Measures of Association

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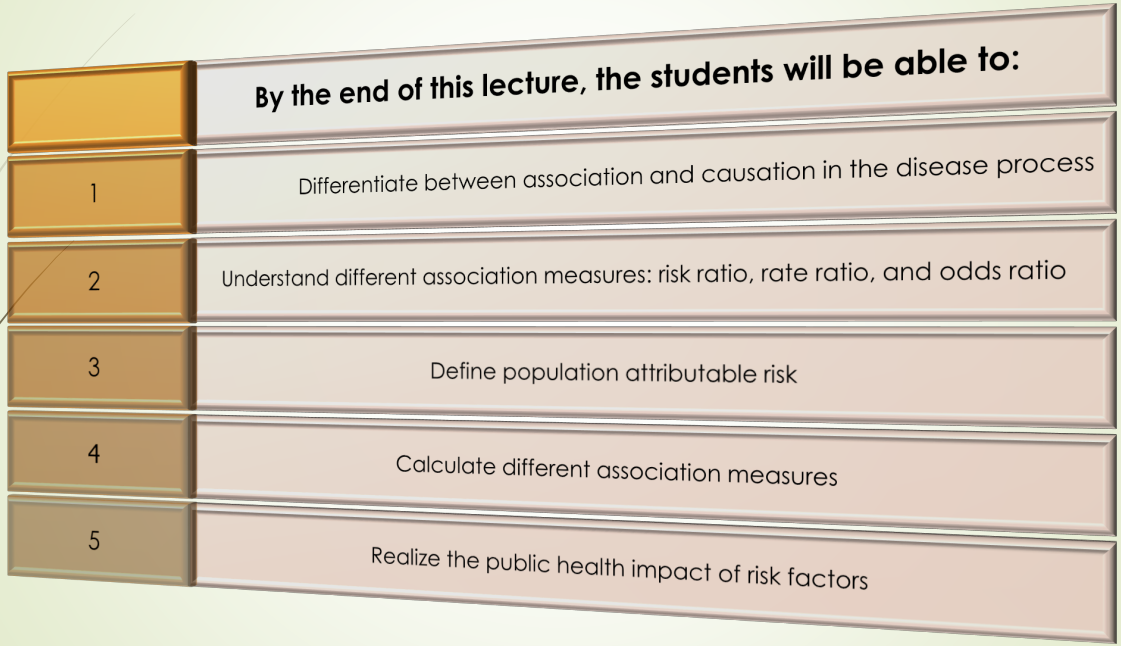
Learning objectives



Association vs. Causation

A. Association
B. Causation
C. Bradford Hill's Criteria for Causation (1965)

1. Association

العلاقة مابين الـ factor والـ disease

- ***Definition:***

  An association exists when two variables (e.g., exposure and disease) are related. They occur together more (or less) often than expected by chance.

  الرابط — outcome — Accidental / Incidental / By chance

- Association does not mean that one causes the other.

  * هذا الاثنين ماشين مع بعض بس مش شرط واحد منهم مسبب للتاني .

  The relationship might be due to:

  A. Chance

  B. Bias (systematic error) — خطأ

  C. Confounding (a third factor related to both) — متل كانوا بيحكوا انه اللي بيشربوا قهوة بيصير معهم CHD لكن بعدين حكوا انه اصلا اللي بيشربوا قهوة مدخنين ومع السيجارة هو confounder والتدخين مع القهوة هو

Example: Coffee consumption and heart disease

- People who drink more coffee tend to have higher rates of heart disease.
- This is an **association.** Coffee drinking and heart disease appear to occur together, but it does **not prove causation**.
- **Why it may not be causal?**
  - **Confounding:** Coffee drinkers might also smoke more or have higher stress levels; these factors could actually cause the heart disease.

2. Causation

- **Definition:**

  A causal relationship means that a change in one factor (the cause or exposure) produces a change in another factor (the effect or outcome).

- **Example:**

  Cigarette smoking **causes** lung cancer.

  Risk Factor

  Elimenation Cause → No outcome

- That means smoking is a risk factor for lung cancer.

Bradford Hill's Criteria for Causation (1965)

Bradford Hill's criteria provide guidelines to help determine whether an observed association is likely to be causal rather than coincidental.

* لتحديد اذا هاد Risk Factor او لا

Criterion	Meaning
1. **Strength of Association** (قوة المخرج)	A strong association is more likely to indicate causation. (e.g., higher relative risk)
2. **Consistency** (كل ما اعمل الدراسة بوصل لنفس النتيجة)	The association is observed repeatedly in different studies.
3. **Specificity**	A specific exposure causes a specific disease.
4. **Temporal relation (time sequence effect)** (تتابع زمني التعرض يسبق الـ disease)	The cause must occur before the effect (essential for causation).
5. **Dose–Response effect**	Higher exposure levels are associated with higher risk of disease.
6. **Biological Plausibility**	There is a biologically reasonable explanation for the observed association.
7. **Coherence**	The association is compatible with existing theory and knowledge of the disease.
8. **Experiment**	Experimental (Rats) or intervention evidence supports the causal relationship.

Common Measures Of Association Include:

- Risk Difference
- Risk Ratio
- Rate Ratio
- Odds Ratio.

incidence

new cases / total popul at risk * 100%

A. Risk Difference (Attributable Risk)

Smoker / Non Smoker

- It provides the difference in risk between two groups, indicating how much excess risk is due to the exposure of interest.
- **Risk difference is the Risk among the exposed − Risk among the unexposed**
- ***Risk (cumulative incidence)=***

Risk difference ↑ , Risk ↑

$$\frac{\text{Number of new cases during a defined period}}{\text{total number of individuals at risk at the beginning of the period}} \times 100$$

Risk difference = $\frac{\textit{number of cases in exposed group}}{\textit{total number at risk in exposed group}} - \frac{\textit{number of cases in unexposed group}}{\textit{total number at risk in unexposed group}}$

Interpretation of Risk Difference results

- A **positive** (+ve) risk difference indicates excess risk due to the exposure
- While a **negative** (-ve) risk difference indicates that the exposure of interest has a protective effect against the outcome.
- Vaccinations would be a good example of an exposure with a protective effect. This measure is often utilized to determine how much risk can be prevented by an effective intervention.

For example

- A cohort study follows two groups of adults for 10 years:

Group	Number of people	Number who developed lung cancer	Risk (%)
Smokers	1,000	100	%10
Non-smokers	1,000	10	%1

Calculate Attributable Risk (AR)?

$$AR = Risk\ in\ Exposed - Risk\ in\ Unexposed$$

$AR = 10\% - 1\% = 9\%$ **(9% of lung cancer cases among smokers are attributable to smoking OR could be prevented if they did not smoke)**

B. Risk Ratio and Rate Ratio (Relative Risk=RR)

- Risk Ratios and Rate Ratios are measures of the strength of the association between the exposure and the outcome.
- They are defined as: ***the ratio of the risk in the exposed group to the risk in the unexposed group***, or **the ratio of the rate in the exposed group to the rate in the unexposed group.**

$$\text{Risk ratio} = \frac{\textit{Risk among exposed}}{\textit{Risk among the unexposed}}$$

$$\text{Rate ratio} = \frac{\textit{Rate among exposed}}{\textit{Rate among the unexposed}}$$

لـ البسط
مش جزء من المقام .

How is a Risk Ratio or Rate Ratio interpreted?

Rate ratios can be interpreted in the same way as a Risk ratio.

RR Value	Meaning
RR = 1	No association (risk is the same in both groups). No relationship between factor + disease
RR > 1 numerator > denominator	Exposure increases risk (positive association).
RR < 1 denominator > numerator	Exposure decreases risk (protective effect, as in the case of vaccines).

(Relative Risk):

Relative risk is a general term that can mean **either the risk ratio or the rate ratio**, depending on whether the denominator is **people at risk** (risk= Cumulative Incidence) or **person-time** (Incidence Rate).

For Example (Risk Ratio=Relative risk=[RR])

- **A study was conducted among 10,000 adults aged 40–60 years to investigate the relationship between smoking and lung cancer over 10 years.**

Group	Number of People	Number Who Developed Lung Cancer	Risk (CI)
Smokers	6,000	120	$\frac{120}{6000}$ x 100=0.02 (2%)
Non-Smokers	4,000	20	$\frac{20}{4000}$ x100=0.005 (0.5%)

Risk Ratio (RR)=Risk in Exposed/ Risk in non-Exposed= $\frac{0.02}{0.005}$=4 (smokers are 4 times more likely to develop lung cancer compared to non-smokers)

1 : 4

non Smoker : Smoker

For Example (Rate Ratio= Relative Risk[RR])

- A cohort study followed factory workers exposed to a chemical and unexposed office workers for 5 years. Calculate the incidence rate of skin cancer?

Group	Total Person-Years of Observation	Number of Cases	Incidence Rate (per person-year)
Exposed	3,000	30	$\frac{30}{3000}$= 0.01
Unexposed	5,000	10	$\frac{10}{5000}$ = 0.002

$$\text{Rate Ratio (RR)} = \frac{\text{Incidence Rate in exposed}}{\text{Incidence Rate in Unexposed}} = \frac{0.01}{0.002} = 5$$

→ The rate of skin cancer among exposed workers is 5 times higher than that among unexposed workers.

Relative Ratio > odds Ratio

C. Odds Ratio (OR)

case control Study
العكس.
بجيب ناس معها Lung c وناس ما معها وبشوف مين الـ Smoker ومين لـ.
Backward in time

Cohort Study
هون انا بجيب مجموعتين
Smoker
Non Smoker
وبتابعهم لاشوف مين حيصير عنده Lung cancer ومين لـ.
Forward in time

Odds

$$\text{Odds} = \frac{number\ of\ indiviuals\ \underline{with}\ the\ health\ outcome}{number\ of\ individuals\ \underline{without}\ the\ health\ outcome}$$

The formula for the OR is:

$$\textbf{Odds Ratio} = \frac{odds\ among\ the\ exposed}{odds\ among\ the\ unexposed}$$

- The odds ratio is interpreted in the same manner as the risk ratio or rate ratio, with an OR of **1.0 indicating no association**, an OR **greater than 1.0 indicating a positive association**, and an OR **less than 1.0 indicating a negative**, or protective association.

Odds Ratio > 1 , positive association
Odds Ratio < 1 , negative association , protective

For example

- A study aimed to investigate the relation between smoking and lung cancer.

The Exposure	Lung Cancer	No Lung Cancer	Total
Smokers	60	40	100
Non-Smokers	30	70	100

- **Calculate the odds ratio using the previous 2x2 table?**
- **Odds of cancer in smokers** = 60 / 40 = **1.5**
- **Odds of cancer in non-smokers** = 30 / 70 = **0.43**
- **Odds Ratio (OR)** = 1.5 / 0.43 = **3.5** (**OR = 3.5 → smokers are 3.5 times more likely to develop lung cancer**).

Another method for the Odds Ratio calculation

طريقة سهلة .

The Exposure	Lung Cancer	No Lung Cancer	Total
Smokers	60 (a)	40 (b)	100
Non-Smokers	30 (c)	70 (d)	100

Odds Ratio (OR) = $\frac{a \; x \; d}{b \; x \; c}$ = 60 x 70/ 40 x 30 = **3.5** **(OR = 3.5**

→ smokers are 3.5 times more likely to develop lung cancer).

Population Attributable Fraction (PAF)

Definition:

- The Population Attributable Fraction (PAF) is the proportion of all cases (or risk) in the population that can be attributed to a specific exposure.
- **It answers the question** ⟶

"If we could remove the exposure, what fraction of disease cases in the whole population would not occur?"

How to calculate PAF?

- Formulat of PAF $= \frac{P_e(RR-1)}{P_e(RR-1)+1}$

Where:

- P_e = Proportion of the population exposed
- RR= Relative Risk (Risk Ratio)

Example

- In Mansoura city: 40% of people (0.4) are smokers ($P_e = 0.4$)
- The relative risk (RR) of lung cancer in smokers vs. non-smokers = 5

Calculate PAF?

$$\text{PAF} = \frac{0.4(4)}{0.4(4)+1} = \frac{1.6}{2.6} = 0.615 \text{ x } 100 = 61.5\%$$

- **Interpretation**

About 61.5% of lung cancer cases in the population are attributable to smoking. If smoking were eliminated, approximately 62% of lung cancer cases could theoretically be prevented.

References

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THANKYOU