

Measuring Excess Risk

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In this lecture, I will talk about measuring excess risk, which is critically important to epidemiology.

Relative Risk

Oftentimes, as epidemiologists we're asked to estimate the association between certain exposures and the occurrence of disease and declare, with some amount of certainty, that there's a significant relationship between the two. We can do this by measuring the relative risk. The **relative risk** measures the relative change in incidence associated with the presence of an exposure. It measures the strength of an association between the exposure and the outcome. The numerator is the risk of the disease in the exposed, and the denominator is the risk of the disease in the unexposed. It is also called a risk ratio or rate ratio, depending on your measure of risk.

If relative risk is greater than 1, then there is an increased risk of the outcome in the exposed group. If the relative risk is equal to 1, then there is no difference in the risk between the exposed and unexposed groups. When the relative risk is less than 1, there is a reduced risk of the outcome in the exposed group.

So, to calculate the relative risk, we can create a two-by-two table, which puts the exposure in rows and the outcome in the columns all of those in the exposure group. The table shows the number of individuals with each combination of exposure and outcome status. The total

	Outcome	No outcome	
Exposed	A	B	A + B
Unexposed	C	D	C + D

number of exposed is A plus B. The total number of unexposed is C plus D.

Using the cumulative incidence approach, we can calculate the risk of the outcome in the exposed group. The cumulative incidence among the exposed A divided by A plus B. Similarly, the risk of the outcome in the unexposed group is C divided by C plus D.

Finally, the relative risk is the ratio of the two risks. While it may not be initially intuitive, by creating a table like this, you should be able to calculate the risk separately for the exposed and unexposed groups, and then calculate the relative risk.

$$\text{Cumulative incidence in exposed (CI}_e\text{)} = \frac{A}{A + B}$$

$$\text{Cumulative incidence in unexposed (CI}_u\text{)} = \frac{C}{C + D}$$

$$\text{Relative risk (RR)} = \frac{A / A + B}{C / C + D}$$

What we're trying to do here is determine whether the incidence of the outcome is different depending on the presence of the exposure, that is, whether or not the outcome and the exposure are associated.

We can take a similar approach when working with the incidence rate. In this case, we need to know the number of incident outcomes and the total amount of person-time at risk for both the exposed and unexposed groups.

	Outcome	Person-time at risk
Exposed	A	PY_e
Unexposed	C	PY_u

We calculate the rate of the outcome in the exposed group and the rate of the outcome in the unexposed group. We then calculate the relative rate by dividing the rate in the exposed by the rate in the unexposed. As you can see, the specific approach that we use to calculate the relative risk will depend on the information that is available to us.

$$\text{Risk of outcome in exposed group (IR}_e\text{)} = \frac{A}{PY_e}$$

$$\text{Risk of outcome in unexposed group (IR}_u\text{)} = \frac{C}{PY_u}$$

$$\text{Relative risk (RR)} = \frac{A / PY_e}{C / PY_u}$$

Let's look at an example of where the outcome is incident cases of Alzheimer's disease (abbreviated AD), and the exposure of interest is a family history of Alzheimer's. The risk of Alzheimer's among those who have a family history is 0.032, and the risk among those who do not have a family history of Alzheimer's is 0.018. Therefore, the relative risk is 1.78.

	Alzheimer's Disease (AD)	No Alzheimer's Disease (AD)	Total
Family history	60	1800	1860
No family history	40	2200	2240

$$CI_e = \frac{60}{1860} = 0.032$$

$$CI_u = \frac{40}{2240} = 0.018$$

$$\text{Relative risk (RR)} = \frac{0.032}{0.018} = 1.78$$

Another way of interpreting the relative risk is to say that

those with a family history are 78% more likely to develop Alzheimer's. We can calculate this by taking the relative risk, subtracting 1, and multiplying by 100. So, those who have a family history are 78% more likely to develop Alzheimer's disease compared to those who do not have a family history.

Odds Ratio

The **odds ratio** is the ratio of the "odds" in contrast to the relative risk, which is the ratio of "risks". Odds ratios approximate the relative risk when the outcome is rare. In a 2 by 2 table, we can calculate the odds of the outcome in the exposed group and the odds of the outcome in the unexposed group. The odds ratio will be A multiplied by D divided by B multiplied by C.

	Outcome	No outcome
Exposed	A	B
Unexposed	C	D

$$\text{Odds of outcome in exposed group} = \frac{A}{B}$$

$$\text{Odds of outcome in unexposed group} = \frac{C}{D}$$

$$\text{Odds ratio (OR)} = \frac{A \times D}{B \times C}$$

Using the Alzheimer's disease example, we can see the odds ratio is 6 multiplied by 102, which is divided by 9 multiplied by 40, which equals 1.70. The interpretation of the odds ratio is similar to the relative risk except that we don't say "risk" here. Those who have a family history have 1.7 times the odds of Alzheimer's disease compared to those who do not have a family history.

	Alzheimer's Disease (AD)	No Alzheimer's Disease (AD)
Family history	6	40
No family history	9	102

$$\text{Odds ratio (OR)} = \frac{6 \times 102}{9 \times 40} = \frac{612}{360} = 1.70$$

Risk Difference & Attributable Risk

Now let's talk about risk difference and attributable risk. The **risk difference** is the difference in the risk between the exposed and unexposed persons. To calculate the risk difference, take the incidence among those with the exposure and subtract the incidence among those without the exposure.

The **attributable risk** is the difference in incidence between an exposed and unexposed group when we assume that the exposure actually causes the difference in risk that we see between the exposed and unexposed. If the exposure causes the disease, then risk difference and attributable risk are the same.

Population attributable risk (PAR) is the incidence of disease in the total population that is due to the exposure. To calculate the PAR, subtract the incidence among those without the exposure from the incidence in the total population.

We've talked about measures of association and ways to determine if the incidence of an outcome differs depending on the presence of the exposure. It is important to note that these associations alone don't imply causation. If an exposure causes a disease, then we'll see an association. However, if an exposure of interest and a disease are associated, it doesn't necessarily mean that the exposure causes the outcome. Most epidemiologic studies focus on measuring associations, that their ultimate goal is usually to make conclusions about causation. We'll talk more about causation in a different part of this course.

In this lecture, I covered the definitions, calculations, and interpretations of different important measures of excess risk—relative risk, odds ratio, risk difference, and attributable risk.