

## Comparison of methods for ordinal lens opacity data from atomic-bomb survivors: univariate worse-eye method and bivariate GEE method using global odds ratio

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**Abstract** In analyses of bivariate ordered polytomous cataract data from atomic-bomb survivors, we compared two methods, the univariate worse-eye method, and the bivariate generalized estimating equations (GEE's) method using global odds ratio by Williamson et al. (*Journal of the American Statistical Association*, 90, 1432–1437, 1995). When the association was large and only subject level covariates were used, model selection in the univariate and bivariate methods resulted in the same mean model and similar risk estimates. We showed that the mean parameter and the standard error (SE) in the univariate model are emphasized relative to those in the bivariate model, the biases of which are negligible when the association between both eyes is large. Large sample simulation studies indicated that the univariate Wald statistics are slightly conservative. The simulations also showed that, in bivariate cases, irrespective of the degree of association, the independence estimating equations method with robust SE, and the GEE method with model-based and robust SE are almost fully efficient in parameter estimation when only subject level covariates are included in the mean.

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**Keywords** Maximum likelihood · Ordered polytomous · Global cross ratio · IEE · AIC · QIC · Cataract