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REVIEW ARTICLE

How Odd is Odds Ratio to Understand and How Risky is Risk Ratio to Interpret?

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ABSTRACT

Odds ratios and risk ratios are one of the most widely used statistical data interpretation tool while reporting the data from any clinical trial or biomedical research. Both the odds ratios and risk ratios are a way of representing the probability and carry an inherent difference among them. Although some may be comfortable with the concept of risk and risk ratio, most find it hard to understand odds and odds ratios. This article illustrates the concept and presents the approach to help researcher understand what odds and risk ratio means and when can they be used interchangeably for reporting the clinical finding.
Keywords: Ratio, Odds ratio, Risk ratio, Relative risk.

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INTRODUCTION

Odds ratio and risk ratio (relative risk) are sometimes difficult to understand for many healthcare professionals [1] because the choice of the appropriate statistical parameter is varied amongst statisticians. Some suggest use of risk ratio[2], or absolute risk reduction[3], while others advocate use of the number needed to treat criteria[4,5] , whereas some consider the odds ratio to be the method of choice [6]. It is quite intuitive that the choice of statistical parameter used depends on the study and its design. Odds ratio is recommended in dealing with retrospective and cross-sectional studies as their aim is to determine the association rather than differences between the groups in question, and where the risk ratio or risk difference cannot be meaningfully calculated. Odds ratio is also used in case-control studies, in which the risk ratio cannot be estimated. The risk ratio or risk difference is recommended in follow-up studies.

The odds ratio for an event that occurred is the inverse of the odds ratio for the event that did not occurred as the odds ratio is symmetrical with regard to the outcome definition. In the case of risk ratio, this symmetry is lacking, so it is necessary to estimate both risk ratio for event that occurred and for event that did not occurred. A criterion under which a measure of association remains invariant to the omission of certain variables is referred as collapsibility. It is the property of risk ratio but not of odds ratio and thus the size of the risk ratio does not vary even if adjustment is made for a variable that is not a confounder. Owing the property of collapsibility, the risk ratio, assuming no confounding factors were involved, has a useful interpretation as the ratio changes to average risk due to exposure among the exposed. Odds ratio does not carry the property of collapsibility, so they lack any interpretation either as the change in average odds or the average change in odds (the average odds ratio) [7].

UNDERSTANDING THE RATIO

In simple terms, the comparison between the two groups by division rather than subtraction is called a ratio. A ratio of 1 for either the odds ratio or the risk ratio implies perfect similarity between the two groups. As the ratio deviates from 1, it indicates dissimilarity between the groups. Higher the ratio deviates from 1, greater is the dissimilarity.

Although ratios are skewed measures, deviations less than 1 are compressed compared with deviations greater than 1. For example, a ratio of 0.80 on the low end and a ratio of 1.25 on the high end both represent a comparable amount of dissimilarity. It might look strange, but it helps in representing the ratios as fractions (4/5 and 5/4, respectively). Similarly, a ratio of 0.67 (2/3) on the low end corresponds to a ratio of 1.5 (3/2) on the high end [8].

UNDERSTANDING THE ODDS AND THE RISK

The odds are a way of representing probability, especially familiar with people involved in betting: the probability of an event divided by the probability of the event not happening. Thus, the odds of an event would be probability/ (1– probability). As it is a ratio, their values range from zero to infinity.

Risk is the number of subjects who experience an event divided by the total number of subjects at risk of having that event. The risk itself is the probability of an event occurring. It is usually expressed as a proportion or as a percentage.

To make it clear, we can say odds of an event is the number of those who experience the event divided by the number of those who do not. It is expressed as a number from zero (event will never happen) to infinity (event is certain to happen).

Odds are fairly easy to interpret when they are greater than one, but difficulty arises when the value is less than one. Thus, odds of six, i.e., six to one, imply that six people will experience the event for every single that does not (a risk of six out of seven or 86%). An odds of 0.2, however seems less intuitive: 0.2 people will experience the event for every single that does not. This translates to one event for every five non-events (a risk of one in six or 17%).

Suppose, we consider getting a flight cancelled as a risk and the airport authority announces that; the probability of getting a flight cancelled is 10% or 0.10 (may be due to bad weather), then it becomes quite easy to understand that, the risk of getting a flight cancelled is 10% or 0.10, but what about the odds of cancellation? The odds of cancellation would be 0.10/ (1-0.10) or 0.10/0.90 = 0.11, so the odds of the cancellation 1/9 means one chance “yes” to 9 chance “no”. When the chance of cancellation is low, the risk (0.10) and odds (0.11) of cancellation are similar, and the terms could be used interchangeably. Now let’s consider a situation, where winters are in full swing and the airport authority suggests that there is 90% probability of getting a flight cancelled (may be due to fog (!)). The risk of cancellation this time would be 90% or 0.9 but notice the change in odds of cancellation which turns out to be 0.90/(1-0.90) or 0.90/0.10 = 9.0, so with the fog all over; the odds of the flight cancellation are 9/1 means nine chances “yes” to one chance “no”.

The odds and risk both sometimes can be understood interchangeably but the relation is not straight forward. Table no. 1 shows the odds for various risks. For risk of less than about 20% the odds are not greatly dissimilar to the risk, but as the risk climbs above 50% the odds start to look very different.

Risk	Odds
0.05 or 5%	0.053
0.1 or 10%	0.11
0.2 or 20%	0.25
0.3 or 30%	0.43
0.4 or 40%	0.67
0.5 or 50%	1
0.6 or 60%	1.5
0.7 or 70%	2.3
0.8 or 80%	4
0.9 or 90%	9
0.95 or 95%	19

Table No.1 Risk and Odds one-on-one.

Table no. 2 represents data from a hypothetical randomized trial of a drug D. Now, we should be able to determine the risk and odds. The risk of death among patients who received drug D is 0.25 and the odds of death for the same group is 0.33. The risk of death among patients given placebo is 0.50 whereas, the odds for the same group is 1. From this we can draw an inference that odds and risk should not always be used interchangeably.

Treatment	Outcome No.		Risk of death	Odds of death
	Died	Survived		
Drug D	25	75	25/(25+75)= 0.25	25/75=0.33
Placebo	50	50	50/(50+50)=0.50	50/50=1.00

Table No: 2 Hypothetical data for the trial of drug D.

UNDERSTANDING THE ODDS RATIO

The odds ratio is a tool for statistical analysis, which may be used to assess the risk of a particular outcome, if a certain factor (or exposure) is present. It may be used in case control studies, cohort studies, or clinical trials. The odds ratio is a measure of effect size, describing the strength of association or non-independence between two binary data values [9-11], and how much more likely that someone who is exposed to the factor under study will develop the outcome as compared to someone who is not exposed. Increasingly, they are being used to report the findings from the primary studies in generating the systematic reviews and meta-analyses. Although Odds ratio is a way of presenting probabilities, they are sometimes hard to comprehend directly and are usually interpreted as being equivalent to the risk ratio [12, 13]. As it has been discussed in table no. 1, there is a recognised problem that, odds of an event do not approximate well to the risk of that event when the initial risk, i.e. the prevalence of the outcome of interest is high, so the same problem extends while interpreting odds ratio and risk ratio interchangeably. As the name implies, an odds ratio is the odds of the outcome in one group divided by the odds of the outcome in the other group, analogous to risk ratio. As a ratio, it extends from zero to infinity (figure no. 1).

$$\text{Odds ratio} = \frac{P_1/(1-P_1)}{P_2/(1-P_2)}$$

Figure No. 1

Here, P_1 refers to the probability of the outcome in group 1, and P_2 is the probability of the outcome in group 2. We assume that the table no. 2 represents the data from some clinical finding, and we have to report the result in the terms of odds ratio. The odds ratio can be calculated as follow (figure no. 2);

$$\text{Odds ratio} = \frac{\text{Odds of death in drug D arm}}{\text{Odds of death in placebo arm}}$$

$$\text{Odds ratio} = \frac{0.33}{1.00}$$

$$\text{Odds ratio} = 0.33$$

Figure No. 2

If the odds ratio is less than one, then the event is less likely to happen (event of death in this example). If the odds ratio is greater than one, then the event is more likely to happen than not.

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UNDERSTANDING THE RISK RATIO

The risk ratio of a treatment is simply the ratio of risk of the treated and the control group (placebo arm in our example), also called the relative risk. Thus, the risk ratio allows us to quantify the magnitude of influence a factor's (drug D in our example) presence has on the outcome. Risk ratio is readily understood as compared to that of odds ratio. For example; a risk ratio of 0.25 shows that the initial risk has been reduced to one fourth; a risk ratio of 2 shows that the initial risk has been increased twice.

Now we will again consider the example of table no. 1 to further explain the concept of risk ratio. The risk ratio for the given data can be calculated as follow (figure no. 3);

Here, the risk ratio of 0.5 indicates that the risk of death is reduced to half in the drug D arm.

$$\text{Risk ratio} = \frac{\text{Risk of death in drug D arm}}{\text{Risk of death in placebo arm}}$$

$$\text{Risk ratio} = \frac{0.25}{0.50}$$

Risk ratio = 0.5

Figure No. 3

As in the previous discussion, It can be inferred that the probability can simply be considered as the risk, provided one is concerned about the probability of unwanted event, so one can replace the probability with risk and a formula can be devised for conversion of risk to odds and vice a versa as shown in table no. 3.

Risk to Odds	Odds to Risk
Risk/(1-Risk)=Odds	Odds/(Odds+1)= Risk
Example: Calculation of odds from the risk (for the drug D arm) using data from the table No. 1	Example: Calculation of Risk from the Odds (for the drug D arm) using data from the table No. 1
Odds of death = 0.25/(1-0.25) = 0.33	**Risk of death = 0.33/(0.33+1) = 0.25**

Table no. 3 Converting Risk to Odds and Odds to Risk

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There are methods available to approximate the risk ratio from an adjusted odds ratio [14, 15]. The formula proposed by Zhang and Yu [15] **Error! Bookmark not defined.**(figure no. 4) can be use useful while converting risk ratio to odds ratio and vice versa:

$$\text{Risk ratio} = \frac{\text{Odds ratio}}{[(1-P_0)+(P_0 \times \text{Odds ratio})]}$$

Figure No. 4

Where, P_0 is the proportion of those unexposed who develop the outcome. As the background rate of the outcome gets low (i.e., P_0 approaches zero in the "rare disease assumption"), the denominator in brackets approaches 1.0, and the risk ratio approaches the odds ratio.

CONCLUSION

The sole intent of above discussion and the hypothetical examples were aimed at making the odd not so odd and risk even less risky. It is important that one should know the difference between the odds and risk ratio. One must be aware of the fact that; they both depend on the risk and odds in their respective groups. Odds ratio may be non-intuitive but with the clear understanding of the situation as to where they should be used, can make them more obvious to understand.

A simple approach is described that permits the understanding for odds ratios and risk ratios. A practical way to determine the association of an exposure with a condition is to prospectively follow two groups, one exposed and the other unexposed, and then observe the frequency with which each group develops the condition. The risk ratio (relative risk) may be defined as the ratio of the frequency of an outcome between an exposed and unexposed group. This ratio indicates how many more times likely an outcome occurred in a group exposed to a certain factor. If the size of population is unknown and estimation of the risk of an outcome with an exposure is complicated, we can determine an odds ratio by comparing a group with the condition to one without. Further, one can evaluate the likelihood of exposure to be found in the group with the condition to that of without.

The utility of both risk and odds ratios is often enhanced with the information about frequency of the outcome disease and the prevalence of exposed risk factor. The discussion above has made it clear that odds ratio and risk ratio can be used interchangeably only while reporting the event of rare occurrence.

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