Education for Statistics in Practice

Understanding and tackling measurement error: a whistle stop tour of modern practical methods

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Extended abstract

Measurement error and misclassification of variables are frequently encountered in many fields of research and can impact strongly on the results of statistical analyses. However, investigators often do not pay serious attention to the biases that can result from mismeasurement. This session discusses the issues raised by measurement error and practical approaches for analysis which mitigate its effects. Our aim is that participants gain the knowledge and confidence to understand the effects of measurement error and to apply techniques for measurement error correction in their own work.

The session will be arranged in sections of 20-30 minutes. The emphasis will be on practical application and worked examples will be used throughout. Examples will be given using the freely available R software. Practical resources will be made available to course participants which will facilitate application of the methods covered. The following topics will be covered.

Effects of measurement error

We will begin with an introduction to the effects of measurement error in statistical regression analyses. The primary focus will be on measurement error in explanatory covariates and on 'classical' measurement error. The later part of the course includes special sections on measurement error in outcome variables and more complex types of error.

Methods for mitigating the effects of measurement error

There is a large literature on methods for 'correcting' the effects of measurement error. This section will focus on the following methods:

- Regression calibration
- Simulation extrapolation (SIMEX)
- Likelihood-based methods
- Bayesian methods

The emphasis will be on their practical application. The advantages and limitations of the different methods will be discussed. Most methods require information on the form of the measurement error, via gold standard measures or repeated measures, or from an external source. The role of sensitivity analyses will also be considered.

Specialised types of error

A variety of measurement error structures can arise from different settings, with particular examples being in nutritional epidemiology and environmental epidemiology. We will give an overview of the impacts of different types of errors, including differential and Berkson error, and outline the extension of the earlier methods to these potentially more complex situations.

Special considerations for misclassification in categorical variables

While our main focus will be on error in continuous variables, we will also include a discussion of the effects of and methods to address misclassification in categorical variables, which is typically characterised in terms of sensitivities and specificities for dichotomous variables.

Outcome measurement error

We consider the effects of measurement error in an outcome variable, which are different from those in a covariate. The effects of measurement error in outcomes have tended to be under-studied in the past, but there is now a growing recognition of their potential impact.

Case study of a more advanced design

We will go through a detailed data example, in which we will estimate the structure of the measurement error in an exposure using regression calibration and carry out an adjusted analysis of this exposure with a time-to-event outcome. This analysis will also demonstrate methods for obtaining appropriate standard errors and confidence intervals for the association parameter of interest.

Implications for study design

We will discuss how measurement error in a covariate of interest affects power and present ways to adjust the study design to accommodate measurement error. We also briefly discuss study design issues for calibration/reliability studies.

About the presenters

Pam Shaw is an Associate Professor at the University of Pennsylvania Perelman School of Medicine (Department of Biostatistics, Epidemiology and Informatics). Dr. Shaw's research interests include measurement error, design of clinical trials, and chronic disease epidemiology. She has a particular interest in behavioral intervention studies and nutritional and physical activity epidemiology.

Ruth Keogh is an Associate Professor at the London School of Hygiene and Tropical Medicine (Department of Medical Statistics). Aside from measurement error, Ruth's research interests include missing data, survival analysis and dynamic prediction, and case-control study design and analysis. She is especially interested in applications in cystic fibrosis and nutritional epidemiology.

Drs Shaw and Keogh are representing the **STRATOS initiative**'s measurement error topic group, which is led by Professor Laurence Freedman and Dr Victor Kipnis.

References

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