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Mediation

Relationships between two variables are rarely simple in real world data and are often modified by the addition of a third measure, which can be a suppressor, confounder, mediator, or moderator, among other kinds. [1] Because this third variable (broadly referred to as the intervening variable) affects the relationship between an independent variable and the outcome, it’s important to test its effect correctly in order to accurately model the outcome of interest.

MacKinnon et al. evaluated the statistical power and type 1 error rates of 14 different intervening variable tests, in order to make general statistical recommendations. They found that in general, the commonly used causal steps approaches had “low Type I error rates and the lowest statistical power in all conditions studied.” [2] The rest of the methods have advantages in different situations, depending on whether certain population parameters are close to 0. [2] MacKinnon provides a lot of detail about hypothesis testing and checking assumptions for these approaches, but in general they have been replaced by computational methods. [3]

MacKinnon has more recently developed a program called PRODCLIN and an R package called “RMediation” for finding confidence intervals (CIs) for mediation effects using these computational techniques, which can be divided into four general approaches: distribution of the product, the Monte Carlo method, resampling (bootstrapping), and the asymptotic normal distribution method. MacKinnon has shown that the distribution of the product method results in “CIs with higher coverage rates, especially when the sample size is small.” [3] A small simulation study designed to test the “RMediation” package confirmed those prior results, although the package is able to calculate CIs using several bootstrap methods as well. As a result of these studies, the distribution of the product method appears to be the preferred approach to mediation analysis because “the analytical solution for testing the mediated effect already exists and is implemented in the RMediation package” and “for sample sizes less than 100, the bootstrap methods may result in undercoverage (i.e., coverage less than 95%) for the CIs, since the confidence limits vary considerably across the bootstrap samples.” [3]

Questions

1. MacKinnon was involved in all of the recommended papers for this topic. In your research, did you come across anything contradicting his work?
2. What are some issues with the distribution of the product method? Has it been validated with real-world data?
3. Have there been advancements in this field since 2011? Are there new techniques or new recommendations for the bootstrapping and distribution of the product methods?

References

1. Fairchild, A.J. and D.P. MacKinnon, *A general model for testing mediation and moderation effects.* Prev Sci, 2009. **10**(2): p. 87-99.

2. MacKinnon, D.P., et al., *A comparison of methods to test mediation and other intervening variable effects.* Psychological Methods, 2002. **7**(1): p. 83-104.

3. Tofighi, D. and D.P. MacKinnon, *RMediation: an R package for mediation analysis confidence intervals.* Behav Res Methods, 2011. **43**(3): p. 692-700.