

# Measures of Association And Potential Impact

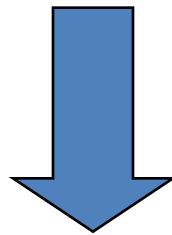
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**Mayfong Mayxay M.D., Ph.D (Trop Med)**

# Some Important Terms

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**Cause = Risk = Factor =  
Risk Factor = Exposure**



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**Disease = Outcome = Effect**

**Risk or intervention?**

**No**

**Yes**

Observational study

Experimental/interventional study or clinical trial

Control?

**Yes**

**No**

Analytical study

Descriptive study

Start with "cause" or "effect"?

- Clinical descriptive
- Cross-sectional
- Longitudinal

- Randomized controlled trial (RCT) or true experimental study
- Non RCT or Quasi-experimental study
- Pre-experimental study

**Cause → Effect**

**Cause ← Effect**

**Cause / Effect**

Cohort study

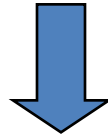
Case-control study

Cross-sectional study

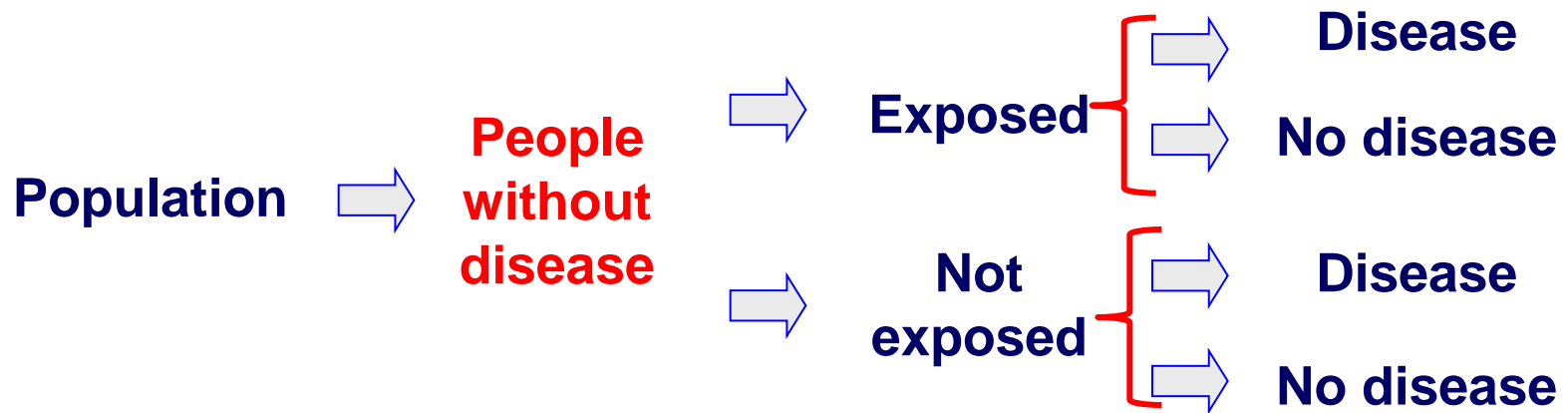
# Measures of Association

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- **Statistical relationship between two or more events, characteristics, or other variables**



- **Statistical relationship between exposure and disease**
- **Association is not causation!**



- **Absolute**

- Risk difference

**exposed - unexposed**

- **Relative**

- Risk ratios

- Odds ratios

**exposed / unexposed**

- **The absolute risk difference of myocardial infarction between men and women is :**  
**4 cases/1000 PY**

$$5 \text{ cases/1000 PY} - 1 \text{ case/1000 PY} = 4 \text{ cases/1000 PY}$$

- **The relative risk of myocardial infarction in men compared with women is : 5**

$$\text{Risk ratio} = \frac{\text{Risk}_{\text{men}}}{\text{Risk}_{\text{women}}} = \frac{5 \text{ cases/1000 PY}}{1 \text{ case/1000 PY}} = 5$$

# Epidemiologic Measures of Association

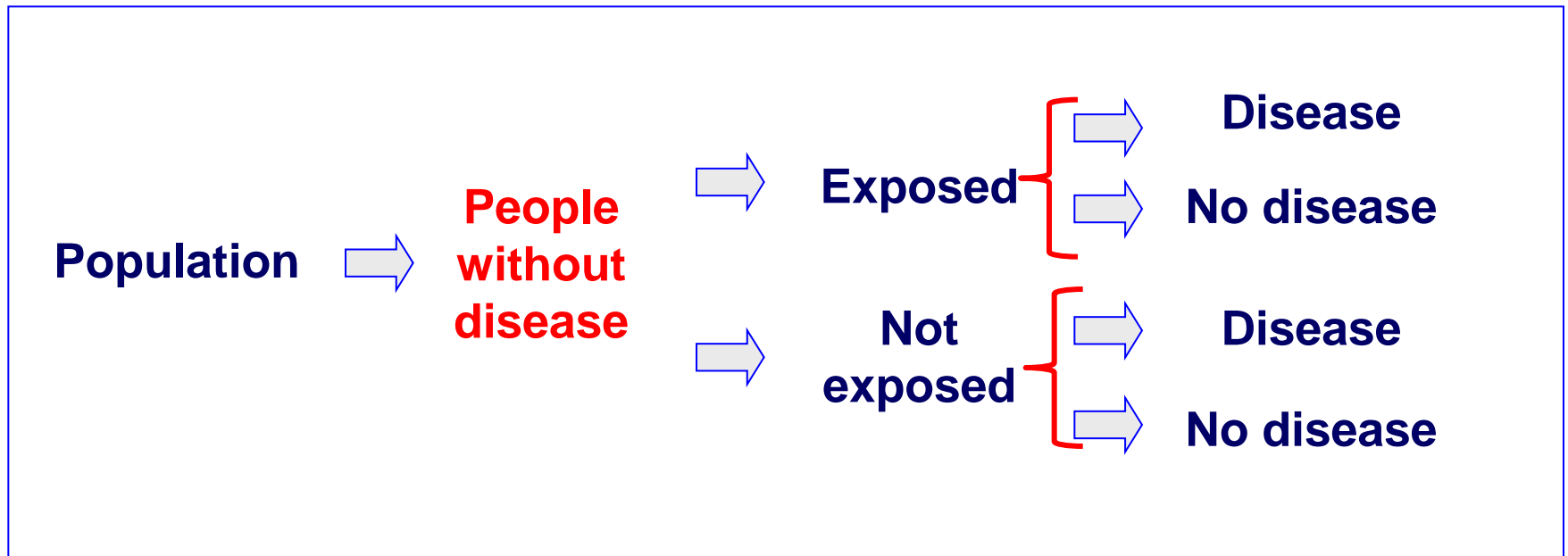
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- **Relative risk (Cohort study)**
- **Odds ratio (Case-control study)**
- **Attributable risk/population attributable risk percent**
- **Standardized mortality ratios**

# Cause - Effect Relationship: Cohort study

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Cause/risk/exposure → Effect/disease/outcome





# 2 x 2 Tables in Epidemiology

Used to summarize frequencies of disease and exposure and used for calculation of association

		Disease		Total
		Yes	No	
Exposure	Yes	$a$	$b$	$a + b$
	No	$c$	$d$	$c + d$
Total		$a + c$	$b + c$	$a + b + c + d$

# 2 x 2 Tables in Epidemiology

Used to summarize frequencies of disease and exposure and used for calculation of association

Exposure	Disease		Total
	Yes	No	
Yes (exposed)	<i>a</i>	<i>b</i>	<i>total # exposed</i>
No (unexposed)	<i>c</i>	<i>d</i>	<i>total # unexposed</i>
Total	<i>total # with disease</i>	<i>total # with no disease</i>	<i>Total Population</i>

# Relative Risk: Cohort Study

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- The ratio of the risk of disease in persons exposed compared to the risk in those unexposed
- Often, a measure of association between incidence of disease and exposure of interest

$$RR = \frac{\text{Incidence rate of disease in exposed}}{\text{Incidence rate of disease in unexposed}}$$

		Disease		Total
		Yes	No	
Exposure	Yes	<i>a</i>	<i>b</i>	<i>a + b</i>
	No	<i>c</i>	<i>d</i>	<i>c + d</i>
Total		<i>a + c</i>	<i>b + d</i>	<i>a + b + c + d</i>

$$\text{Relative Risk} = \frac{a / (a + b)}{c / (c + d)}$$

# Example: Relative Risk

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	Develop CHD	Do Not Develop CHD	Totals	Incidence per 1000/yr
Smokers	84	2916	3000	28.0
Non- smokers	87	4913	5000	17.4

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**Incidence in smokers =  $84/3000 = 28.0$**

**Incidence in non-smokers =  $87/5000 = 17.4$**

**Relative risk =  $28.0/17.4 = 1.61$**

# Interpretation of Relative Risk

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- **1 = No association between exposure & disease**
  - incidence rates are identical between groups
- **> 1 = Positive association**
  - exposed group has higher incidence than non-exposed group
- **< 1 = Negative association or protective effect**
  - non-exposed group has higher incidence
  - example: 0.5 = half as likely to experience disease

# Interpretation of Relative Risk

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- A relative risk of **1.0 or greater** indicates an increased risk
- A relative risk **less than 1.0** indicates a decreased risk

# Odds Ratio: Case-Control Study

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- The ratio of the odds of a condition in the exposed compared with the odds of the condition in the unexposed
- Usually applied to prevalence studies rather than incidence studies

$$\text{OR} = \frac{\text{odds of disease in exposed}}{\text{odds of disease in unexposed}}$$



# Odds Ratio

		Disease		Total
		Yes	No	
Exposure	Yes	$a$	$b$	$a + b$
	No	$c$	$d$	$c + d$
Total		$a + c$	$b + c$	$a + b + c + d$

$$\text{Odds Ratio} = \frac{[ a / b ]}{[ c / d ]} = \frac{[ ad ]}{[ bc ]}$$

**Based on the Odds Ratio formula, what is the Odds Ratio for each disease status in this famous smoking study?**

### **Smoking and Carcinoma of the Lung**

<b>Disease Status</b>	<b>Number of smokers</b>	<b>Number of non-smokers</b>	
<b>Males Lung cancer</b>	<b>647</b>	<b>2</b>	
<b>Males Controls</b>	<b>622</b>	<b>27</b>	
<b>Females Lung cancer</b>	<b>41</b>	<b>19</b>	
<b>Females Controls</b>	<b>28</b>	<b>32</b>	

**Doll R. Bradford, Hill A. Smoking and carcinoma of the lung: preliminary report. British Medical Journal 1950, 2: 739-748.**

# Measures of Potential Impact

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- Reflect the expected contribution of a study factor to the frequency of a disease in a particular population.
- Useful for predicting the efficacy or effectiveness of therapeutic maneuvers and intervention strategies within a specific population, e.g., vaccine

Essentially, potential impact measures are a combination of frequency and association measures

# Impact Measures in 2 ways

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- In exposed cases
- In the population

# In Exposed Cases: Attributable Fraction ( $AF_e$ )

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$$AF_e = \frac{RR - 1}{RR}$$

- Proportion of exposed cases that would be averted if hazardous exposure was absent
- Ex: British Doctors Study  $\Rightarrow$   $RR = 10.4$  for moderate smoking and lung cancer. Therefore,

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

~90% of cases: exposed cases due to exposure

# In Population: Attributable Fraction ( $AF_p$ )

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- Proportion of population cases averted with annihilation of the exposure
- Three equivalent formulas:

$$AF_p = \frac{R - R_0}{R}$$

where  $R$  = overall rate and  $R_0$  = rate in nonexposed population

$$AF_p = \frac{p_e (RR - 1)}{1 + p_e (RR - 1)}$$

where  $p_e$  = prevalence of exposure in population

$$AF_p = AF_e \times p_c$$

where  $p_c$  = proportion of cases that are exposed

# $AF_p$ for Overall Cancer Mortality and 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%	-

