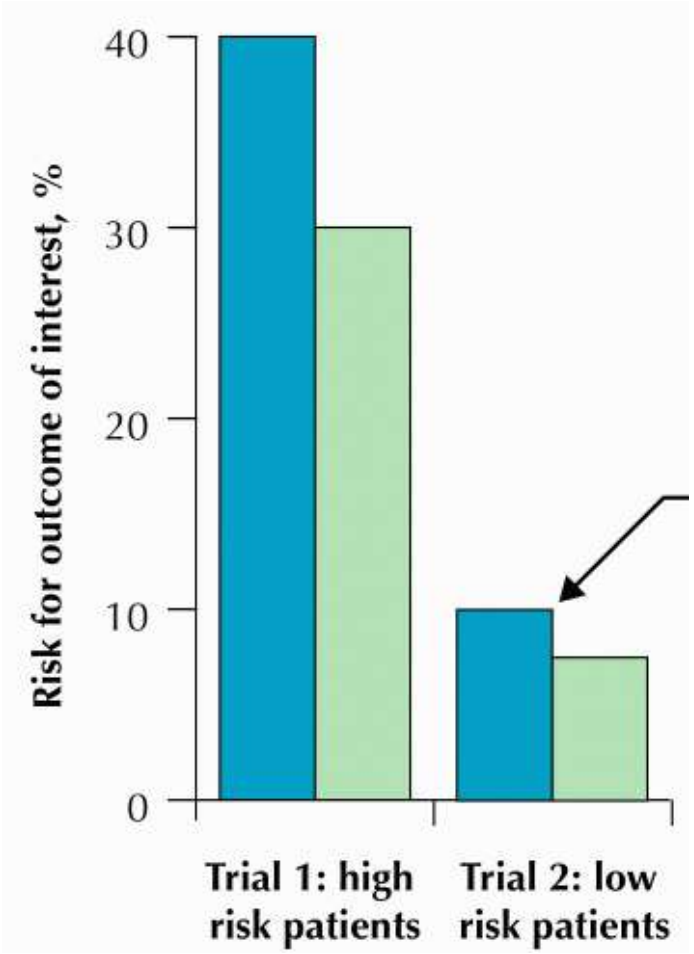
If you have risk factors such as family history, high blood pressure, age, low HDL ('good' cholesterol) or smoking.



*That means in a large clinical study, 3% of patients taking a sugar pill or placebo had a heart attack compared to 2% of patients taking Lipitor.

LIPITOR®
atorvastatin calcium
tablets

What is the NNT for trial 1 and trial 2



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Exercise

Global Burden of Atherosclerotic Cardiovascular Disease in People Living With HIV

Circulation. 2018;138:1100–1112

Disability adjusted life years

Let's Say There is a Village of 100 People in 2012…

One child suddenly dies from malaria at **age 3**, when ideal life expectancy is **86**. So that child **lost 83 years** of life.

86 LIFE EXPECTANCY
- 3 CURRENT AGE
83 YEARS OF LIFE LOST

One man contracts TB when he's 54. Over the course of his illness, lets assume he will **lose 3 years** of healthy life.

3 DISABLED
3 YEARS LIVED WITH DISABILITY

One woman suddenly **dies** in childbirth from postpartum hemorrhage at **age 26**, when ideal life expectancy is **86**. She's **lost 60 years** of life.

86 LIFE EXPECTANCY
-26 CURRENT AGE
60 YEARS OF LIFE LOST

The remaining 97 people in the village are all healthy and do not get sick or die in 2012.

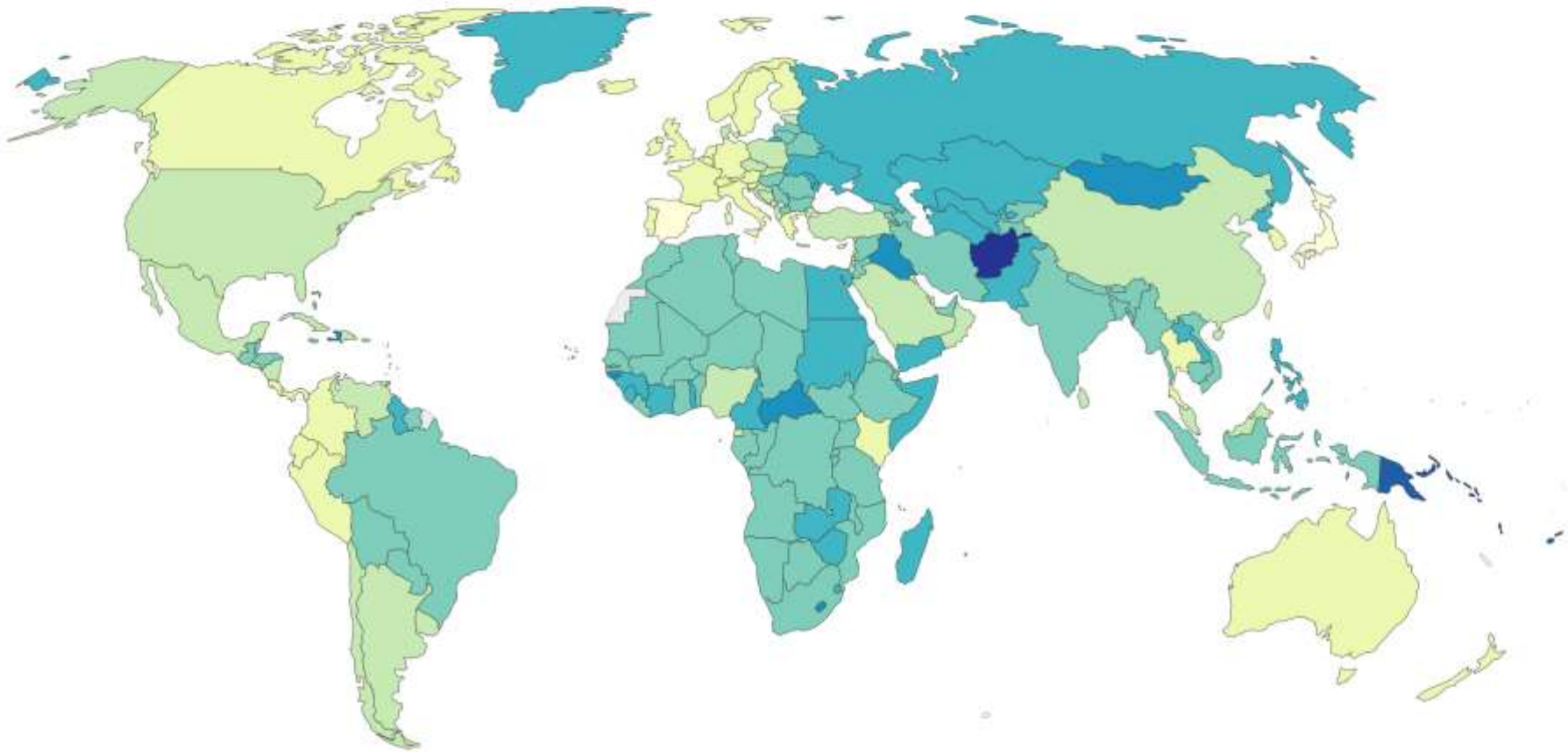
So, to estimate the **DALYs** lost in this village in 2012

83 + 3 + 60 = 146 DALYs

Burden of disease rates from non-communicable diseases (NCDs), 2016

Age-standardized DALY (Disability-Adjusted Life Year) rates per 100,000 individuals from non-communicable diseases (NCDs). DALYs are used to measure total burden of disease - both from years of life lost and years lived with a disability. One DALY equals one lost year of healthy life.

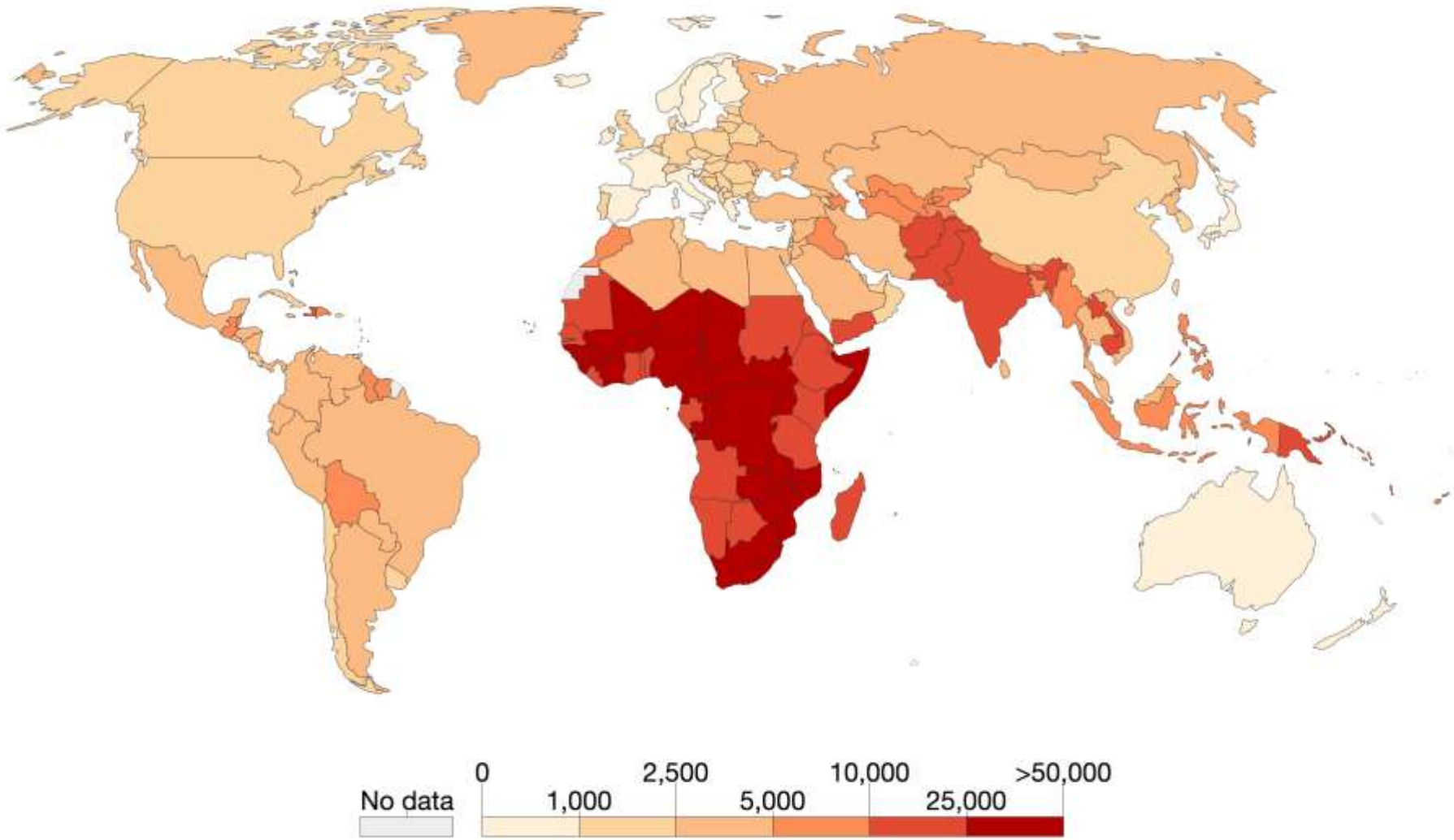
Our World in Data



Source: IHME, Global Burden of Disease

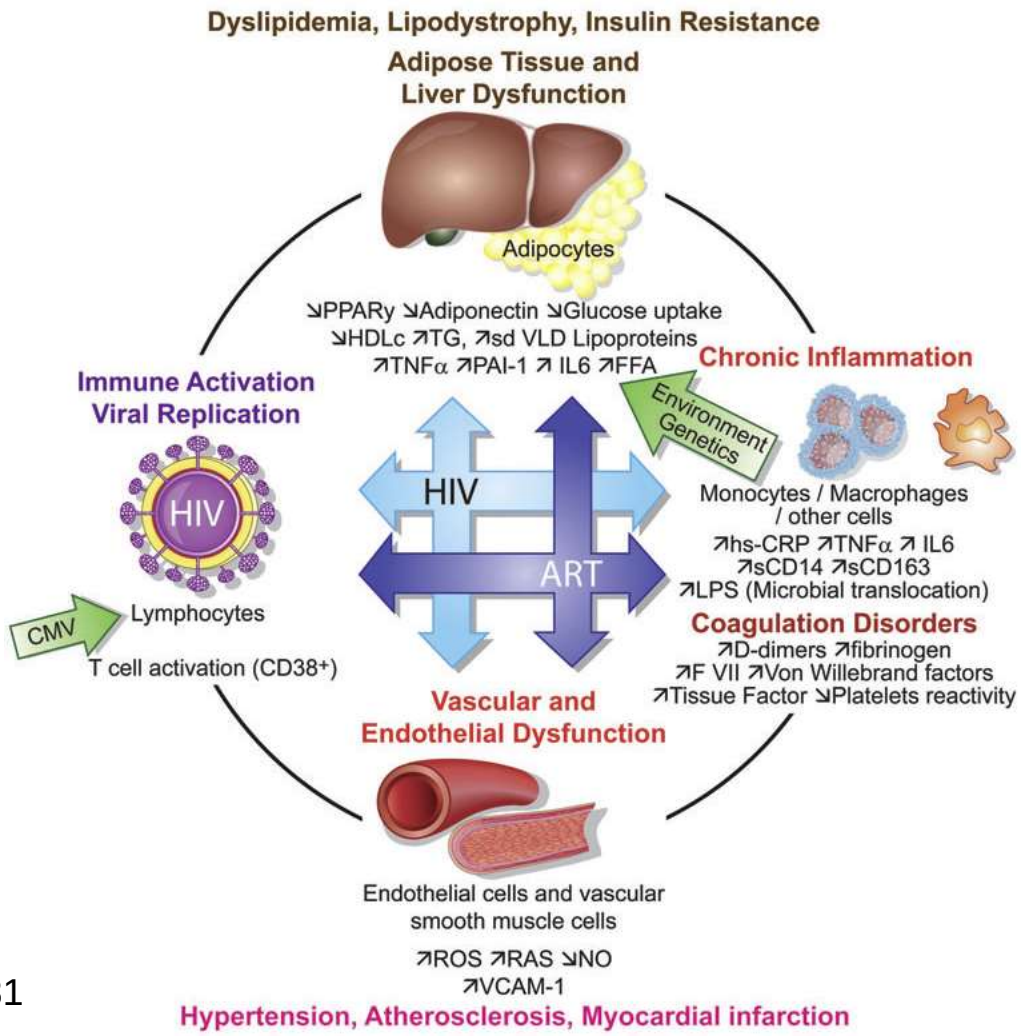
Burden of disease rates from communicable, neonatal, maternal & nutritional diseases, 2016

Age-standardized DALY (Disability-Adjusted Life Year) rates per 100,000 individuals from non-communicable diseases (NCDs). DALYs are used to measure total burden of disease - both from years of life lost and years lived with a disability. One DALY equals one lost year of healthy life.



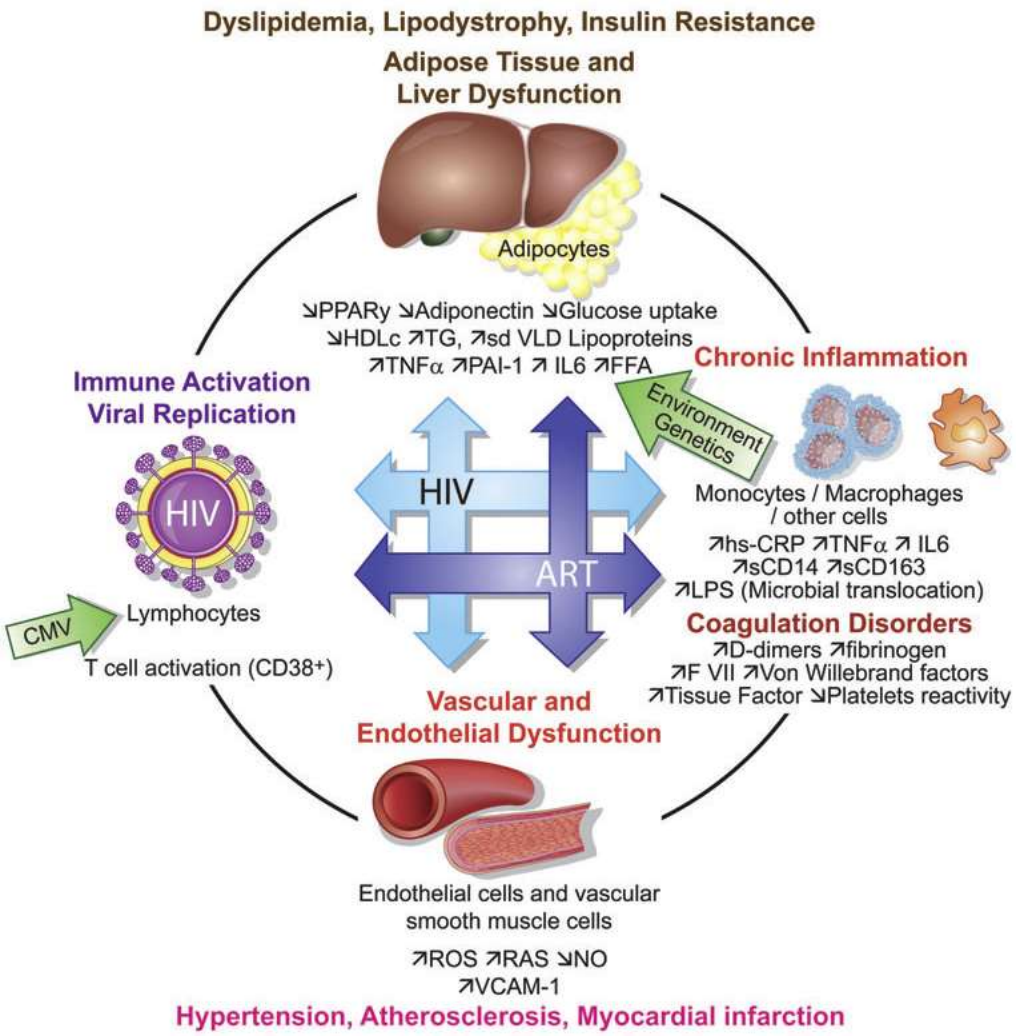
Source: IHME, Global Burden of Disease

Pathophysiology of CVD in HIV infections



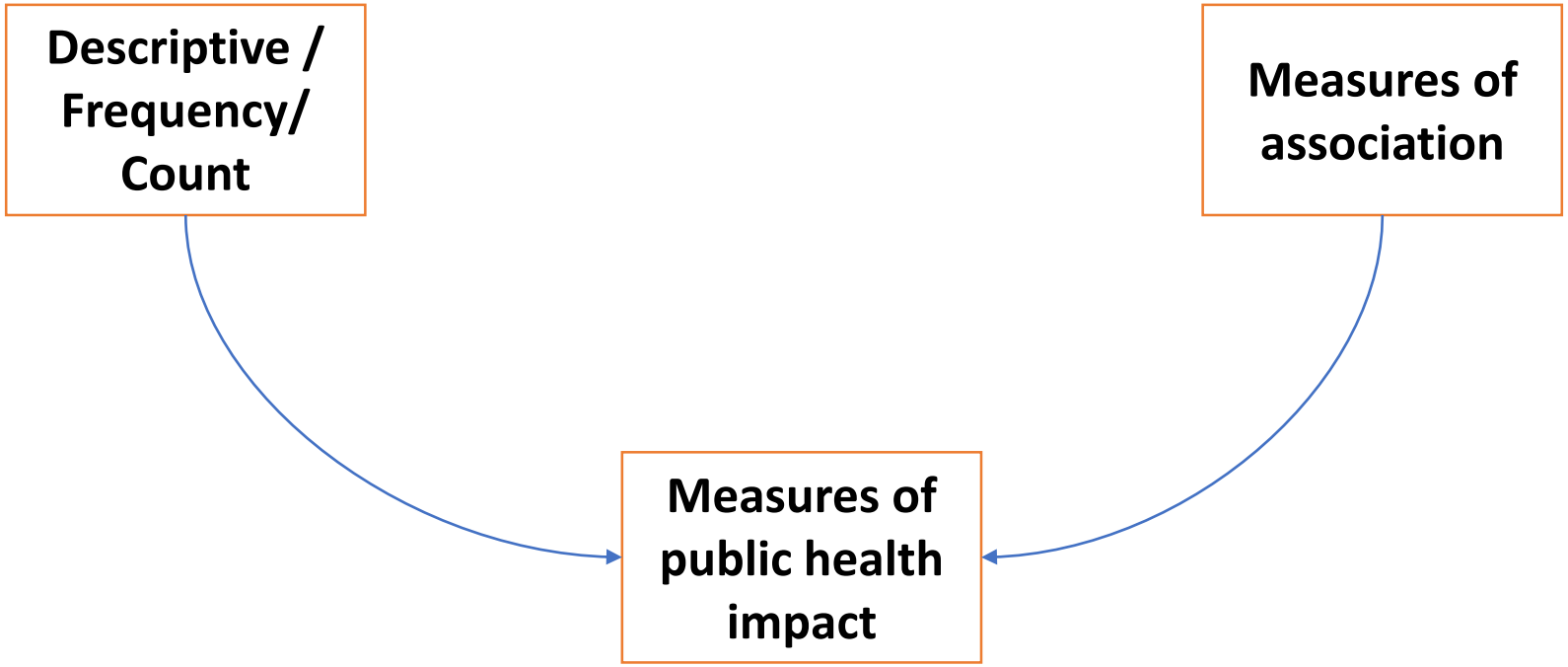
European Heart Journal (2014) 35, 1373–1381

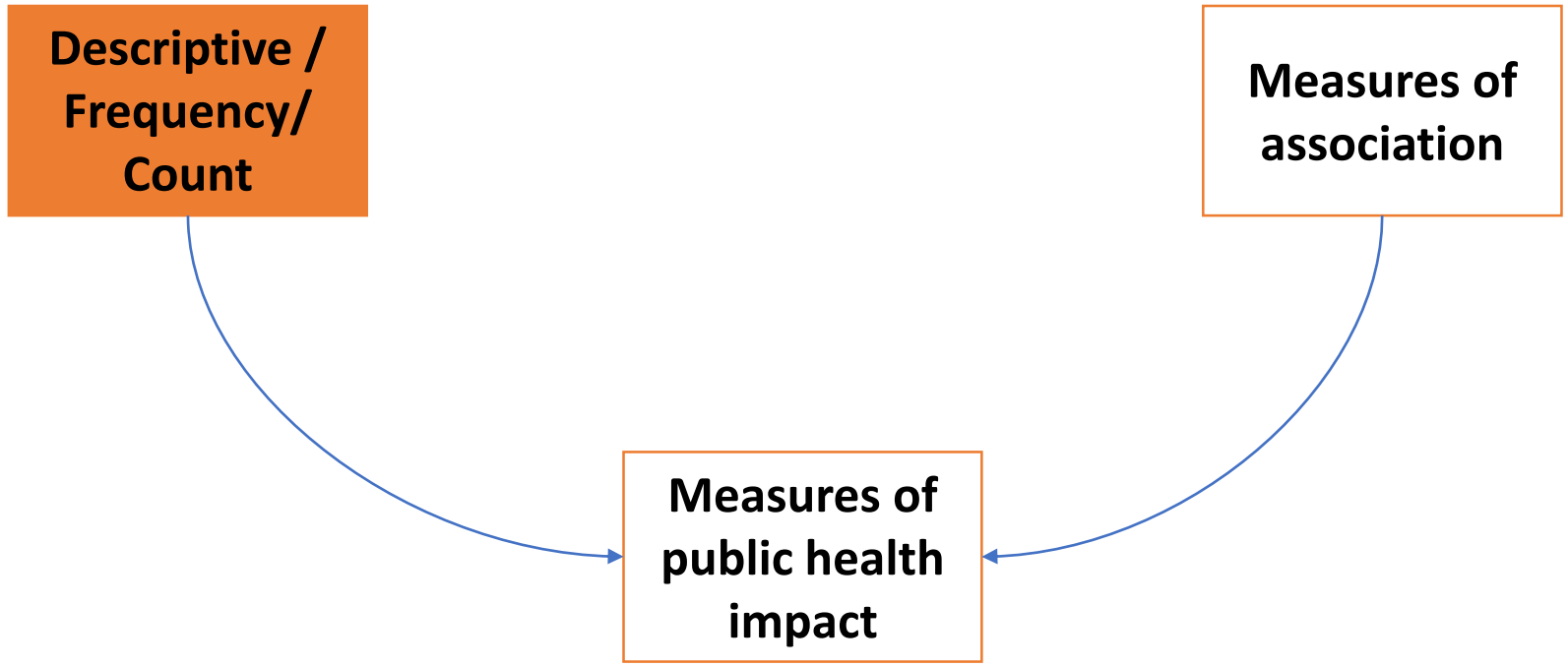
Draw a causal diagram – HIV and CVD

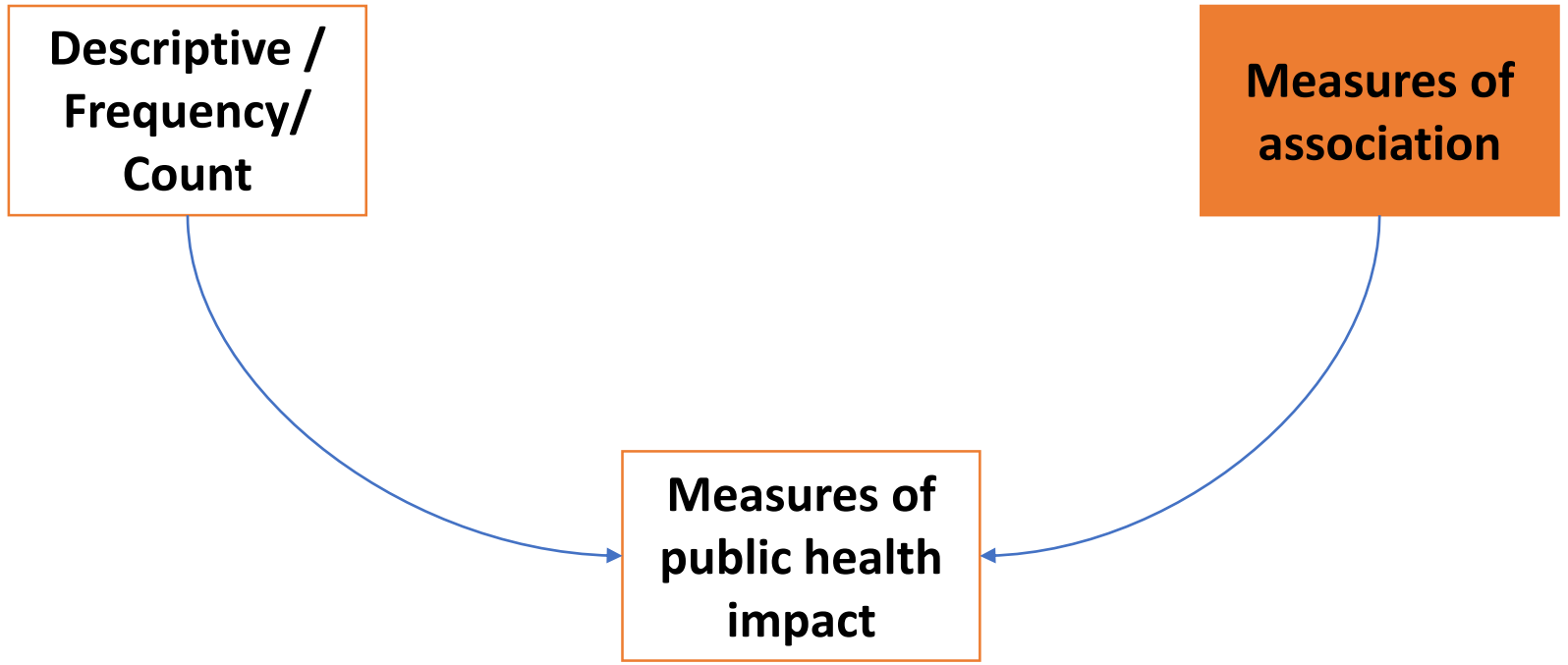


How can we estimate burden?

Types of epidemiological estimates / measures of risk




Descriptive / Frequency/ Count
Measures of association
Measures of public health impact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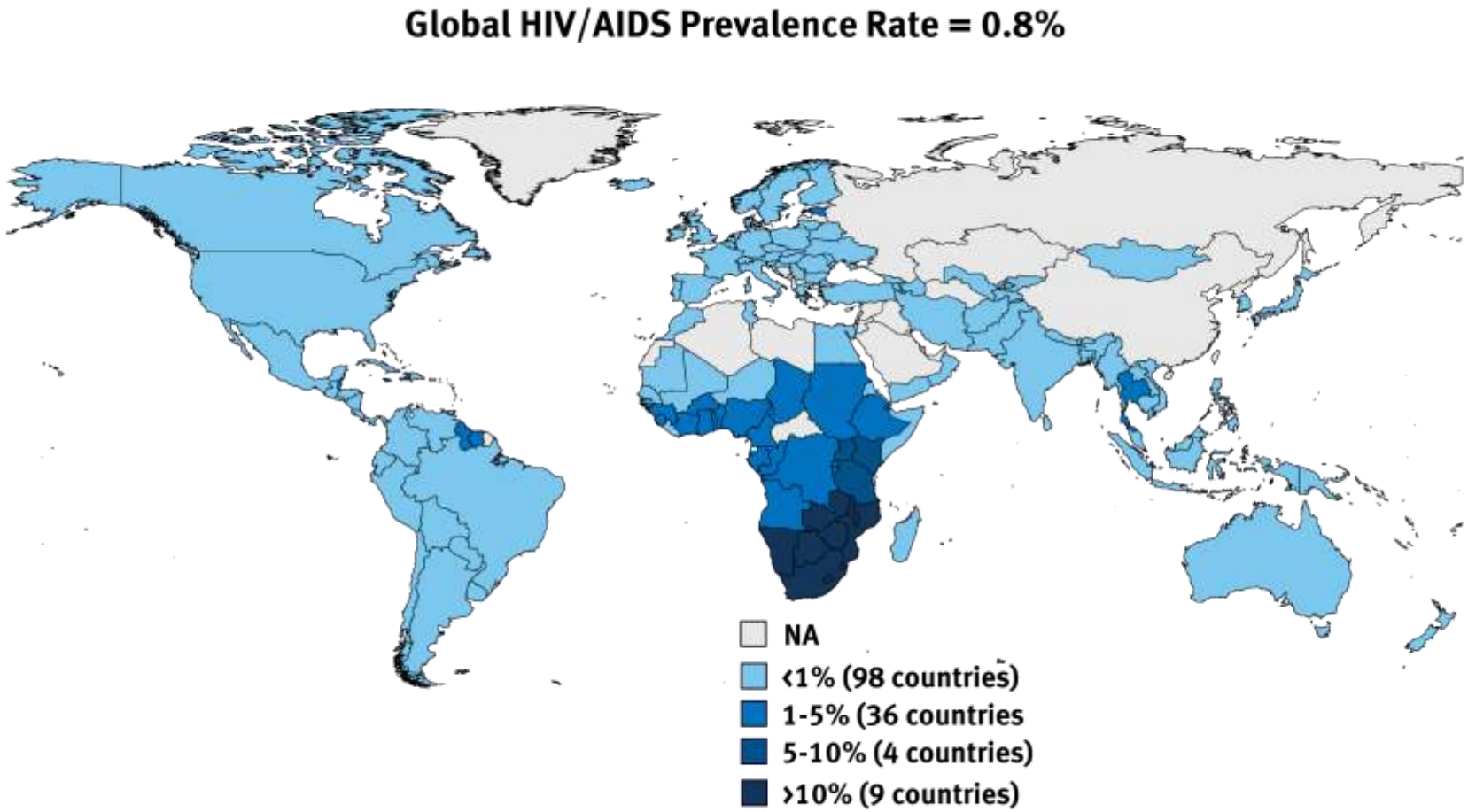
Adult HIV Prevalence Rate, 2012



NOTES: Data are estimates. Prevalence rates include adults ages 15-49. The estimate for Sudan represents data for South Sudan. An estimate was not provided for Sudan.
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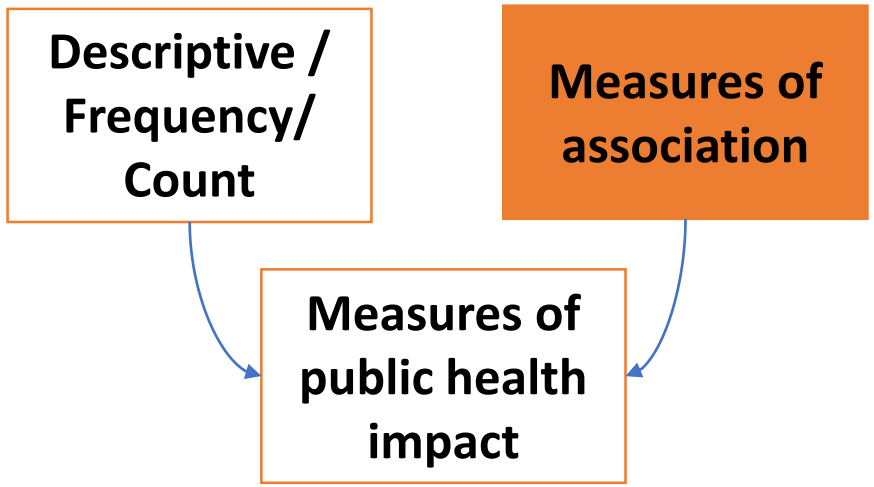
THE HENRY J. KAISER FAMILY FOUNDATION


Descriptive / Frequency/ Count
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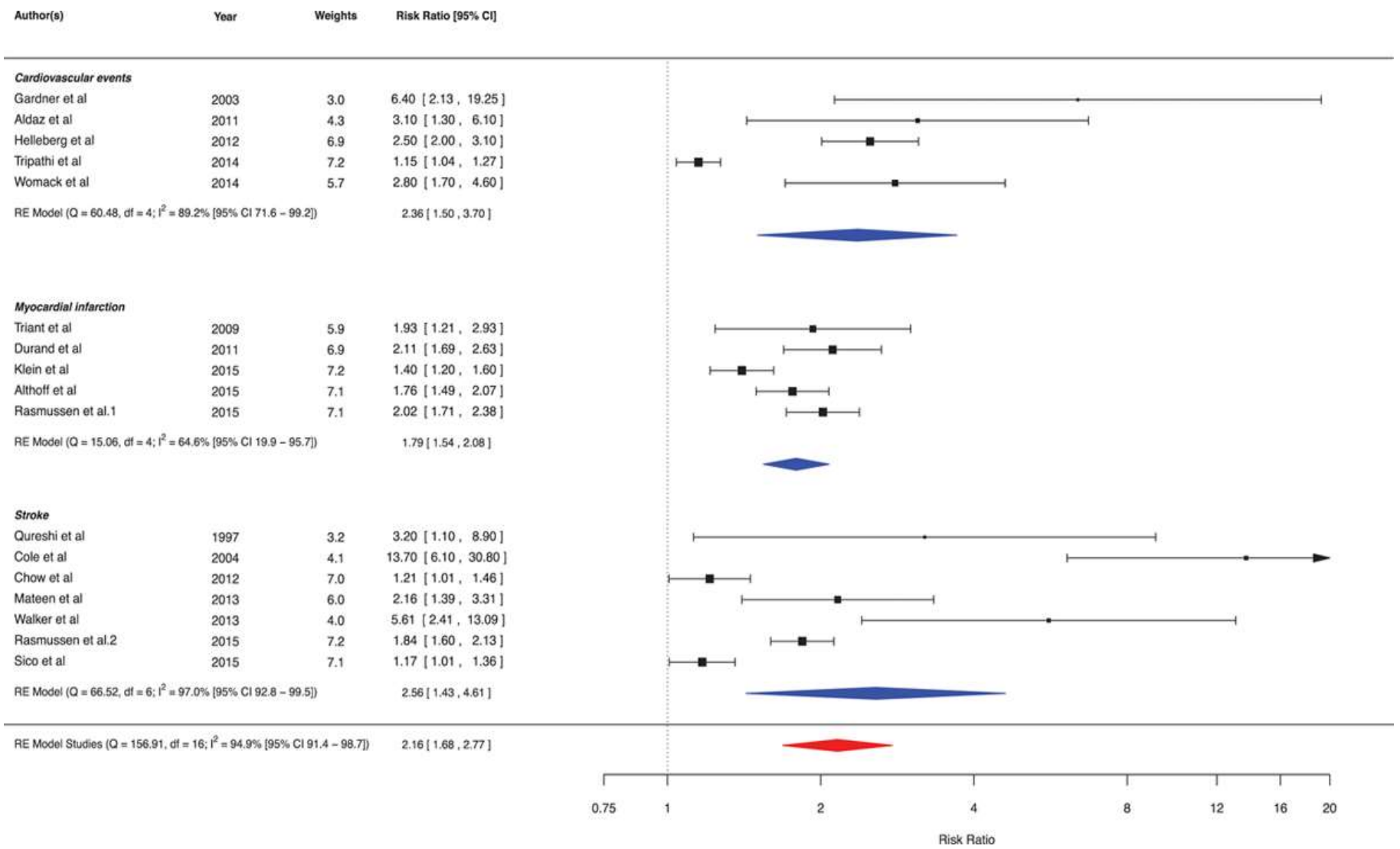
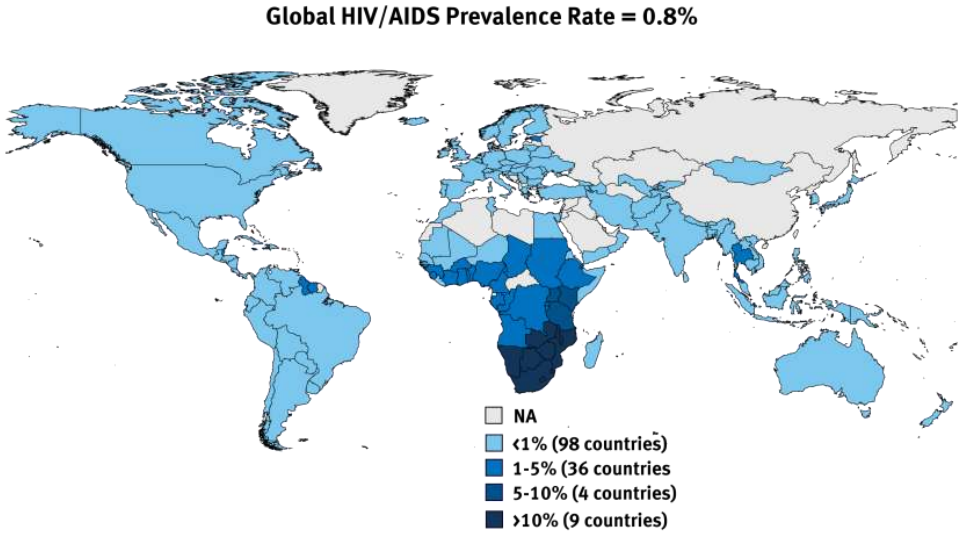
Systematic review of HIV associated CVD



RR: 2.16

Global Burden of Atherosclerotic Cardiovascular Disease in People Living With HIV, Volume: 138, Issue: 11, Pages: 1100-1112, DOI: (10.1161/CIRCULATIONAHA.117.033369)

Adult HIV Prevalence Rate, 2012



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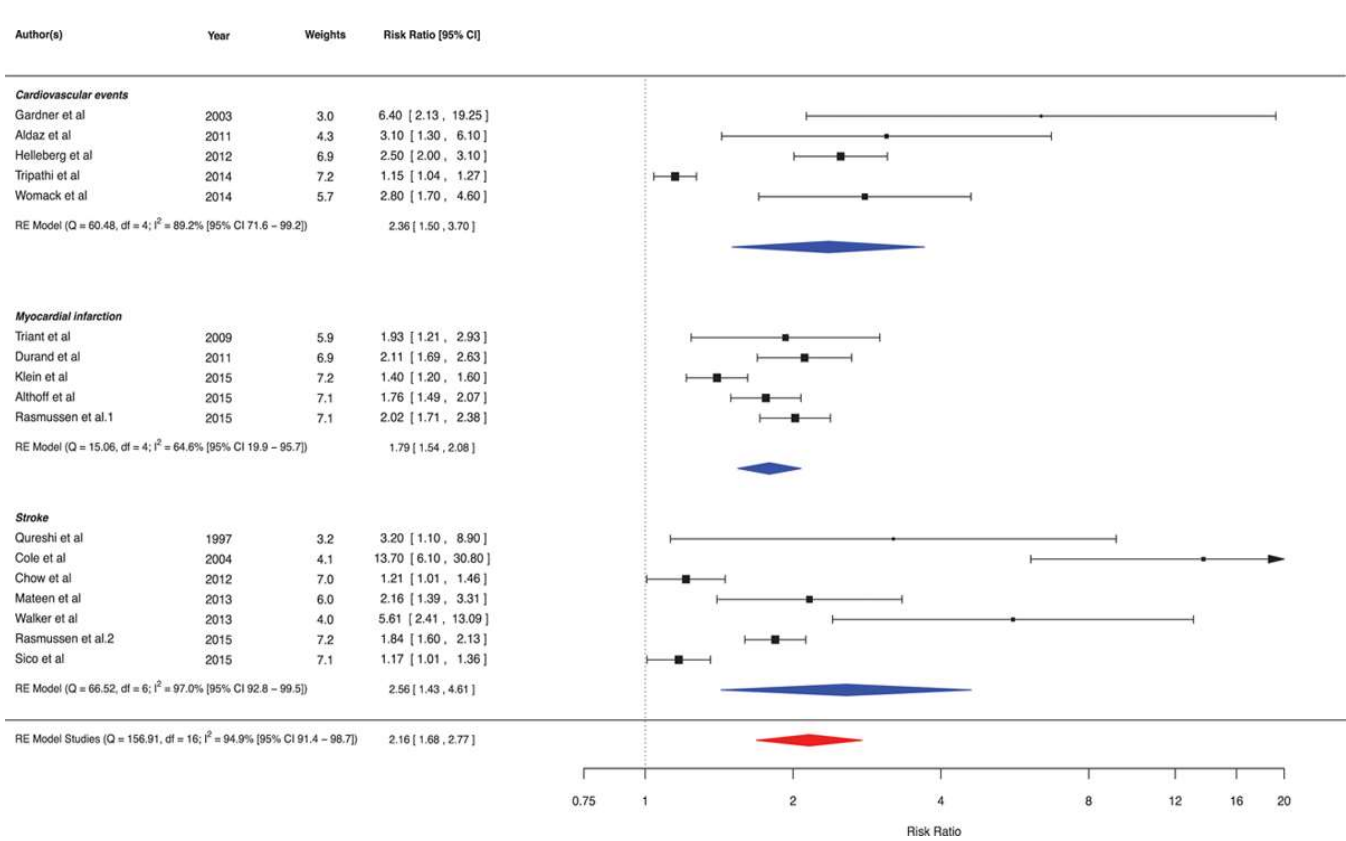
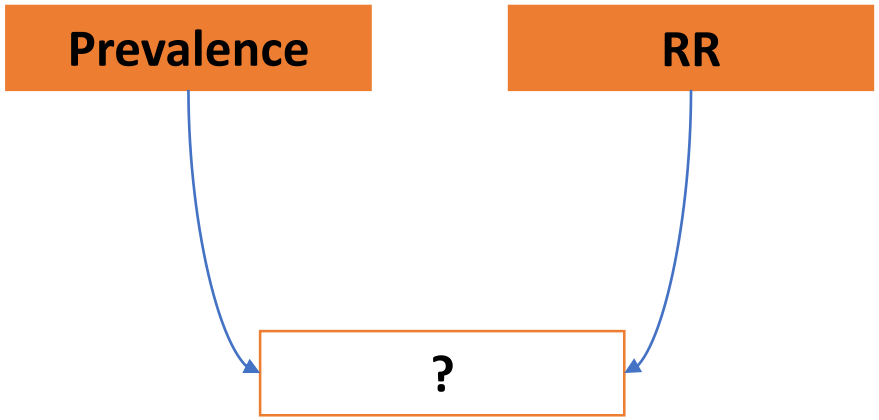
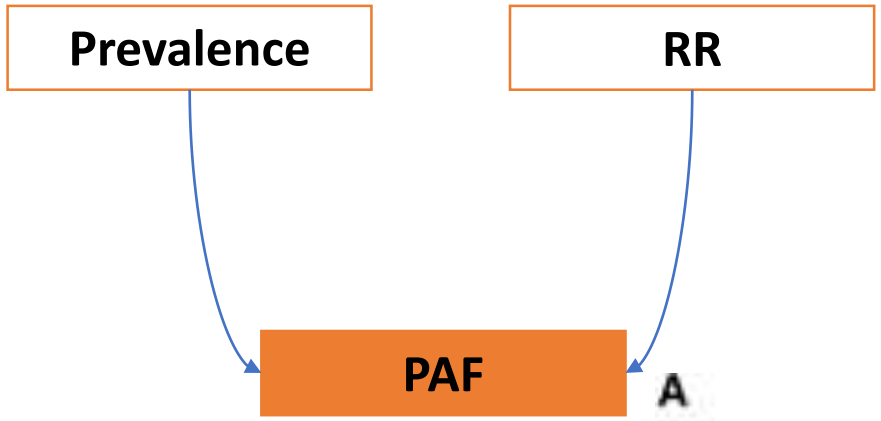
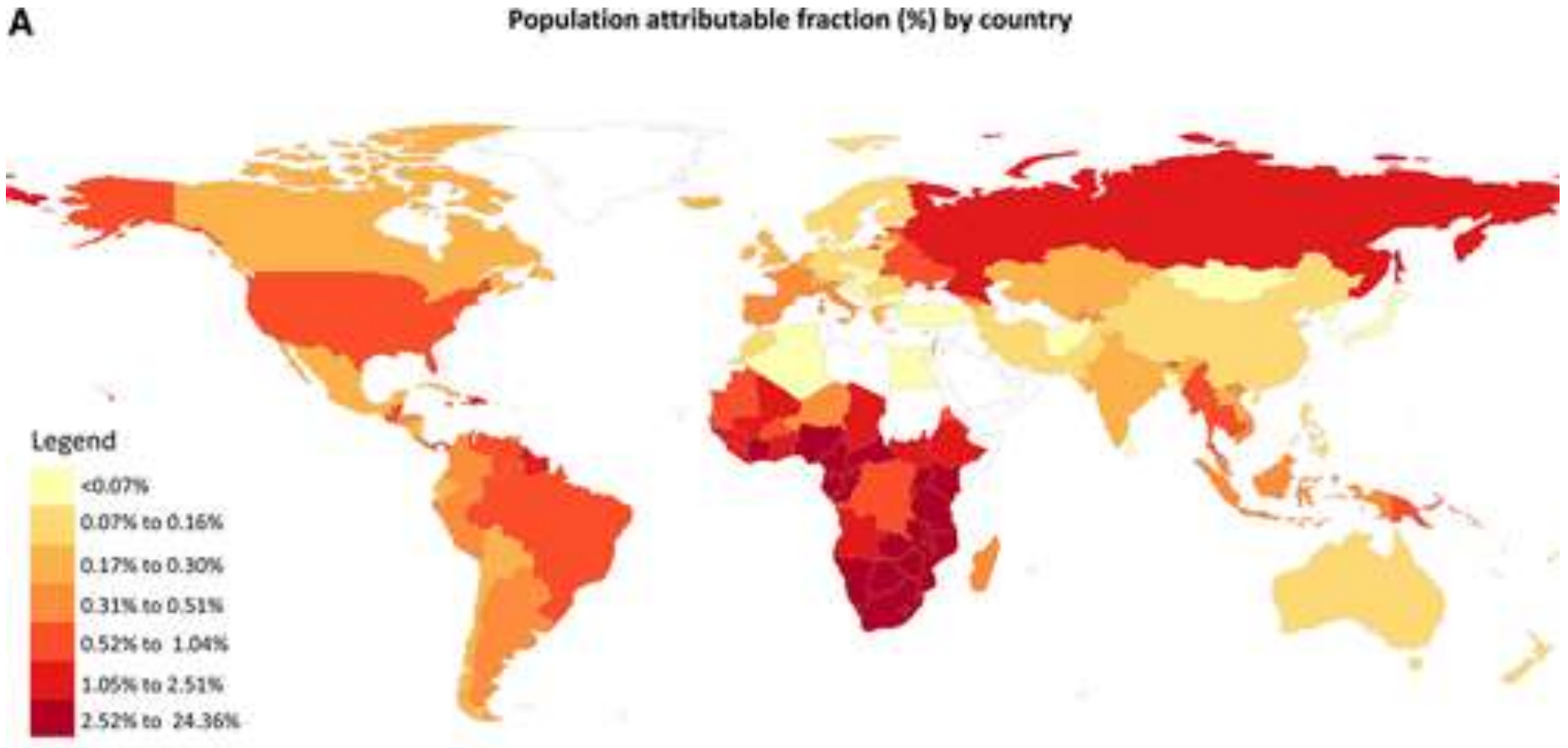
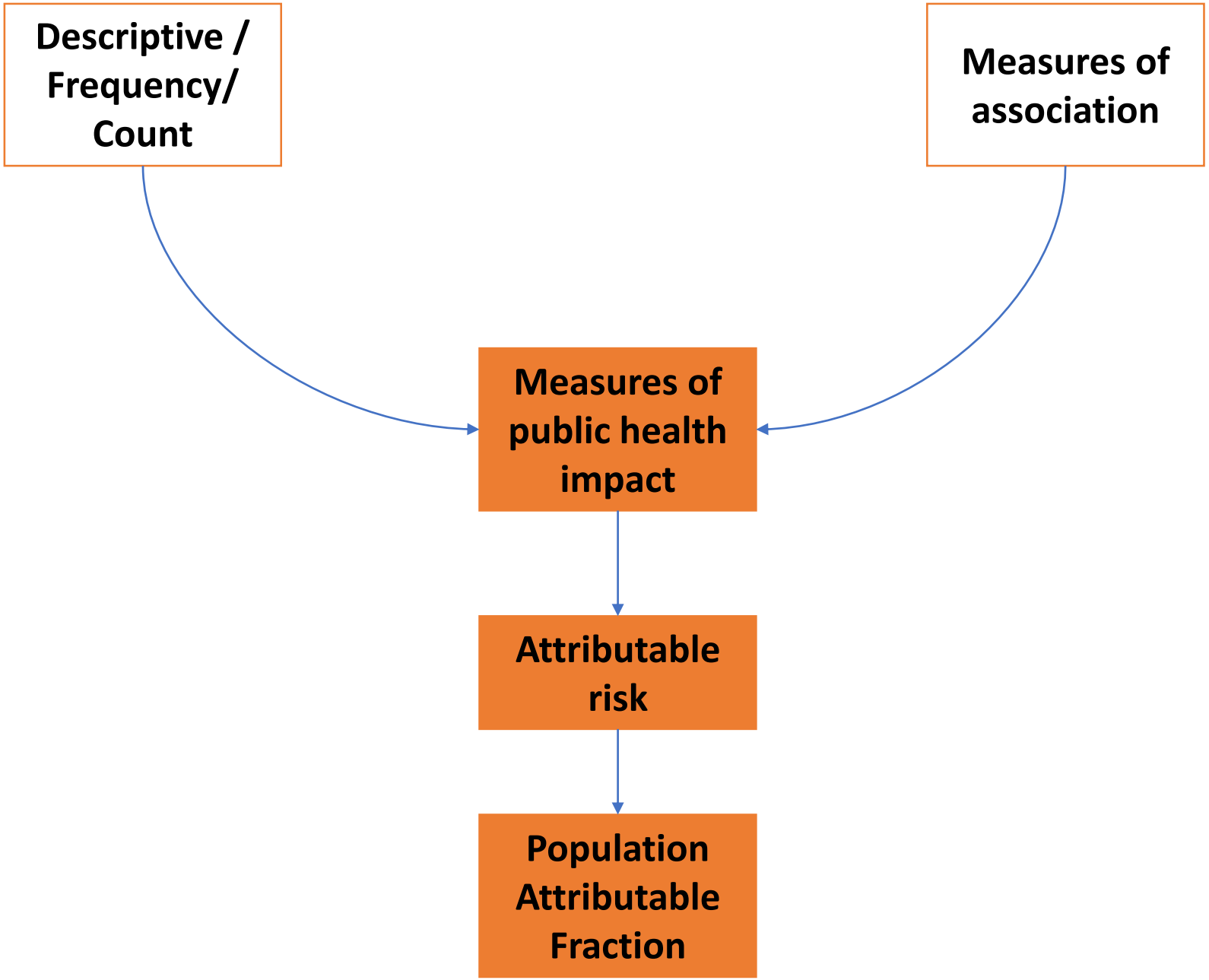





Prevalence
RR
PAF


A
Population attributable fraction (%) by country
Legend
<0.07%
0.07% to 0.16%
0.17% to 0.30%
0.31% to 0.51%
0.52% to 1.04%
1.05% to 2.51%
2.52% to 24.36%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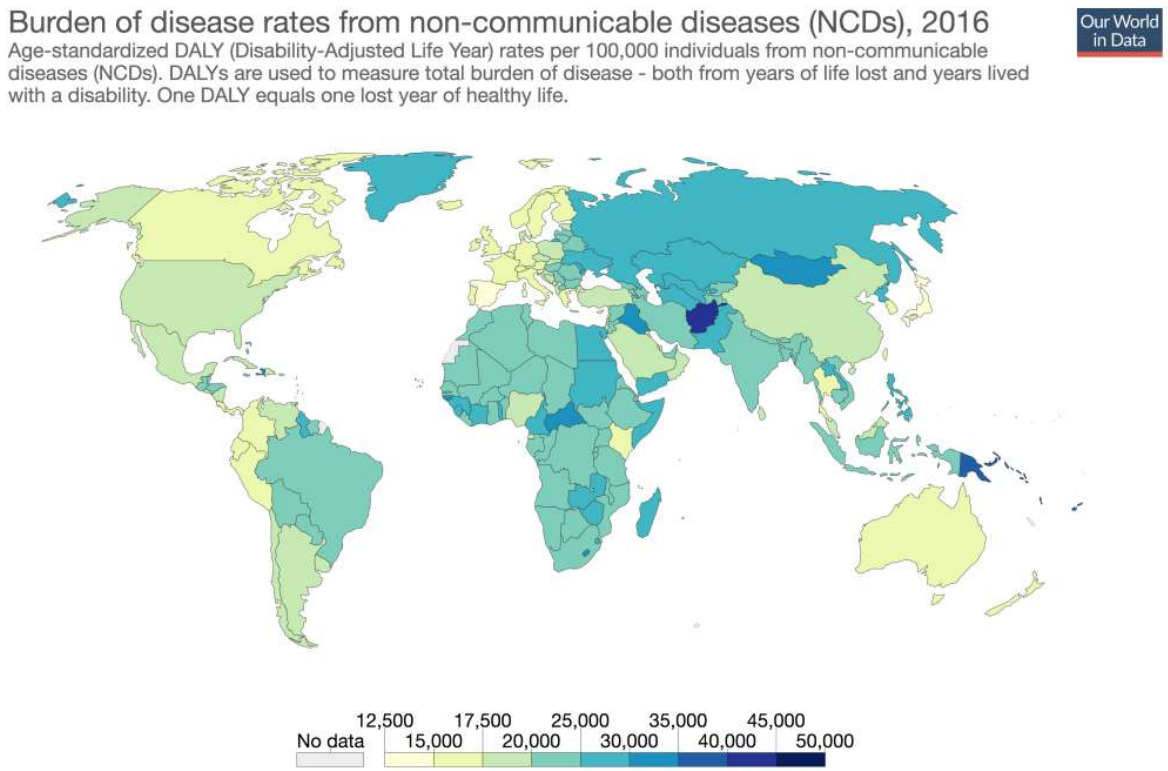
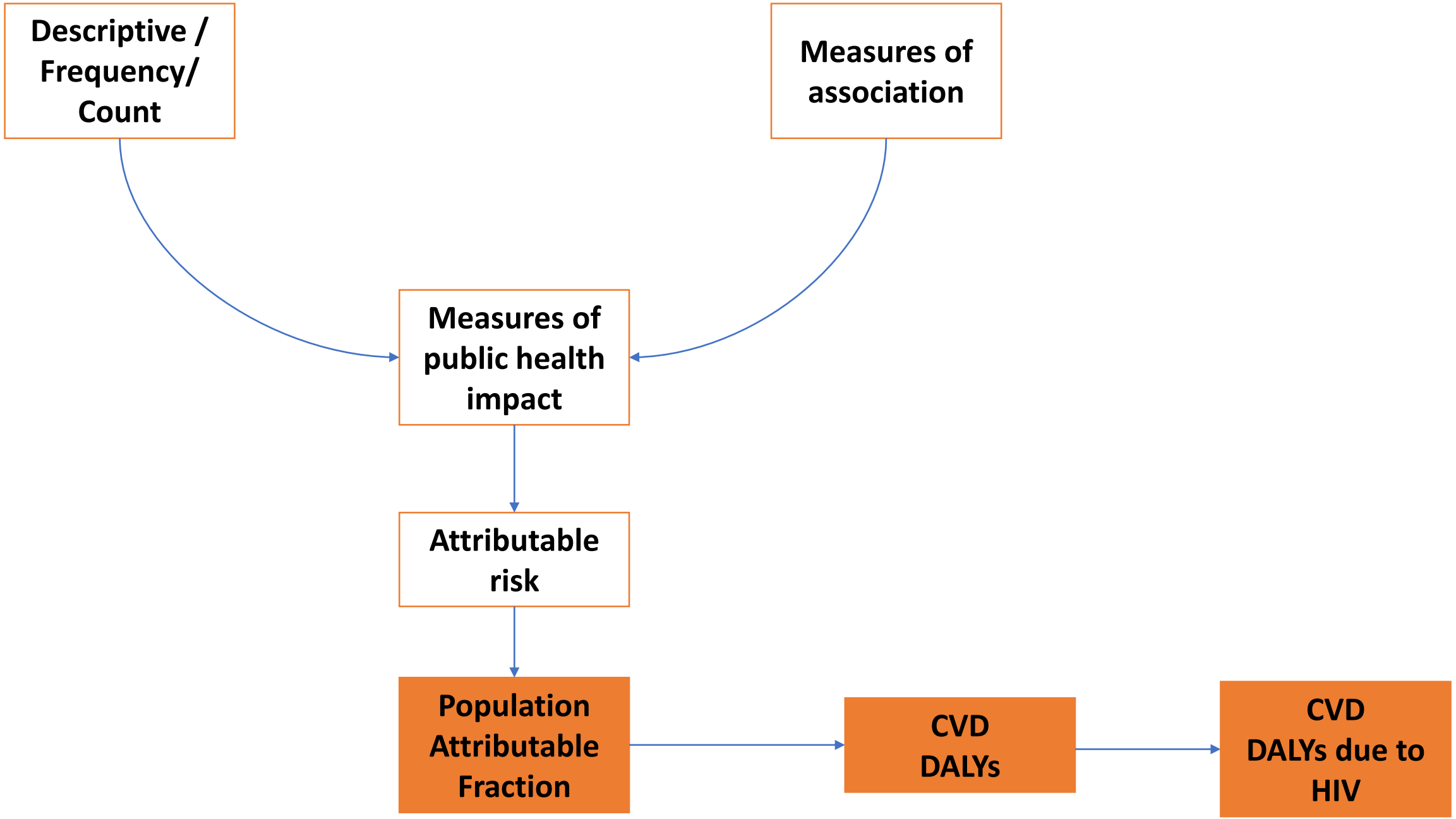
Attributable risk

Population Attributable Fraction

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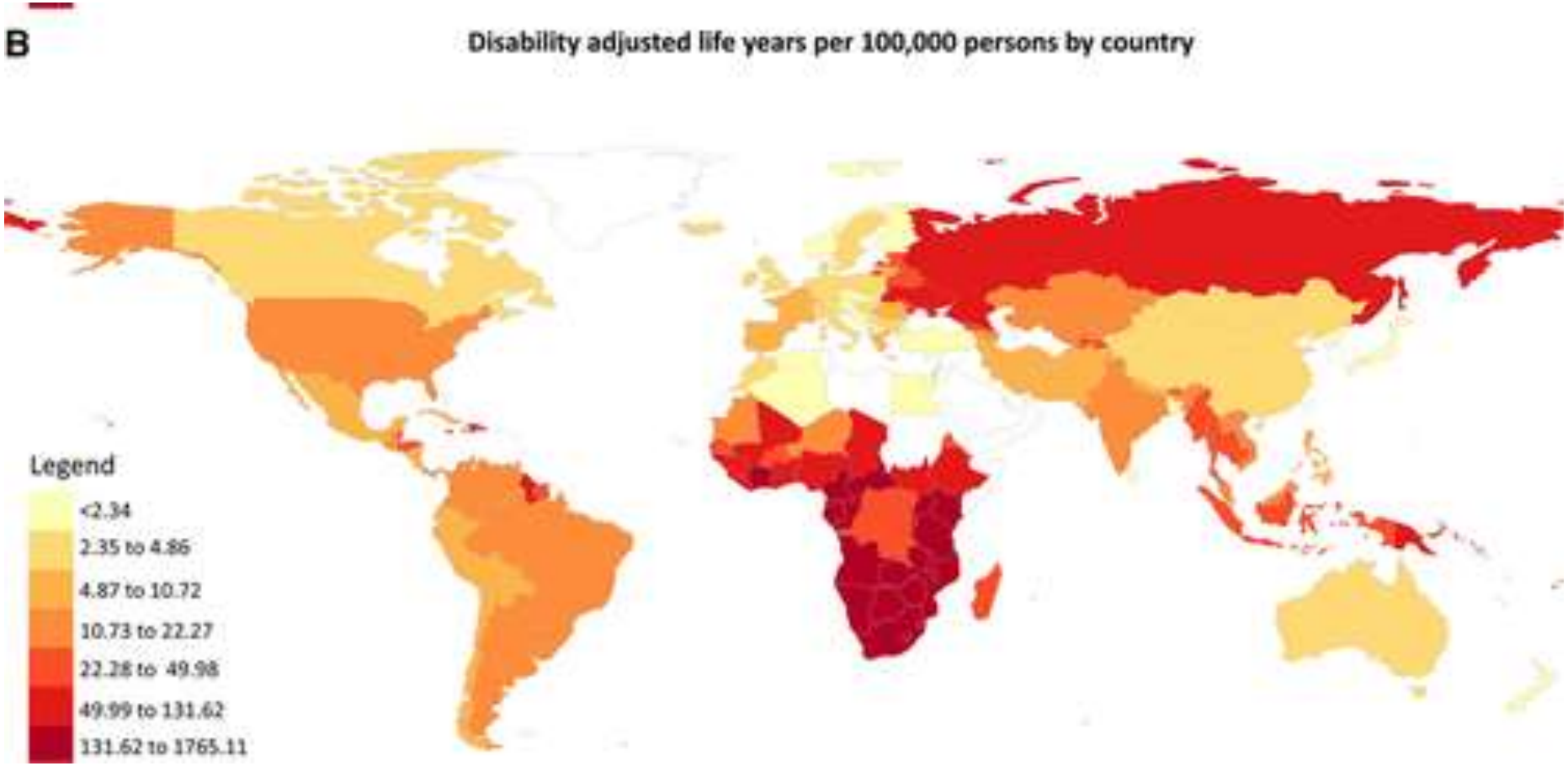
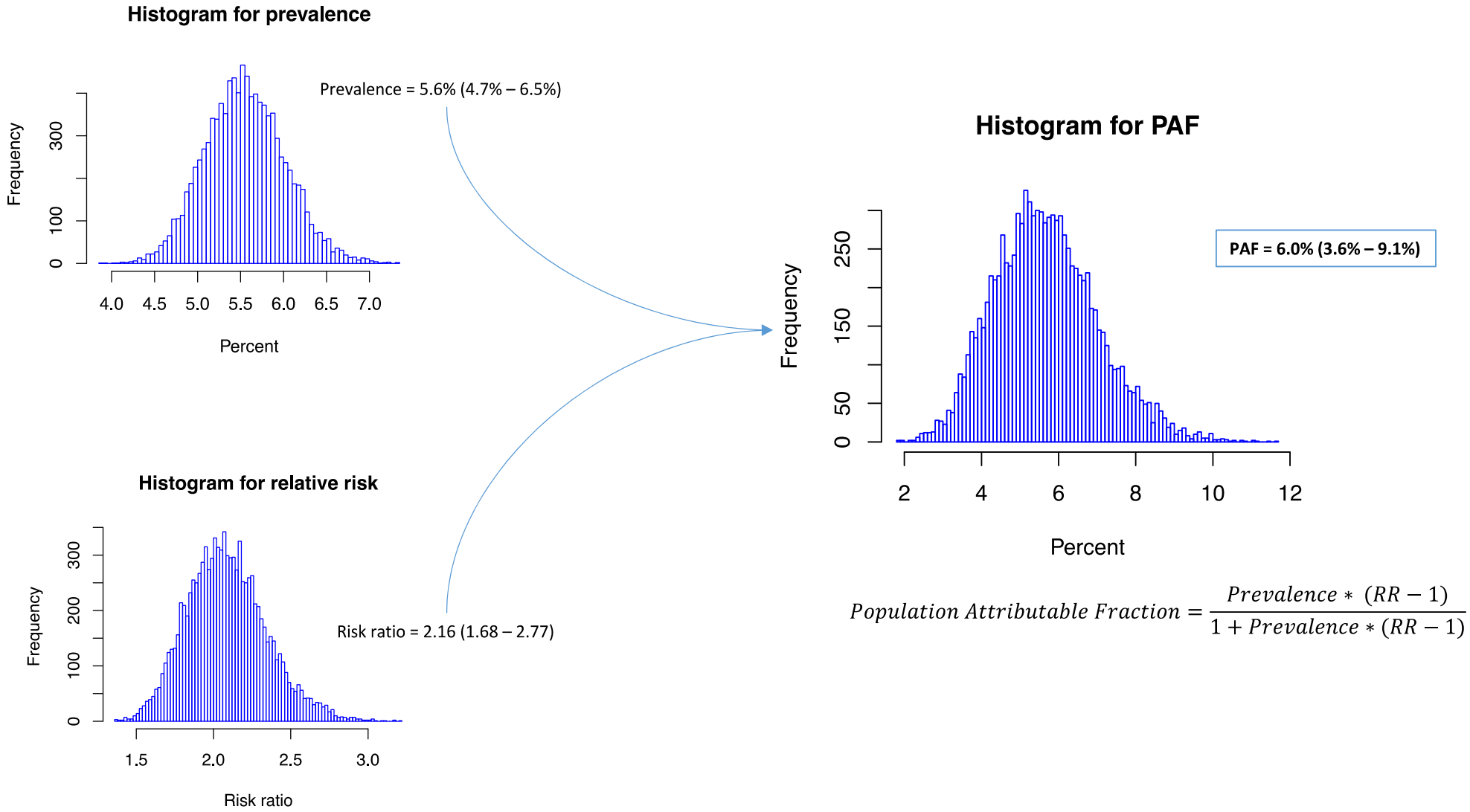
Attributable risk
Population Attributable Fraction
CVD DALYs
CVD DALYs due to HIV

CVD DALYs Attributable to HIV



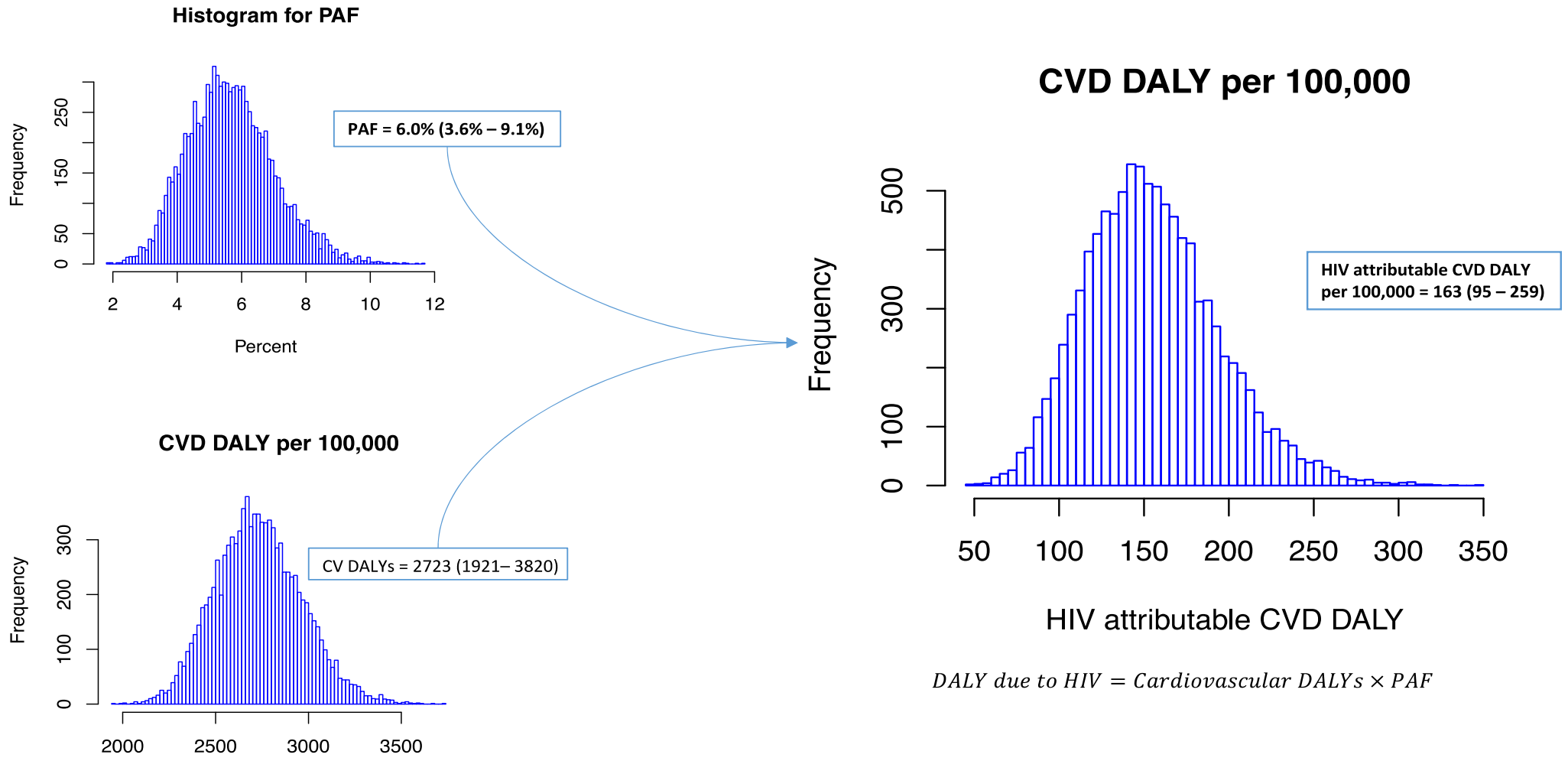
Kenya
Illustration for deriving population attributable fraction (PAF)



$$Population\ Attributable\ Fraction = \frac{Prevalence * (RR - 1)}{1 + Prevalence * (RR - 1)}$$

Kenya

Illustration for deriving HIV attributable CVD disability adjusted life years (DALYs) per 100,000 persons



$$DALY\ due\ to\ HIV = Cardiovascular\ DALYs \times PAF$$

Conclusion

- Understand the different measures of descriptive epidemiology
- Understand measures of risk
- Never forget about confounding!
- Both parameters can be combined to derive powerful metrics of burden that can be used to drive policy change and decisions