ERIC Notebook

Second Edition

Risk and Rate Measures in Cohort Studies

Second Edition Authors:

Lorraine K. Alexander, DrPH

Brettania Lopes, MPH

Kristen Ricchetti-Masterson, MSPH

Karin B. Yeatts, PhD, MS

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 ratios, rate ratios, attributable risks (risk or rate differences) and attributable risk percent.

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 $\text{Risk}_{exposed}$ to the $\text{Risk}_{unexposed}$. 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 Rate ratio	Exposure
<1	Exposure is protective
=1	Exposure is neither preventive nor harmful (null association)
>1	Exposure is harmful

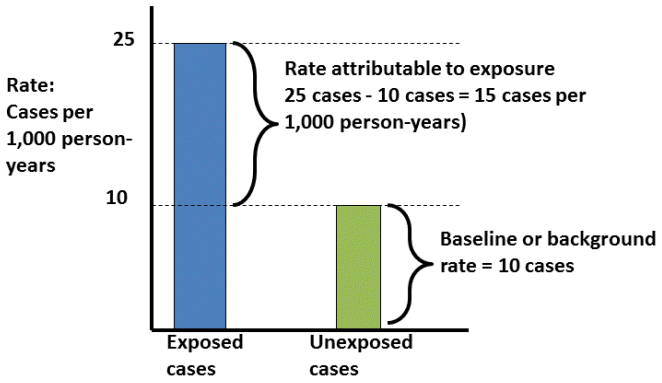
The farther away the risk ratio or rate ratio is from the null value of one, the greater the effect of exposure is on the study group. This is shown in the following diagram.

RR=risk ratio or rate

Rate differences

In order to find the absolute effect of an exposure a health outcome the attributable rate (AR), or rate difference, must be computed. The term attributable rate is same as rate difference (RD). The attributable rate is the excess rate among the exposed population attributed to exposure. It is defined as the rate in the exposed minus the rate in the unexposed. The rate difference can also be reported as a percent (see figure below).

Rate Difference



Adapted from Gordis L. Epidemiology, p. 156

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

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

$$\text{Rate Difference} = \text{Rate}_{\text{exposed}} - \text{Rate}_{\text{unexposed}}$$

References

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