Epidemiologic Measures of Association and Impact Part III

Nasir Mushtaq, PhD, MBBS
Associate Professor

Department of Biostatistics and Epidemiology
Hudson College of Public Health

Department of Family and Community Medicine
OU-TU School of Community Medicine

Overview

1. Estimating risk:
   - Is there an association between exposure & disease?
   - How strong is the association?
2. Estimating potential for prevention:
   - What is the amount of disease incidence that can be attributed to an exposure?
3. Interpretation of study results

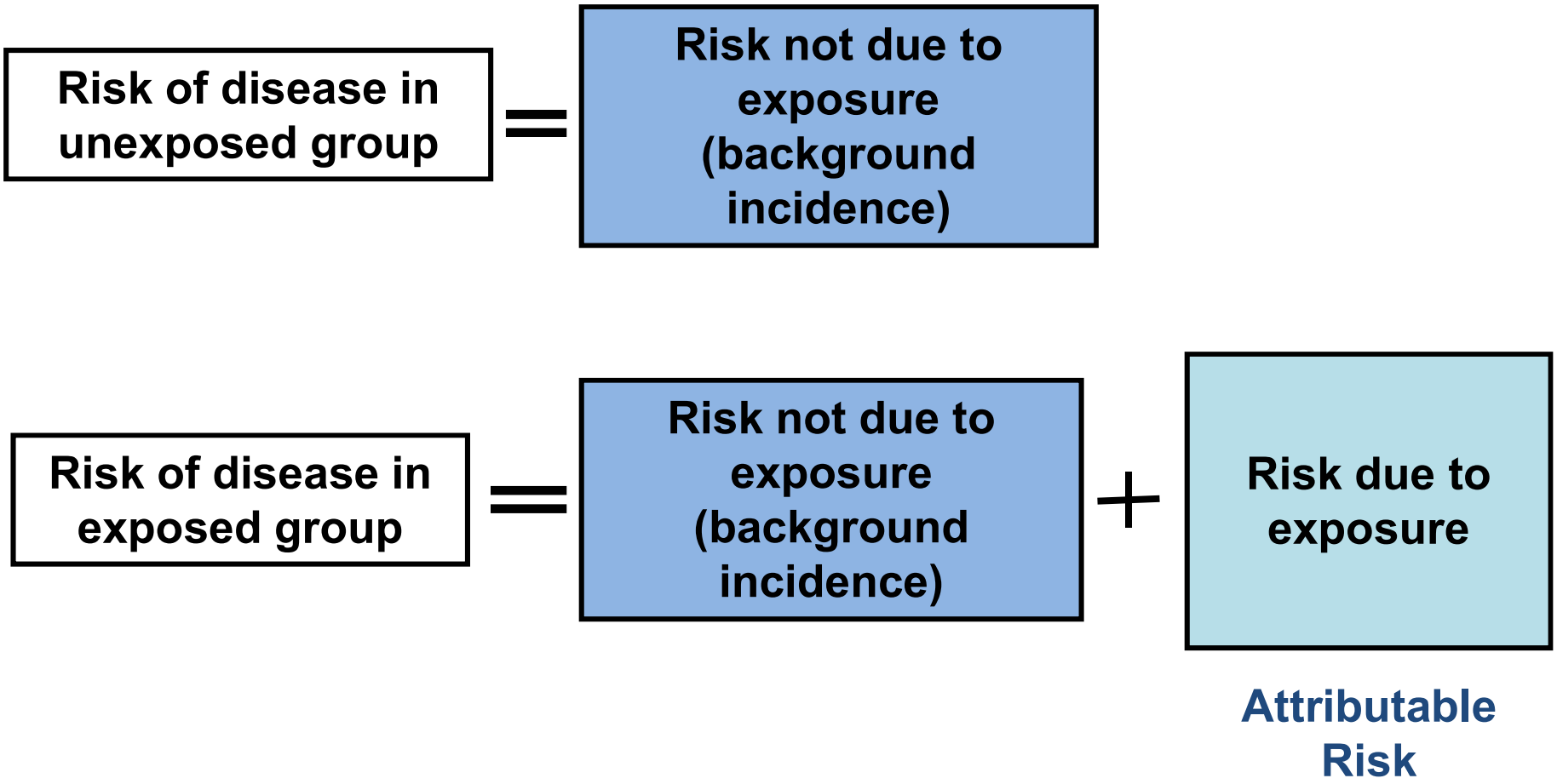
Beyond Estimating Associations

Estimating Potential for Prevention

Measures of Impact

- Attributable risk
- Attributable risk %
- Population attributable risk
- Population attributable risk %

Attributable Risk Model



Attributable Risk (AR)

Attributable risk – Risk difference

- Amount of disease risk, **among exposed**, that can be attributed to a specific exposure
- Importance for public health & clinical practice:
  - How much of the disease risk, **among exposed**, can be prevented if we eliminate the exposure?

AR = risk in exposed – risk in unexposed
(i.e., background risk)

Attributable Risk

Questions

1. How much of the risk of lung cancer, **among smokers**, is due to smoking?
2. How much of the risk of lung cancer, **among smokers**, can be prevented if they did not smoke?

Attributable Risk – Example

Risk in exposed

	Lung Cancer	No Lung Cancer	Total
Smokers	90 (a)	710 (b)	800
Nonsmokers	10 (c)	1190 (d)	1200
Total	100	1900	2000

$$\text{Risk}_e = \frac{90}{800} = 0.113$$

= 113 per 1,000

Attributable Risk – Example

Risk in nonexposed

	Lung Cancer	No Lung Cancer	Total
Smokers	90 (a)	710 (b)	800
Nonsmokers	10 (c)	1190 (d)	1200
Total	100	1900	2000

$$\text{Risk}_o = \frac{10}{1200} = 0.008$$

= 8 per 1,000

Attributable Risk – Example

	Lung Cancer	No Lung Cancer	Total
Smokers	90 (a)	710 (b)	800
Nonsmokers	10 (c)	1190 (d)	1200
Total	100	1900	2000

$AR = Risk_e - Risk_o = 0.113 - 0.008 = 0.105$

105 of the 113 incident cases of lung cancer among 1,000 smokers are attributable to smoking.

Attributable Risk Proportion (AR%)

- Proportion of risk in **exposed persons** that is due to the exposure
- Importance for public health/clinical decisions:
  - What proportion of the disease, **among exposed**, can be prevented if we eliminate the exposure?

$$AR\% = \frac{\text{Risk in exposed} - \text{Risk in unexposed}}{\text{Risk in exposed}}$$

$$= (RR-1)/RR$$

Attributable Risk %

Questions

1. What proportion of the risk of lung cancer, **among smokers**, is due to smoking?
2. What proportion of the risk of lung cancer, **among smokers**, can be prevented if they did not smoke?

Attributable Risk % – Example

Risk in exposed

	Lung Cancer	No Lung Cancer	Total
Smokers	90 (a)	710 (b)	800
Nonsmokers	10 (c)	1190 (d)	1200
Total	100	1900	2000

$$\text{Risk}_e = \frac{90}{800} = 0.113$$

= 113 per 1,000

Attributable Risk % – Example

Risk in nonexposed

	Lung Cancer	No Lung Cancer	Total
Smokers	90 (a)	710 (b)	800
Nonsmokers	10 (c)	1190 (d)	1200
Total	100	1900	2000

$$\text{Risk}_o = \frac{10}{1200} = 0.008$$

= 8 per 1,000

Attributable Risk % – Example

	Lung Cancer	No Lung Cancer	Total
Smokers	90 (a)	710 (b)	800
Nonsmokers	10 (c)	1190 (d)	1200
Total	100	1900	2000

$$AR\% = \frac{Risk_e - Risk_o}{Risk_e} = \frac{0.113 - 0.008}{0.113} = 0.93$$

93% of the risk of lung cancer in smokers is attributable to smoking.

Measures of Impact

- Attributable risk
- Attributable risk %

→ Among Exposed

- Population attributable risk
- Population attributable risk %

Population Attributable Risk (PAR)

- Amount of disease, **in population**, attributable to exposure

- Importance for public health/clinical practice:
  - How much of the disease, **in population**, can be prevented if we eliminate the exposure?

PAR = Risk in population – Risk in unexposed

Population Attributable Risk

Questions

1. How much of the total risk of lung cancer, in the **population**, is attributable to smoking?

2. How much of the total risk of lung cancer, in the **population**, could be prevented if we eliminated smoking?

PAR – Example

Risk in total population

	Lung Cancer	No Lung Cancer	Total
Smokers	90 (a)	710 (b)	800
Nonsmokers	10 (c)	1190 (d)	1200
Total	100	1900	2000

$$\text{Risk}_t = \frac{100}{2000} = 0.05$$

= 50 per 1,000

PAR – Example

Risk in nonexposed

	Lung Cancer	No Lung Cancer	Total
Smokers	90 (a)	710 (b)	800
Nonsmokers	10 (c)	1190 (d)	1200
Total	100	1900	2000

$$\text{Risk}_o = \frac{10}{1200} = 0.008$$

= 8 per 1,000

PAR– Example

	Lung Cancer	No Lung Cancer	Total
Smokers	90 (a)	710 (b)	800
Nonsmokers	10 (c)	1190 (d)	1200
Total	100	1900	2000

$PAR\% = Risk_t - Risk_o = 0.05 - 0.008 = 0.042$

If smoking were eliminated, the risk of lung cancer in the population would be reduced by 42 cases per 1,000 population.

Population Attributable Risk Proportion

PAR%

- Proportion of risk, **in the population**, attributable to the exposure (i.e. relative to all other exposures).

- Importance for public health/clinical practice:
  - What proportion of the disease, **in the population**, can be prevented if we eliminate the exposure?

$$\text{PAR\%} = \frac{\text{Risk in population} - \text{Risk in unexposed}}{\text{Risk in population}}$$

Population Attributable Risk Proportion

Questions

1. What proportion of the total risk of lung cancer, in the **population**, is attributable to smoking?

2. What proportion of the total risk of lung cancer, in the **population**, could be prevented if we eliminated smoking?

PAR% – Example

	Lung Cancer	No Lung Cancer	Total
Smokers	90 (a)	710 (b)	800
Nonsmokers	10 (c)	1190 (d)	1200
Total	100	1900	2000

$Risk_t = 100 / 2000 = 0.05 = 50$ per 1,000

$Risk_o = 10 / 1200 = 0.008 = 8$ per 1,000

$$PAR\% = \frac{Risk_t - Risk_O}{Risk_t} = \frac{0.05 - 0.008}{0.05} = 0.84$$

84% of lung cancer incidence in total pop is due to smoking.

Assumptions of Attributable Risk

- The association is causal.
- All other variables equally distributed between exposed and unexposed.

  The only difference is the presence of the exposure

Relative Risk

vs.

Population Attributable Risk

Mortality rates per 1,000 person years

	Smokers	**Non-smokers**
Lung Cancer	1.30	0.07
CVD	9.51	7.32

Mortality rates per 1,000 person years

	Smokers	Non-smokers
Lung Cancer	1.30	0.07
CVD	9.51	7.32

Among smokers, risk of death from CVD is higher than the risk of death from lung cancer.

Which Cause of death has a stronger association with smoking?

	Lung Cancer	CVD
RR	18.5	1.3
AR%	95%	23%

Which Cause of death has a stronger association with smoking?

	Lung Cancer	CVD
RR	18.5	1.3
AR%	95%	23%

	Lung Cancer	CVD
RR	18.5	1.3
AR%	95%	23%
PAR	0.87/1000 pop	1.55/1000 pop

Why is the PAR of CVD higher compared to PAR of lung cancer?

Reminder

- PAR = Risk in population – Risk in unexposed
- When risk in population is high $\rightarrow \uparrow$ PAR

- In our example, deaths due to CVD were high (more people die from CVD than from lung cancer, in the population)

Mortality rates per 1,000 person years

	Smokers	**Non-smokers**
Lung Cancer	1.30	0.07
CVD	9.51	7.32

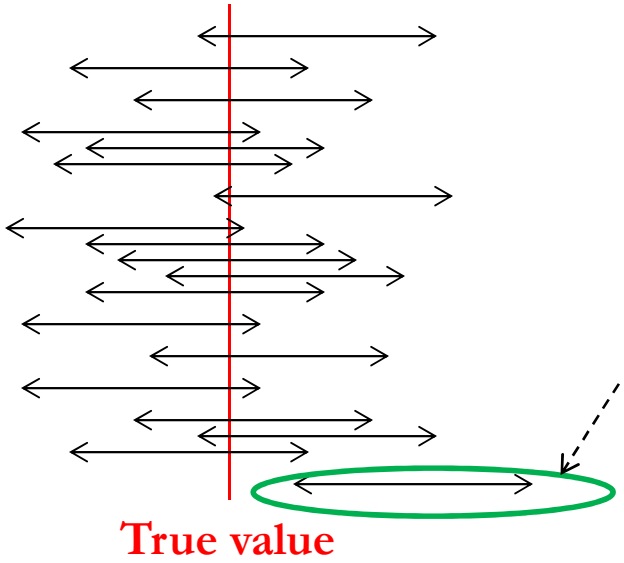
Confidence Intervals

Confidence Interval

- Range of plausible results (UL and LL)
- Provides info on precision
- Degree to which results would vary if measured multiple times.

Interpretation - 95% Confidence Interval

If we sample the same population the same way 100 times, 95 times the true value of the parameter of interest (OR or RR or IRR or PPR) would be included in our 95% CI.



In 5% of the times, the 95%CI does NOT include the true value

Example

- OR = 2.5
- 95% CI (1.4, 4.6)

- 95 times out of 100, the true OR will lie between the calculated interval (1.4 and 4.6 in this example)

  i.e., we are 95% confident that the true population OR lies between 1.4 and 4.6

Statistical Significance From CI

- Null value: RR or OR = 1
- Is the null value (1.0) included in the interval?
- If 95% CI includes 1.0 $\rightarrow$ p > 0.05
- If 95% CI excludes 1.0 $\rightarrow$ p $\leq$ 0.05

OR CI Examples

1. 95% CI: 0.7 - 3.5
2. 95% CI: 1.4 – 3.5
3. 95% CI: 0.65 – 0.89

Effect of Sample Size

- Width of interval indicates amount of variability in estimate i.e. effect of sample size
- Larger sample size $\rightarrow$ narrow interval (more precision)
- Smaller sample size $\rightarrow$ wider interval (less precision)

Width of CI – Examples

- Which confidence interval would arise from a larger sample size when considering sampling from a study setting and population with a fixed OR value?
  - 95% CI: 1.4 – 1.9
  - 95% CI: 0.5 – 5.3

Review Question

Choose the measure that would best address the following question.

- How many lung cancer cases could be prevented among smokers if smoking were eliminated?
  - Relative Risk
  - Attributable Risk
  - Attributable Risk Proportion
  - Population Attributable Risk
  - Population Attributable Risk Proportion

Review Question

Choose the measure that would best address the following question.

- What proportion of lung cancer risk in the total population is attributable to smoking?
  - Relative Risk
  - Attributable Risk
  - Attributable Risk Proportion
  - Population Attributable Risk
  - Population Attributable Risk Proportion

Summary

- Measures of impact of a given exposure
  - Attributable Risk
  - Attributable Risk Proportion
  - Population Attributable Risk
  - Population Attributable Risk Proportion
- Confidence intervals
  - Convey uncertainty and variability in our estimate
  - Width indicates degree of precision
  - Compare CI for ratios to 1 and CI for differences to 0