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Quantifying Associations: Understanding Relative Risks and Odds Ratios

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During a prenatal visit, the couple asks you about the risks and benefits of circumcision. They have heard that circumcised boys are less likely to get urinary tract infections (UTIs), but they want to understand how much the risk is decreased. In your literature search, you find this article:

Craig JC, Knight JF, Sureshkumar D, et al. Effect of circumcision on incidence of urinary tract infection in preschool boys. *J Peds.* 1996;128 (1):23–27.

This is a case-control study (n = 886) designed to determine whether circumcision decreases the risk of symptomatic UTI in boys younger than 5 years of age. Participants were recruited from a large pediatric ambulatory center. The authors use odds ratios (ORs) to report their results. How can you use this information to help answer the family's question?

Relative risks (RRs) and ORs are measures used to quantify associations between an *exposure* and an *outcome*. In epidemiology texts, exposures generally are environmental or infectious, and outcomes may include death or development of disease. In clinical trials, the intervention being studied (eg, a medication) is the exposure, and the outcome is a specific clinical end point (eg, resolution of symptoms).

Constructing a 2 × 2 Table

When assessing associations between an exposure and an outcome, it is helpful to construct a 2 × 2 table (Table 1).

To determine whether the exposure is associated with the outcome,

we must compare the *risk* of developing disease in the two groups. For example, is circumcision (exposure) associated with UTI (outcome) (Table 2).

Risk

The *absolute risk* of developing disease is calculated by dividing the number of people who develop disease by the total number of people in a given exposure group (a/a + b). The absolute risk of UTI in the circumcision group above is $5/5 + 95 = 0.05$ or 5%. By itself, the absolute risk in the exposed group tells you only the magnitude of risk in that group. It does not account for the degree of baseline risk in the unexposed group. In other words, it does not allow you to answer the question of how much *more likely* is a circumcised child to have a UTI than an uncircumcised child. RRs and ORs can be used to describe this kind of excess risk.

The *RR* compares the probability of an outcome in the exposed group to the probability of the outcome in the unexposed group $[(a/a + b)/(c/c + d)]$. In our example, the RR of UTI in the circumcised

Table 1. **Standard 2 × 2 Table**

	Outcome	
	Disease	No Disease
Exposure		
Exposed	a	b
Not Exposed	c	d

Table 2. UTI in Boys in Hypothetical Study

	UTI	No UTI
Circumcised	5	95
Uncircumcised	200	800

group is $(5/5 + 95)/(200/200 + 800) = 0.25$. Therefore, a child in the circumcised group is 0.25 times as likely to develop a UTI as a child in the uncircumcised group. In other words, his risk of developing a UTI is decreased by 75%.

Odds Ratio

Another way to describe associations uses a proportion of odds known as the *OR*. Odds represent a ratio of the probability that an event will occur to the probability that it will not $(a/a + b)/(b/a + b) = a/b$. Odds are not the same as probabilities. For example, if one of four people has freckles, the odds of having freckles are 1:3, but the probability of having freckles is 1/4. In our example, the odds of developing a UTI in the circumcised group is 5/95 or 0.05, meaning that 0.05 circumcised boys will develop a UTI for every one who does not. Essentially, the probability that a circumcised boy will *not* develop a UTI is much greater than the probability that he will.

The OR represents the odds of an outcome in one group compared with the odds of that outcome in another $(a/b)/(c/d) = ad/cb$. In our example, the OR comparing the odds of developing a UTI in the circumcised group to the odds of developing a UTI in the uncircumcised group is $(5/95)/(200/800) = 0.21$. So, the odds of developing a UTI are reduced by 79% with circumcision.

Interpreting Relative Risks and Odds Ratios

RR and OR are ratios; therefore, if the RR or OR = 1, the risk or odds for exposed individuals is the same as the risk or odds for unexposed individuals. When this occurs, there is no evidence of association between the exposure and the outcome. However, if the RR or OR is >1, the risk or odds in the exposed group is greater than the risk or odds in the unexposed group. This finding is a *positive association*. If the RR or OR is <1, the risk or odds in the exposed group is less than the risk or odds in the unexposed group. This finding is a *negative association*. Additional statistics must be used to determine whether an association represents a statistically significant difference between the two groups.

Choosing the Appropriate Statistic

Which statistic researchers choose to report their findings depends upon the study question and design. RR applies to studies that start with exposures and end with outcomes (prospective cohort, clinical trials). OR applies to studies that start with outcomes and look back to determine exposure status (case-control, retrospective cohort, cross-sectional).

Although RR is understood more intuitively by most people, the OR has some advantages. First, OR has the benefit of yielding the same result whether your outcome of interest is an event (eg, UTI) or the corresponding nonevent (eg, no UTI). Second, in some instances, it is easier to adjust for confounders when using OR. Confounders are factors associated with both the outcome and the exposure (eg, age). The term *adjusted OR (aOR)* refers to the new OR value that results after controlling for confounders.

Odds Ratio as an Approximation of Relative Risk

Despite the advantages of OR, many clinicians and researchers still want to understand associations in terms of risk. OR and RR are related, and in many studies their values are quite similar, but they are not interchangeable. Interpreting the OR as the RR will overstate the effect of an exposure. However, OR can be considered a reasonable approximation of RR in studies in which the outcome of interest is rare in both groups. If the outcome occurs >10% to 20% of the time in either group, however, the OR and RR diverge.

In the article by Craig et al, the aOR comparing odds of UTI in circumcised boys to uncircumcised boys is 0.18 (95% confidence interval: 0.1–0.8). This negative association between circumcision and UTI is statistically significant. Because UTI occurs 20% of the time in the uncircumcised group, you cannot use the aOR as an approximation of RR. Your interpretation is that the odds of a circumcised boy having a UTI are 0.18 times the odds of an uncircumcised boy having a UTI. You explain to the family that, in this study, the odds of UTI are decreased by ~80% in the circumcision group.

Suggested Reading

Craig JC, Knight JF, Sureshkumar P, Mantz E, Roy LP. Effect of circumcision on incidence of urinary tract infection in preschool boys. *J Pediatr.* 1996;128(1): 23–27

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