Measurement of Association and Impact

Attributable Risk

Attributable Risk in Exposed

Population Attributable risk

Attributable Risk (AR)

- Measures of association based on the absolute difference between two risk estimates
- Used to imply causal-effect relationship

Caution:

- interpreted as a true etiologic fraction
- causal relationship between exposure and outcome

Attributable Risk in Exposed (ARexp)

- Measures the excess risk for a given Exp level associated with the Exp
- Different Exp levels - Referent Exp levels

q_+ incidence in exposed

q_- incidence in unexposed

$$AR_{exp} = q_+ - q_-$$

Caution:

- most Exp effects are cumulative
- cessation of Exp usualy does not reduce the risk in Exp = risk in non-Exp
- prevention rather than cessation

Percent Attributable Risk (%AR_{exp})

- Percentage of the total risk in the exposed attributable to the exposure

- $\%AR_{exp} = \dfrac{\{q_+ - q_-\}}{q_+} \times 100$

- Concept of percent efficacy in assessing vaccine

Population Attributable Risk (Pop AR)

- Measures the proportion of the disease risk in the total population associated with Exp
- When

q_+ incidence in exposed

q_- incidence in unexposed

p_e exposure prevalence in the population

$1- p_e$ non-exposure prevalence

Risk in the total population (q_{pop})

= weight sum of risks in the Exp and NonExp

= $[q_+ \times p_e] + [q_- \times (1- p_e)]$

Pop AR = $q_{pop} - q_-$

- **Exposure cessation would decrease q_{pop} to the risk of NonExp**

(*if it is causal relationship and Exp can be completely reversible*)

- **Pop AR expressed in percentage**

$$\%\text{Pop AR is} = [(q_{pop} - q_{-}) / q_{pop}\ ] \times 100$$

Example of Integrating all Measurements

You are in charge of health prevention

- Want to reduce automobile-related deaths

- Have a limited budget

- Conduct a cohort study to examine causes

Relative Risk of Automobile-related Death

Driving too fast 5.0 times

more likely to die than those who drove not too fast

Driving while drunk 10.7 times

more likely to die than those who drove without drunk

Cohort Study

Risk Difference

For a cohort study:

Risk difference = $\text{Risk}_{\text{exposed}}$ - $\text{Risk}_{\text{unexposed}}$

Automobile Deaths, Country A

	Dead	Not dead		Risk	Risk Difference
Fast	100	1900	2000	0.050	0.050 - 0.010 = 0.040
Slow	80	7920	8000	0.010	
	180	9820	10000		

	Dead	Not dead			
Drunk	45	255	300	0.150	0.150 - 0.014 = 0.136
Not Drunk	135	9565	9700	0.014	
	180	9820	10000		

Attributable Risk Percent

Also called "attributable fraction among the exposed" and "etiologic fraction“ (if causal relationship)

Proportion of cases in the exposed group presumably attributed to the exposure

What proportion of drunk drivers had an automobile related death because they were drunk?

$$ARP = (Risk_{exposed} - Risk_{unexposed})/Risk_{exposed}$$
$$= (RR - 1)/RR$$

Only appropriate if RR > 1.0

%AR

Automobile Drivers

	Dead	Not dead		Risk
Fast	100	1900	2000	0.050
Slow	80	7920	8000	0.010
	180	9820	10000	

$$\frac{Risk_{exposed} - Risk_{unexposed}}{Risk_{exposed}}$$

$$\frac{0.050 - 0.010}{0.050} = \frac{.04}{.05} = 80\%$$

	Dead	Not dead		
Drunk	45	255	300	0.150
Not Drunk	135	9565	9700	0.014
	180	9820	10000	

$$\frac{0.150 - 0.014}{0.150} = \frac{0.136}{0.150} = 91\%$$

Conclude

Percentage of a disease that may be eliminated among those with the risk factor if the effects of the risk factor can be completely removed.

Among fast drivers who had an automobile-related death, 80% presumably died because they were driving too fast

Among drunk drivers who had an automobile-related death, 91% presumably died because they were drunk

Case-Control Study

Attributable Risk Percent

For case-control study, can't calculate risk!

If the odds ratio is an approximation of the relative risk (rare disease assumption), then

$$\%AR = (OR - 1.0) / OR$$

Prevented Fraction in the Exposed Group (Vaccine Efficacy)

Risk ratio is <u><1.0</u>

Proportion of potential new cases which would have occurred if the exposure had been absent

or

Proportion of potential cases prevented by the exposure

$$PF=(Risk_{unexposed} - Risk_{exposed}) / Risk_{unexposed}$$
$$= 1 - RR$$

Measles and Vaccination Status

Texarcana, USA, 1970

	Measles	No measles		Risk/1000	Relative Risk
Vaccine	27	6323	6350	4.2	0.04
No vaccine	512	4323	4835	105.9	
	539	10646	11185		

Vaccine efficacy = $(Risk_{unexposed} - Risk_{exposed})/Risk_{unexposed} = 1 - RR$

$= (105.9 - 4.2)/105.9 = 0.96 = 1 - 0.04$

Conclude: 96% of the cases that would have occurred among the vaccinated group had they not been vaccinated were prevented by vaccination

Population Attributable Risk

Also called population attributable Fraction *(assumption of etiology)*

Proportion of cases in entire population presumably attribtuable to the exposure

What proportion of automobile-related deaths were due to drunk driving?

Calculation of PopAR

$$(Risk_{overall} - Risk_{unexposed})/Risk_{overall}$$

$$(P_c)(Risk_{exposed} - Risk_{unexposed})/Risk_{exposed}$$

$$(P_c)(\text{Attributable Risk Percent})$$

$$(P_c)(RR-1)/RR$$

$$P(RR-1)/((P(RR-1) + 1)$$

Where P = proportion of population exposed
Pc= proportion of cases exposed

Cohort Study

Pop AR: Driving Speed

	Dead	Not dead	
Fast	100	1900	2000
Slow	80	7920	8000
	180	9820	10000

Risk unexposed=80/8000=0.010

Risk overall=180/10000=0.018

$$PopAR = (Risk_{overall} - Risk_{unexposed}) / Risk_{overall}$$

$$= (0.018 - 0.010) / 0.018$$

$$= 44\%$$

Pop AR: Drunk Driving

	Dead	Not dead	
Drunk	45	255	300
Not Drunk	135	9565	9700
	180	9820	10000

Risk unexposed=135/9700=0.014

Risk overall=180/10000=0.018

$$PopAR = (Risk_{overall} - Risk_{unexposed}) / Risk_{overall}$$

$$= (0.018 - 0.014) / 0.018$$

$$= 22\%$$

Conclude

Percentage of the risk in a population that is associated with the exposure to a risk factor

44% of the driving-related deaths were presumably due to driving too fast

22% of the driving-related deaths were presumably due to drunk driving

Case-Control Study
Population Attributable Risk

Cohort study: Pop AR=P(RR-1)/(P(RR-1)+1)

where P=proportion of population exposed

If OR approximates RR (rare disease) and assume that the proportion of controls exposed approximates the proportion of the population exposed, then

$$\text{Pop AR} = P_{control}(OR-1)/(P_{control}(OR-1)+1)$$

where $P_{control}$=proportion of controls exposed

Summary

	Fast Driving	Drunk Driving
Relative risk	5.0	**10.7**
Risk difference	4%	**14%**
Attributable risk	80%	91%
% all drivers with risk	**20%**	3%
Population attributable risk	**44%**	22%

	Measure of association	Measure of impact	Question
RR / OR	Yes	No	How much the association could be?
Risk difference	Yes	Yes	What is the excess risk between exposed and unexposed persons?
Attributable risk	No	Yes	What proportion of the exposed persons had an outcome presumably due to the exposure?
Population attributable risk	No	Yes	What proportion of persons in the total population had the outcome presumably because of the exposure?

What is the Appropriate Measure?

"Why should I quit smoking? My friend had lung cancer and she never smoked?"

"He got lung cancer. But he probably would have gotten lung cancer anyway even if he didn't smoke."

"Should I fly on Air India or British Airlines?"

At beginning of the study	Outcome: Developed CHD	Outcome: Did not develop CHD
Healthy smokers	84	2,916
Healthy non-smokers	87	4,913

The incidence of CHD among smokers is:

The relative risk for CHD in smokers compared to non smokers is:

The incidence of CHD that can be attributed to smoking is:

The proportion of the total incidence of CHD in smokers that is attributable to smoking is:

At beginning of the study	Outcome: Developed CHD	Outcome: Did not develop CHD
Healthy smokers	84	2,916
Healthy non-smokers	87	4,913

The incidence of CHD among smokers is: 28/1000

The relative risk for CHD in smokers compared to non smokers is: 1.61

The incidence of CHD that can be attributed to smoking is: 11/1,000

The proportion of the total incidence of CHD in smokers that is attributable to smoking is: 37.9%


Thank you