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CAUSAL INFERENCE

Special Issue on Causal Inference

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Special Issue on Causal Inference

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Abstract

We provide a brief editorial introduction to a special issue of *The International Journal of Biostatistics* dedicated to several papers presented at a workshop held at the Banff International Research Station, Canada, in May 2009.

KEYWORDS: causal inference

The goal of most, if not all, scientific investigation is to uncover causal relationships. Although many standard inferential procedures may be able to conclude that an observed association between two variables is not simply due to chance, they cannot in general say whether the relationship is causal. Causal inference attempts to uncover the generating structure of a dataset and eliminate all non-causative explanations for an observed association. An explicit introduction of the philosophy of and approaches to causation was brought to the statistical literature in 1986 by Paul Holland, although references to causal approaches exist in the literature up to 60 years prior (see, for example, Neyman, 1923, or Rubin, 1974). In recent decades, research on causality has flourished in a variety of disciplines.

In May 2009, a small group of inter-disciplinary researchers gathered at the Banff International Research Station to review recent advances in causality. The workshop brought together researchers from statistics, economics, computer sciences, and epidemiology with a common interest in quantitative methods for causal inference. Participants came from Canada, the United States, England, Belgium, and Finland. Five main themes were considered: inference and asymptotic theory, balancing scores and inverse weighting, instrumental variables, adaptive treatment regimes, and Bayesian causal inference. This special issue of the *International Journal of Biostatistics* brings together 18 papers covering a range of topics from each of these themes, opening with a review of the principles of a causal analysis by Judea Pearl.

Causal inference provides a natural testbed for classical asymptotic theory, in particular, semiparametric inference. Several topics were discussed at the meeting; here, van der Laan discusses aspects of targeted maximum likelihood estimator for causal parameters, considering cross-validation to select optimal combinations of many model fits. Small et al. study vaccine efficacy in the context of malaria using a counterfactual framework. VanderWeele presents several results for attributable fractions for sufficient cause interactions, including applications to marginal structural models. Noorbaloochi et al. consider bias reduction and confounding in terms of sufficiency and ancillarity.

Several perspectives on the estimation of optimal dynamic treatment regimes (Murphy, 2003; Robins, 2004) and structural nested models were offered at the meeting. Orellana et al. discuss theoretical properties of dynamic marginal structural models and Cain et al. apply the approach to a large observational study, while Arjas and Saarela consider a Bayesian predictive approach to dynamic treatment regime estimation. Joffe et al. offer a comprehensive presentation of selective ignorability assumptions which can be used to derive valid causal inference in conjunction with structural nested models. Rich et al. introduce model-checking for g-estimation of structural nested models.

Investigations of marginal structural models and inverse weighted estimators (Robins, 1999; Robins et al., 2000) were undertaken by several participants. Rosenblum and van der Laan present targeted maximum likelihood estimation of the parameters of a marginal structural model. Xiao et al. consider the marginal structural Cox model with a novel weighting scheme. Ertefaie and Stephens compare the performance of inverse probability of treatment weighting and propensity scores in the estimation of direct effects. Lefebvre and Gustafson study model mis-specification in regression and doubly-robust inverse probability of treatment weighting.

Many of the methods of causal inference including regression on propensity scores, marginal structural models, and instrumental variables require two-step approaches in which a number of nuisance parameters must be estimated. A Bayesian framework allows for cohesive propagation of the uncertainty in the models. McCandless et al. address Bayesian techniques to adjust for unmeasured confounding, and proposes novel methods for observational studies with binary covariates that models the confounding effects of measured and unmeasured confounders as exchangeable. Gustafson considers the case of non-identified models from a Bayesian perspective, with an emphasis on the example of instrumental variables analysis.

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