

# Risks, Rates and Odds: What's the Difference and Why Does It Matter?

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“The little things are infinitely the most important.”—Sherlock Holmes, *A Case of Identity*, 1892

Clinicians, as consumers of clinical research, seek to understand the association between treatment and outcome in providing the best care for their patients. Measures of association frequently encountered include risks, rates and odds, and their relative terms of risk ratios, rate ratios and odds ratios. Too often, these terms are used interchangeably, yet they all have important distinctions.

## Definitions

Let's begin by defining the terms and then proceed to explore what other information we can obtain from these measures of association.

### Risk

Risk is defined as the number of new cases that occur during a specified time period in a population at risk of becoming a case (the study population). Because risk includes only *new* cases, individuals must be free from the condition at the start of the time period. This is also referred to as the absolute risk.

An example would be the risk of C5 palsy within 1 week following a laminoplasty for cervical myelopathy. To calculate, all patients must be free of C5 palsy before surgery, and therefore, “at risk” of having a C5 palsy after surgery (denominator). The number of new cases becomes the numerator.

Risk ranges from 0 to 1, and in the spine literature, risk is often expressed as a percent. For example, one might read that C5 palsy occurred in 15.7% of patients (16/102) within 1 week following laminoplasty for cervical myelopathy.

Use risk when studying the effect of an intervention or risk factor when the follow-up period is the same for all participants.

### Rate

Rate is defined as the number of new cases that occur per the total amount of time a person is at risk of becoming a case. It differs from risk in that it accounts for the sum total of time that study members are at risk of developing the outcome of interest. Rate ranges from 0 to  $\infty$ , and is expressed as cases per person-time.

For example, in Figure 1 below we have a study trying to determine the frequency of revision surgery in 10 patients. The investigators have 3-year follow-up. Note that one died before the end of the follow-up. The *risk* of revision surgery over 3 years is 44% (4/9, 4 cases out of 9 possible, excluding the person who died). The *rate* of revision surgery is 17.8 per 100 person-years. This is calculated by dividing the 4 cases by the sum of the time each patient has not had a revision and converting to 100. Patient 1 contributed 0.5 years; patients 2, 3, 6, 8, and 10 contributed 3 years each; patient 4 contributed 2 years; patient 5, 2.5 years; patient 7, 1 year; and patient 9, 1.5 years before dying. The rate of revision in our example is 4/22.5 person-years or 17.8 per 100 person-years.

Use rates when participants have different lengths of follow-up or to handle a high loss to follow-up or loss to competing risks such as death.

### Odds

Odds is the likelihood of a new case occurring rather than not occurring. It is the probability that an event will occur divided by the probability that the event will not occur. It

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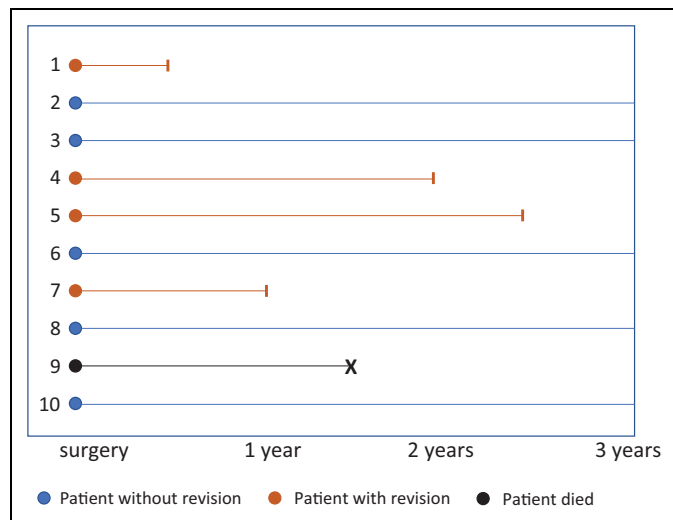
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**Figure 1.** Frequency of revision in 10 hypothetical patients.

differs from risk in that the denominator does not include the patients with the condition. In our example in Figure 1, the odds of revision is 80%,  $(4/9)/(5/9)$ . Note that the odds of revision (80%) is markedly different than the risk of revision (4/9, 44%). However, odds approaches risk when the risk is small. If the risk of a pulmonary embolism following a surgery is 1/100, the odds are 1/99, which is nearly the same. The general rule of thumb is that the odds approaches risk when the risk is less than 10%.

Odds are not intuitive and you rarely see absolute odds in the spine research. Therefore, use odds when you go to the racetrack.

## Ratios

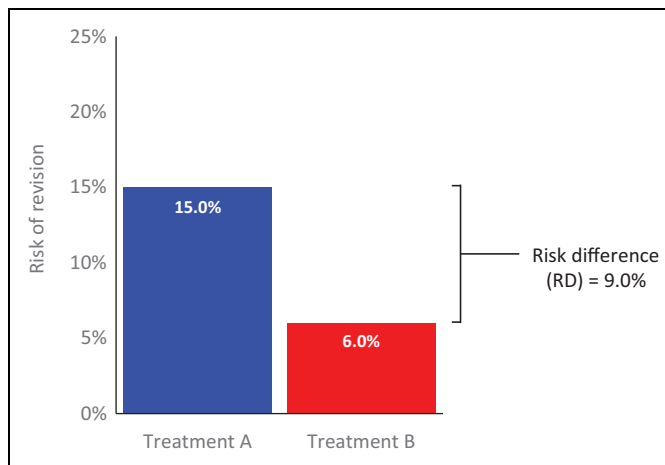
“Everything is relative except relatives, and they are absolute.”—Alfred Stieglitz, photographer

Ratios are used to describe the relative effect of a certain intervention or risk factor compared with another.

### Risk Ratios or Relative Risk (RR)

The formula for RR equals (risk of an event in one group)/(risk of an event in a second group). It is an indication of the strength of the association between the 2 risks. Its interpretation is intuitive. If there is a 15% risk of revision surgery after treatment A but only 6% following treatment B, the RR is  $15\%/6\% = 2.5$ . The interpretation is that a patient is 2 and half times more likely to receive revision surgery with treatment A compared with B. Given the RRs are ratios, their values are  $\geq 0$ . Therefore, the closer the RR is to 1, the smaller difference between groups.

In addition to calculating the absolute risks (15% and 6%) and the risk ratio (2.5), one can also calculate the risk difference (RD) between the groups. The RD is simply the difference between the absolute risks. In our example, the RD equals 9% (15%-6%) and represents the extra risk



**Figure 2.** Risk difference.

associated with treatment A above the risk associated with treatment B, Figure 2. From the RD, the number of patients needed to be treated (NNT) in order to prevent one revision can be calculated. The formula is  $1/RD$ ; in our example  $1/.09 = 11$ . In plain language, for every 11 patients treated with treatment B, one revision can be prevented compared with treatment A.

### Rate Ratios and Odds Ratios (OR)

Like the RR, rate ratios and odds ratios divide the rate or odds in one group by the rate or odds in a second group to provide a relative effect. Unlike absolute odds, the OR is used frequently in the spine literature, in part because of its unique statistical properties. And, if the risk is low,  $\leq 10\%$ , it is good estimator of the relative risk. But in general, beware how you interpret the OR when the risk of an outcome is higher than 10%, as the OR will overstate the risk effect size.

## Summary

- Absolute risk, rate and odds and their ratios are different measures of association between exposure (treatment or risk factor) and outcome.
- Risk is the number of new cases that occur during a specified time period divided by a population at risk of becoming a case. It is often expressed as a percent.
- Rate is the number of new cases that occur per the total amount of time a person is at risk of becoming a case. It is expressed as person-time such as 17.8 cases per 100 person years.
- Odds is the likelihood of a new case occurring rather than not occurring. It differs from risk in that the denominator does not include the patients with the condition.

- Ratios (risk, rate and odds) provide a relative effect of an intervention or risk factor.
- The risk difference (RD) is the difference between the absolute risks of 2 interventions or risk factors. The RD represents excess risk attributed to the group with the higher risk.
- The odds ratio can estimate the risk ratio when the probability of an event is  $\leq 10\%$ .

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