Covariate Adjustment May Not Be Better: Thresholds of Relative Risk for Reductions in MSE

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In theory, covariate-adjusted rates have smaller mean squared errors (MSE) with known variance components. In practice, variance components are unknown and their sample estimators are used instead. We develop guidelines to determine when adjusted rates have smaller MSEs than crude rates using sample estimates of cigarette smoking rates as an example. We simulated a series of populations and samples, with male-to-female ratios from 0.25 to 4, male smoking rates from 40 to 68%, and relative risk of smoking (RR = male rate / female rate) ranging from 1 to 5.67. From each population and sampling plan, sampling was simulated 10,000 times. Adjusted rates were estimated using the sample covariance between smoking and gender, and population variance of gender. The ratios of MSEs of the adjusted rates to MSEs of the crude rates were computed, and the thresholds of RRs, above which adjusted rates have smaller expected MSEs, were estimated graphically. The MSE reductions due to covariate adjustment depend on sample sizes, gender ratios and RRs. In populations with balanced gender ratios, the adjusted rates had smaller MSEs when RRs were above 1.6, 1.4, 1.3 and 1.2 for sample sizes of 25, 50, 100 and 200, respectively. In populations with unbalanced gender ratios, the RR thresholds were higher. In sum, adjusted rates should not be used in all settings, and in particular, not when both RRs and sample sizes are small.

Category: 1) Epidemiologic method
2) Survey research method
Relative Risk Threshold for MSE Reduction due to Covariate Adjustment (by population and sample sizes)

% of Males in population

- DPS
- DPP