Measures of Association

By :YOMIYU T (BSc., MPH)

Learning Objectives:

1. Define different measures of associations

2. Calculate and interpret different measures of association

3. Describe different impact measures and discuss their
   importance

4. Calculate and interpret impacts measures

MEASURES OF ASSOCIATION

- Epidemiologic data are often presented in the form of two-by-two (contingency) table

- 2X2 table contains 4 cells → A, B, C, D

Two by Two Table

EXPOSURE		Disease		
		Yes	No	Total
	Yes	a	b	a+b
	No	c	d	c+d
	Total	a+c	b+d	a+b+c+d

- Statistical tests like Chi-square show mainly the presence or absence of association.

- The strength of association is assessed by calculating Relative Risk (RR), Odds Ratio (OR) or other measures of association.

Measures of Association

- Risk is a proportion

  $$\frac{\text{The chances of something happening}}{\text{The chances of all things happening}}$$

- Odds is a ratio

  $$\frac{\text{The chances of something happening}}{\text{The chances that it is not happening}}$$

A. Relative Risk (RR) or Risk Ratio

- RR shows the magnitude of association between exposure & disease
- Indicates the likelihood of developing the disease in exposed group relative to non exposed
- RR can also be used to compare risks of death, injury, and other possible outcomes of the exposure

Relative Risk

- RR = Incidence among exposed (Ie)
  Incidence among nonexposed (Io)

$$RR = \frac{a/a+b}{c/c+d} = CIe/CIo$$

Relative Risk cont...

Risk Ratio

- Cumulative incidence ratio

$$\frac{\text{Cumulative incidence in exposed}}{\text{Cumulative incidence in non exposed}}$$

$$= CIe/CIo$$

Relative Risk cont...

- Rate ratio
- Incidence density ratio
  - Incidence density in exposed

    Incidence density in non exposed

    $$IDe/IDo = \frac{a/PY_1}{c/PY_0}$$

Example 1

- Among 2390 women aged 16 to 49 years who were free from bacteriuria, 482 were OC users at the initial survey during 1973, while 1908 were not. At a second survey in 1976, 27 of the OC users had developed bacteriuria, as had 77 of the non users. Calculate the measure of association and interpret it.

Example:

		Bacteruria		
		Yes	No	Total
OC USE	Yes	27	455	482
	No	77	1831	1908
	Total	104	2286	2390

- Calculate RR

$$RR = \frac{Ie}{Io} = \frac{\frac{27}{482}}{\frac{77}{1908}} = 1.4$$

- **Interpretation:** women who used oral contraceptive had 1.4 times higher risk of developing bacteruria when compared to non-users.

Relative risk cont...

Example 2

A study on postmenopausal hormone use and coronary heart disease among postmenopausal female nurses showed that after a total of 54,308.7 person-years of follow-up, 30 women who reported that they had used hormones developed CHD. For the “never users”, 60 developed CHD among 51,477.5 person-years of follow-up. Draw a two-by-two table and calculate the measure of association.

Relative risk cont...

Hormone use	CHD		Person-Years
	Yes	No	
Yes	30	-	54,308.7
No	60	-	51,477.5
Total	90		105,786.2

Relative risk cont...

- Ie/Io = IDe/IDo = $\frac{a/PY1}{c/PYo}$

$$= \frac{30/54{,}308.7}{60/51{,}477.5} = 0.5$$

B. Odds Ratio (OR)

- In case control studies, RR can be estimated by calculating the ratio of the odds of exposure among the cases to that among the controls i.e

$$RR = OR = \frac{a/c}{b/d} = \frac{ad}{bc}$$

- RR of 1 indicates no association
- RR > 1 indicates a **positive association**, or an increased risk among those exposed to a factor.
- RR < 1 indicates **negative association**, which means the exposure is preventive
- In general the strength of association can be considered:

  High - if the RR is 3.0 or more

  Moderate – if the RR is from 1.5 to 2.9

  Weak – if the RR is from 1.2 to 1.4

Example 2

- Of 156 women with Myocardial Infarction (MI), 23 were current OC users at the time of their hospital admission. Of the 3120 control women without MI, 304 were current OC users. Calculate the measure of association and interpret it.

Example:

		Myocardial infarction		
		yes	No	Total
Current OC use	Yes	23	304	327
	No	133	2816	2949
	total	156	3120	3276

Odds ratio cont...

Calculate OR

$$OR = \frac{ad}{bc} = \frac{(23)\,(2816)}{(304)\,(133)} = 1.6$$

Interpretation: the odds of using OC among women with MI is 1.6 times higher than women without MI

RR can be estimated by OR if the following conditions are fulfilled:

- The controls are representative of the general population
- The selected cases are representative of all cases
- The disease is rare

Impact Measures

- Attributable Risk (AR)
- Attributable Risk Percent (ARP)
- Population Attributable Risk (PAR)
- Population Attributable Risk Percent (PARP)

Impact Measures

All of these measures assume that the association between exposure and disease has already been shown to be **causal.**

C. Attributable Risk (AR) / Risk Difference (RD)

- AR provides information about the absolute effect of the exposure or the excess risk of disease in those exposed.

- AR = Incidence among exposed (Ie) _ Incidence among non-exposed (Io)

- AR quantifies the risk of disease in the exposed group that is attributable to the exposure by removing the risk of disease that occurs due to other causes.

Alternative Naming of AR

- Risk difference
- Rate difference
- Cumulative incidence difference
- Incidence density difference

Example: Refer to example 1 and calculate AR

$$AR = \frac{27}{482} - \frac{77}{1908}$$

$$= 0.0156 = 15660 \text{ per } 100{,}000 \text{ OC users}$$

Interpretation: The excess occurrence of bacteruria among OC users attributable to their OC use is 15660 per 100,000 OC users

Exercise:

Mortality rates per 100,000 person-years from Lung ca and coronary artery disease:

	smokers	Nonsmokers	Ratio	Difference
Lung Ca	48.3	4.5	10.8	44
CAD	294.7	169.5	1.7	125

Exercise

- Which disease mortality is more strongly associated with cigarette smoking? Why?
- If the number of deaths attributable to smoking is used as an index of public health importance which disease has more significance?

D. Attributable Risk Percent

- Estimates the proportion of the disease among the exposed that is attributable to the exposure, or
- the proportion of the disease in the exposed group that could be prevented by eliminating the exposure

$$AR\ \% = \frac{(Ie - Io)}{Ie} \times 100$$

Example:

Refer to example 1 and calculate AR%

$$AR\ \% = \frac{1566/10^5}{27/482} \times 100 = 27.96\ \%$$

- **Interpretation:** If OC use causes bacteruria, about 28 % of bacteruria among women who use OC can be attributed to their OC use and can be eliminated if they did not use oral contraceptives.

E. Population Attributable Risk (PAR)

- PAR shows the effect of eliminating the exposure on the population as a whole,
- PAR takes into account not only the actual incidence rate of the outcome but also the prevalence rate of the exposure
- PAR = AR X prevalence rate of the exposure

Example:

- **C**igarette smoking and death from lung cancer.

- AR = 89 per 100,000 per year
- Prevalence rate of cigarette smoking = 20 %

Calculate PAR.

- PAR = 89 per 100,000 per year X 20 %
  = 17.8 per 100,000 per year

Interpretation:

- In a population of 100,000 smokers, 89 deaths from lung cancer per year could have been avoided by preventing them from smoking (**this refers** to **AR**)

- In a general population of 100,000 with a prevalence rate of cigarette smoking of 20 %, about 18 deaths from lung cancer per year would be prevented by eliminating cigarette smoking (**this refers to PAR**).

PAR cont...

- Both AR and PAR are used to estimate the effect of disease incidence by eliminating a given risk factor,
- AR estimates reduction in disease incidence only in those exposed,
- PAR estimates reduction in disease incidence in the population as a whole.

F. Population Attributable Risk Percent (PAR P)

$$\text{PAR \%} = \frac{\text{PAR}}{\text{Incidence rate in total population}} \times 100$$

Example: PAR = 17.8 per 100,000 per year

Mortality rate in non-smokers = 7 per 10^5

Mortality rate in the total population = 24.8 per 10^5 per year

Calculate PAR %

$$\text{PAR \%} = \frac{17.8 \text{ per } 10^5 \text{ per year}}{24.8 \text{ per } 10^5 \text{ per year}} \times 100 = 71.8\%$$

Interpretation: 72% of deaths from lung cancer occurring in the general population could be prevented by eliminating cigarette smoking.

POSSIBLE OUTCOMES IN STUDYING THE RELATIONSHIP

- No association between exposure and disease : AR=0, RR=1
- Positive association between exposure and disease (more exposure, more disease)

  AR>0, RR>1
- Negative association between exposure and disease (more exposure, less disease)

  AR<0 (negative), RR <1(fraction)

THANK YOU