ERIC Notebook

Second Edition

Risk and Rate Measures in Cohort Studies

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Cohort studies are longitudinal studies where an exposed and an unexposed group (or less exposed group) are followed forward in time to find the incidence of the outcome of interest (e.g. disease, death, or change in health). Two measures of incidence are risks and rates. Risks and rates can be

further manipulated to provide additional information on the effects of the exposure of interest, such as risk or rate ratios, risk or rate differences, and attributable risk fractions.

Risk is defined as the number of new cases divided by the total population-at-risk at the beginning of the follow-up period. An individual's risk of developing the outcome of interest is

$$\text{Risk} = \frac{\#\ of\ new\ cases}{total\ \#\ individuals\ at\ risk}$$

measured.

A rate is the number of new cases of a health outcome divided by the total person-time-at-risk for the population. Person-time is calculated by the sum total of time all individuals remain in the study without developing the outcome of interest (the total amount of time that the study members are at risk of developing the outcome of interest). Person-time can be measured in days, months, or years, depending on the unit of time that is relevant to the study. A rate measures the rapidity of health outcome occurrence in the population.

$$\text{Rate} = \frac{\#\ of\ new\ cases}{total\ person\text{–}time\ at\ risk}$$

Two-by-two tables are generally used to organize the data from a study as shown below.

	Disease	No disease	Total
Exposed	a	b	a+b
Unex-posed	c	d	c+d
Total	a+c	b+d	a+b+c+d

Risk ratios

When risks are computed in a study, the risk ratio is the measure that compares the $\text{Risk}_{\text{exposed}}$ to the $\text{Risk}_{\text{unexposed}}$. The risk ratio is defined as the risk in the exposed cohort (the index group) divided by the risk in the unexposed cohort (the reference group). A risk ratio may vary from zero to infinity.

$$\text{Risk Ratio} = [a / (a+b)] / [c / (c+d)]$$

$$\text{Risk Ratio} = Risk_{exposed}/Risk_{unexposed}$$

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For example, suppose researchers conduct a cohort study and gather the following data on the effects of gasoline fume exposure on respiratory illness among automotive workers.

	Disease	No disease	Total
Exposed	60	140	200
Unex-posed	25	175	200
Total	85	315	400

In this study, the risk in the exposed group is 60/200, or 0.30 cases per person (30 cases per 100 people), and the risk in the unexposed group is 25/200, or 0.125 cases per person (13 cases per 100 people). Therefore, the risk ratio is 0.30/0.125, or 2.4. A risk ratio of 2.4 implies that the exposed group has 2.4 times the risk of developing respiratory illness as the unexposed group.

Rate ratio

When rates are computed in a study, the rate ratio is the measure that compares the $Rate_{exposed}$ to the $Rate_{unexposed}$. The rate ratio is defined as the rate of health outcome occurrence in the exposed cohort (the index group) divided by the rate of health outcome occurrence in the unexposed or less-exposed cohort (the reference group).

$$\text{Rate Ratio} = Rate_{exposed}/Rate_{unexposed}$$

A rate ratio measure also may show whether the exposure was preventive, harmful, or had no effect on the rate of health outcome in the exposed.

If in the previous example, the person-time-at- risk that each automotive worker contributed to the study had been recorded then the table might have looked like the following:

	Disease	No disease	Person-years at risk
Exposed	60	140	175
Unexposed	25	175	188
Total	85	315	363

In this study, the rate in the exposed cohort is 60/175 person- years, or 0.34 cases/person-year. The rate in the unexposed cohort is 25/188 person-years, or 0.13 cases/ person-year. The rate ratio in this study is 0.34/0.13, or 2.6, which is higher than the rate ratio calculated above. This rate ratio reveals that respiratory illness among workers exposed to gasoline fumes is developing at 2.6 times the rate that respiratory illness is developing among workers not exposed to gasoline fumes.

An exposure may be preventive (e.g., vitamin intake) or harmful (e.g., toxic chemical exposure). Confounding, which you will read about in another ERIC notebook issue, is one type of systematic error that can occur in epidemiologic studies. Confounding can cause an over- or under-estimate of the observed association between exposure and a health outcome. Assuming there are no other factors that may confound the association, a risk ratio less than 1 indicates that the risk in the exposed (index) group is less than the risk in the unexposed or less -exposed (reference) group, and therefore, the exposure is preventive. A risk ratio or rate ratio that equals 1 (the null value) indicates that there is no difference in risk or rates between exposed and unexposed groups. A risk ratio greater than one indicates that the risk in the exposed is greater than the risk in the unexposed, and, therefore, the exposure is harmful.

The following table may be applied to both risk and rate ratios.

Risk ratio or	Exposure
<1	Exposure is protective
=1	Exposure is neither preventive nor harmful (null association)
>1	Exposure is harmful

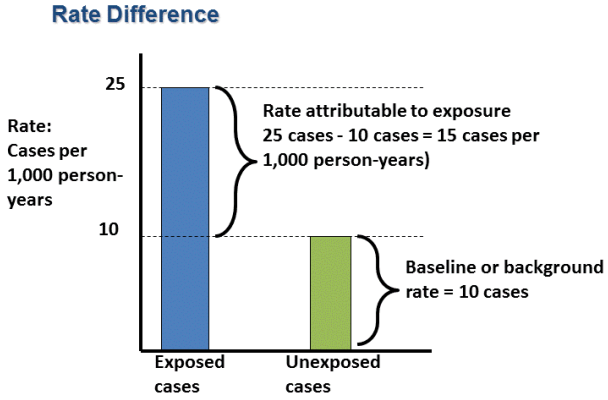
The farther away the risk ratio or rate ratio is from the null value of one, the greater the effect of exposure is on the study group. This is shown in the following diagram.

RR=risk ratio or rate

Risk and Rate differences

Difference measures are absolute measures of disease burden and helpful for public health program planning. Ratio measures are relative measures; they are commonly used to research the etiology of disease. Risk and rate differences answer the question "how much disease is attributed to the exposure?" Risk difference is defined as the risk in the exposed minus the risk in the unexposed (Equation 1). The risk difference is the *excess* risk of disease among the exposed population. Rate difference uses a similar equation (Equation 2.) In the past, risk difference was called "attributable risk"; sometimes attributable risk is still used. "Attributable fraction among the exposed" is the risk difference reported as a percent of the exposed population (Equation 3). "Attributable proportion" or "attributable risk percent" are alternative terms for Equation 3. Lastly, the attributable fraction among the total population (Equation 4) answers the question "what proportion of disease in the *total* population is associated with the exposure?" See figure, terms, and equations defined below.

Figure



Adapted from Gordis L. Epidemiology, p. 156

Equation 1: Risk Difference= $Risk_{exposed}$ - $Risk_{unexposed}$

Equation 2: Rate Difference = $Rate_{exposed}$ - $Rate_{unexposed}$

Equation 3: Attributable fraction among the exposed:

$$RD\%(exposed) = \frac{\text{risk in exposed} - \text{risk in unexposed}}{\text{risk in exposed}} \times 100$$

Equation 4: Attributable fraction among the total population:

$$RD\%(total\ population) = \frac{\text{risk in total pop} - \text{risk in unexposed}}{} \times 100$$

Practice Questions

Answers are at the end of this notebook

1) Researchers conduct a prospective cohort study to assess the association between dietary supplements and cognitive ability among children. A total of 500 children age 12-17 years who take an omega-3 fatty acid supplement are compared with 500 children age 12-17 years who do not take an omega-3 fatty acid supplement. Researchers follow the children for 2 years. During this time, 300 children who take the supplement earn what is classified as a "high" score on a cognitive test while 200 children who do not take the supplement earn what is classified as a "high" score on the same cognitive test.

a) Construct a 2x2 table from the information presented above

b) The risk difference is:

c) The attributable fraction among total population is:

d) The attributable fraction among the exposed is:

2) Researchers conduct a prospective cohort study of the association between working at a high-stress job and depression. A total of 5000 adults are followed for an average of 10 years. Among these 5000 adults, 2500 had a high-stress job while 2500 had a low-stress job. Participants had yearly health checks. A total of 250 incident cases of depression were diagnosed in the high-stress job group while 90 incident cases of depression were diagnosed in the low-stress job group. Assume all cases of depression were diagnosed at the end of year 5 of follow-up.

a) Construct a 2x2 table from the information above

b) Rate exposed =

Rate unexposed =

c) Rate ratio =

d) Rate difference=

References

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Answers to Practice Questions

1.

a)

	Scored "high" on exam	Did not score "high" on exam	Total
Exposed to supplement	300	200	500
Unexposed to supplement	200	300	500
Total	500	500	1000

b) Risk exposed = 300/500= 0.6 cases/person
Risk unexposed = 200/500 = 0.4 cases/person
Using equation 1, we calculate the Risk difference as 0.6 – 0.4 = 0.2 cases/person or 20 cases per 100

c) Attributable fraction in total population (equation 4)
Risk in Total population 500/1000 = 0.5 cases/person
Attributable risk in total population= (0.5-0.4)/0.5= 0.2 cases/person or 20 cases per 100

d) Attributable fraction in exposed (equation 3)
Risk exposed = 300/500= 0.6 cases/person
Risk unexposed = 200/500 = 0.4 cases/person
Attributable risk in exposed = (0.6-0.4)/0.6=0.33 cases/person or 33 cases per 100

2.

a)

Study group	Depression	No depression	Total person-years
High-stress job	250	2250	(250*5+2250*10) = 23,750
Low-stress job	90	2410	(90*5+2410*10)= 24,550
Total	340	4660	48, 300

b) Rate exposed = 250/23,750 person years * 10,000 = 105.3 cases/ 10,000 person years

Rate unexposed = 90/24,550 person years * 10,000 = 36.7 cases/ 10,000 person years

c) Rate ratio = 105.3 cases/ 10,000 person years / 36.7 cases/ 10,000 person years = 2.87