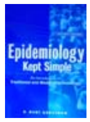
Epidemiology Kept Simple



Chapter 8
Measures of Association & Potential Impact

Important Jargon

- **Exposure (E)** ≡ an explanatory factor; any potential health determinant
- **Disease (D)** ≡ an outcome or response; a health-related outcome
- **Measure of association (syn. measure of effect)** ≡ a statistic that quantifies the relationship between an exposure and a disease
- **Measure of potential impact** ≡ a statistic that quantifies the potential impact of removing a hazardous exposure

Arithmetic (*αριθμός*) Comparisons

- **Measures of association** are *mathematical comparisons*
- **Mathematic comparisons** can be done in *absolute terms* or *relative terms*
- Let us start with this **ridiculously simple example:**
- I have **$2**
- You have **$1**

"For the things of this world cannot be made known without a knowledge of mathematics."- Roger Bacon

Absolute Comparison

- In **absolute terms,** I have
  $2 – $1
  = $1 more than you
- Note: absolute comparison are based on **subtraction**

It is as simple as that…

Relative Comparison

- Recall that I have $2 and you have $1.
- In **relative terms,** I have $2 ÷ $1 = 2, or
  "twice as much as you"
- Note: relative comparison is made by **division**

Applied to Risks

- Suppose,
  I have a 2% risk of a disease
  you have a risk of 1% risk of the same disease
- In **absolute terms,** I have 2% – 1%
  = 1% greater risk
- This is the **risk difference,** or absolute measure of effect

Applied to Risks

- Recall that I have a risk of 2% and you have a risk of 1%
- In **relative terms** I have 2% ÷ 1% = 2, or twice the risk
- This is the **relative risk,** or relative measure of effect

Terminology

For economy of language, the term “risk” will be applied to all incidence and prevalence measures.

Risk Difference

Risk Difference (RD) ≡ absolute effect associated with exposure

$$RD = R_1 - R_0$$

where
R_1 ≡ risk in the exposed group
R_0 ≡ risk in the non-exposed group

Interpretation: *Excess* risk in absolute terms

Relative Risk

Relative Risk (RR) ≡ relative effect associated with exposure

$$RR = \frac{R_1}{R_0}$$

where
R_1 ≡ risk in the exposed group and
R_0 ≡ risk in the non-exposed group

Interpretation: excess risk in relative terms.

Example

Fitness & Mortality (Blair et al., 1995)

- Is improved fitness associated with decreased mortality?
- Exposure ≡ improved fitness (1 = yes, 0 = no)
- Disease ≡ death (1 = yes, 0 = no)
- Mortality rate, group 1: R_1 = 67.7 per 100,000 p-yrs
- Mortality rate, group 0: R_0 = 122.0 per 100,000 p-yrs

Example
Risk Difference

What is the effect of improved fitness on mortality in absolute terms?

$$RD = R_1 - R_0 = \frac{67.7}{100{,}000 \text{ p-yrs}} - \frac{122.0}{100{,}000 \text{ p-yrs}}$$

$$= \frac{-54.4}{100{,}000 \text{ p-yrs}}$$

The effect of the exposure (improved fitness) is to decrease mortality by 54.4 per 100,000 person-years

Example
Relative Risk

What is the effect of improved fitness on mortality in relative terms?

$$RR = \frac{R_1}{R_0} = \frac{67.7 \cancel{\text{ per 100,000 p-yrs}}}{122.0 \cancel{\text{ per 100,000 p-yrs}}} = 0.55$$

The effect of the exposure is to cut the risk *almost* in half.

Designation of Exposure

- Switching the designmation of "exposure" does *not* materially affect interpretations
- For example, if we had let "exposure" ≡ failure to improve fitness
- RR = R_1 / R_0
  = 122.0 / 67.7
  = 1.80
  (or almost double the risk)

2-by-2 Table Format

	Disease +	Disease −	Total
Exposure +	A_1	B_1	N_1
Exposure –	A_0	B_0	N_0
Total	M_1	M_0	N

$$R_1 = \frac{A_1}{N_1} \qquad R_0 = \frac{A_0}{N_0}$$

For true rates:
let N_1 ≡ person-time in group 1 and N_0 ≡ person-time in group 0 and ignore cells B_1 and B_0

Food borne Outbreak Example

Exposure ≡ eating a particular dish
Disease ≡ gastroenteritis

	Disease +	Disease −	Total
Exposure +	63	25	88
Exposure –	1	6	7
Total	64	31	95

$$R_1 = \frac{A_1}{N_1} = \frac{63}{88} = 0.7159 \qquad R_0 = \frac{A_0}{N_0} = \frac{1}{7} = 0.1429$$

Food borne Outbreak Data

	Disease +	Disease −	Total
Exposure +	63	25	88
Exposure –	1	6	7
Total	64	31	95

$$RR = \frac{R_1}{R_0} = \frac{63/88}{1/7} = \frac{0.7159}{0.1429} = 5.01$$

Exposed group had 5 times the risk

What do you do when you have multiple levels of exposure?

Compare rates to least exposed "reference" group

	LungCA Rate (per 100,000 person-years)	*RR*
Non-smoker (0)	10	1.0 (ref.)
Light smoker (1)	52	5.2
Mod. smoker (2)	106	10.6
Heavy sm. (3)	224	22.4

$$RR_1 = \frac{R_1}{R_0} = \frac{52}{10} = 5.2 \qquad RR_2 = \frac{R_2}{R_0} = \frac{106}{10} = 10.6$$

The Odds Ratio

- Similar to a RR, but based on odds (rather than rates or risks)
- Interpretation the *same as a relative risk*, i.e., the relative of incidence associated with exposure
- Used with incidence proportions and prevalence, and a study design known as "case-control"

	D+	D−	Total
E+	A_1	B_1	N_1
E−	A_0	B_0	N_0
Total	M_1	M_0	N

$$OR = \frac{A_1/B_1}{A_0/B_0} = \frac{A_1 B_0}{B_1 A_0}$$

"Cross-product ratio"

Odds Ratio, Example

Milunsky et al, 1989, Table 4

NTD = Neural Tube Defect

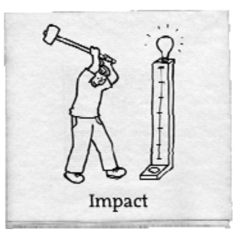
	NTD+	NTD−
Folic Acid+	10	10,703
Folic Acid−	39	11,905

$$OR = \frac{A_1 B_0}{B_1 A_0} = \frac{10 \cdot 11{,}905}{10{,}703 \cdot 39} = 0.29$$

Exposed group had *about* quarter the risk

Measures of Potential Impact

- Impact of removing a hazardous exposure from the population via statistic known as attributable fraction
- Two types of attributable fractions
  - In exposed cases
  - In the population



Attributable Fraction Exposed (AF_e)

Proportion of exposed cases averted with elimination of the exposure

$$\text{Definitional formula}: AF_e = \frac{R_1 - R_0}{R_1}$$

$$\text{Equivalent formula}: AF_e = \frac{RR - 1}{RR}$$

Example: AF_e

RR of lung CA associated with moderate smoking is approx. 10.4. Therefore:

$$AF_e = \frac{RR - 1}{RR} = \frac{10.4 - 1}{10.4} = .904$$

Interpretation: 90.4% of lung cancer in moderate smokers would be averted if they had not smoked.

Attributable Fraction, Population (AF_p)

Proportion of all cases averted with elimination of exposure *from the population*

$$\text{Definitional formula}: AF_p = \frac{R - R_0}{R}$$

where

R = overall rate

R_0 = rate in nonexposed population

AF_p for Cancer Mortality, Selected Exposures

Exposure	Doll & Peto, 1981	Miller, 1992
Tobacco	30%	29%
Dietary	35%	20%
Occupational	4%	9%
Repro/Sexual	7%	7%
Sun/Radiation	3%	1%
Alcohol	3%	6%
Pollution	2%	-
Medication	1%	2%
Infection	10%	-