What’s the Relative Risk? A Method to Directly Estimate Risk Ratios in Cohort Studies of Common Outcomes

ANTHONY S. ROBBINS, MD, PhD, SUSAN Y. CHAO, MS, AND VINCENT P. FONSECA, MD, MPH

INTRODUCTION

For many years, health researchers have been taught about the dangers of using odds ratios (ORs) to approximate risk ratios (RRs). The RR is usually what is in mind when the term “relative risk” is used. When the outcome of interest, e.g., a case of a disease, is common in the study population, ORs may seriously overestimate the true effect of an exposure on the outcome of interest (as measured by the risk ratio [RR]). Since few study designs require ORs (most frequently, case-control studies), their popularity is due to the widespread use of logistic regression. Because ORs are used to approximate RRs so frequently, methods have been published in the general medical literature describing how to convert ORs to RRs; however, these methods may produce inaccurate confidence intervals (CIs). The authors explore the use of binomial regression as an alternative technique to directly estimate RRs and associated CIs in cohort studies of common outcomes.

METHODS: Using actual study data, the authors describe how to perform binomial regression using the SAS System for Windows, a statistical analysis program widely used by US health researchers.

RESULTS: In a sample data set, the OR for the exposure of interest overestimated the RR more than twofold. The 95% CIs for the OR and converted RR were wider than for the directly estimated RR.

CONCLUSIONS: The authors argue that for cohort studies, the use of logistic regression should be sharply curtailed, and that instead, binomial regression be used to directly estimate RRs and associated CIs.

Ann Epidemiol 2002; 12:452–454. © 2002 Elsevier Science Inc. All rights reserved.

KEY WORDS: Cohort Studies, Regression and Analysis, Logistic Models, Odds Ratio.
thus avoiding the need to convert them (or their confidence limits) from ORs. We describe how to do this using the SAS System for Windows (9), a statistical analysis program that is widely used by US health researchers.

**METHODS**

Recent releases of the SAS System for Windows have included a generalized linear modeling procedure known as PROC GENMOD (10). In PROC GENMOD, the user can specify a number of features of the regression model, such as the distribution of the dependent variable, the link function, and whether an offset term is to be used. To perform the popular logistic regression procedure, users would specify a binomial distribution and a logit link. (If we denote a probability as \( p \), the logit of \( p \) refers to the quantity \( \log [p / (1 - p)] \)). However, to perform binomial regression, users would specify a binomial distribution and a log link. By choosing certain options related to the output format, users can have SAS report the results as RRs with associated 95% CIs. (Please, see the Appendix for sample SAS code.) While usually not noticeable because of the widespread availability of powerful personal computers, it must be acknowledged that the fitting of RR models is more difficult computationally. Use of the logit link ensures a fitted probability between 0 and 1; the log and identity link do not.

**RESULTS**

Table 1 shows results from analysis of data from a cohort of 16,778 men on active duty in the US Air Force. These men were given a test that had a binary (pass/fail) outcome, and the values of several predictor variables were measured prior to testing. Only results relating to the effect of obesity, defined as a body mass index (BMI, equal to weight in kg divided by height squared in m\(^2\)) \( \geq 30.0 \) kg/m\(^2\), are shown. The referent group was composed of persons with normal weight, i.e., 18.5 kg/m\(^2\) \( \leq \) BMI \( < 25.0 \) kg/m\(^2\). The outcome (test failure) was common in the study population, and thus, as expected, the OR overestimates the RR. The converted RR, using the Zhang-Yu method (2) is close to the RR estimated using SAS, but the 95% CIs from the two methods differ. If we used the OR in Table 1 as an estimate of the RR, we would have estimated that obesity increased the risk of test failure by 112%, while the RR estimated using binomial regression indicates that the actual effect of obesity is to increase the risk by only 52%. Thus, use of the OR as an estimator of the RR would have led us to overestimate the effect of obesity on risk of test failure more than twofold.

**DISCUSSION**

In order to avoid the recurring problems associated with ORs, we advocate that whenever possible, investigators directly estimate and report RRs. Of course, if an outcome is truly uncommon in a study population (< 5%), ORs will give unbiased estimates of RRs. In such cases, the difference between the OR and RR may be so small that some investigators may prefer the more convenient OR. Moreover, in cohort studies, the OR may be used as an index of association on its own, i.e., not as an estimator of the RR. Computation of ORs for cohort studies may be useful when their results are to be directly compared to those of case-control studies (which require the use of ORs) or combined with those of case-control studies, e.g., in a meta-analysis. While the consistent use of ORs for both cohort and case-control studies would increase comparability of results across study designs, we believe this benefit is outweighed by the potential for misinterpreting the OR as an unbiased estimator of the RR in cohort studies. Finally, it should be noted that in some cases, neither the RR nor the OR may be the index of choice, but instead the risk difference (RD). Wacholder (12) has given examples of research questions for which the RD would be preferred over ratio measures.

Unless investigators begin to routinely report the risk of the outcome in their study population, careful readers will frequently be left to question the validity of results reported as ORs. As demonstrated above, direct estimation of RRs and associated 95% CIs can easily be done using binomial regression in the SAS System for Windows, a statistical analysis program that is familiar to most US health researchers. The use of logistic regression, while popular, is required by few study designs (most notably, case-control

---

**TABLE 1.** Comparison of three methods for estimating relative risk in a cohort study of a common outcome

<table>
<thead>
<tr>
<th>Quantity used to estimate relative risk</th>
<th>Estimate</th>
<th>95% confidence interval</th>
</tr>
</thead>
<tbody>
<tr>
<td>Odds ratio</td>
<td>2.12</td>
<td>(1.88, 2.39)</td>
</tr>
<tr>
<td>Converted risk ratio (using Zhang-Yu method)</td>
<td>1.64</td>
<td>(1.53, 1.75)</td>
</tr>
<tr>
<td>Directly estimated risk ratio (using binomial regression)</td>
<td>1.52</td>
<td>(1.43, 1.63)</td>
</tr>
</tbody>
</table>

\(^1\)Relative risk of test failure among study subjects with obesity (referent group = persons with normal weight). See text for definitions of obesity and normal weight.

\(^2\)See text for discussion and citation of this method.
studies), and for cohort studies, should be sharply curtailed so that readers can be more assured of the validity of relative risk estimates reported in the medical literature.

This work was performed as part of the authors' duties as employees of the US Federal Government, and no other sources of support were involved. The views expressed in this paper are those of the authors only, and should not be interpreted as the official position of the US Air Force or the Department of Defense.

REFERENCES


APPENDIX

Following is sample SAS code to perform binomial regression and output risk ratio estimates and associated 95% CIs. (Other SAS statements not shown would be needed to create the data set used for this procedure.)

```
proc genmod data = temp;
model fail = under_wt over_wt obese / dist = binomial link = log;
estimate 'underweight' under_wt 1 / exp;
estimate 'overweight' over_wt 1 / exp;
estimate 'obese' obese 1 / exp;
run;
```