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Modelling Causal Effects from Complex Longitudinal Data via Point Effects of Treatments

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Abstract : Background and purpose: In many practices, one estimates causal effects arising from a complex stochastic process, where a sequence of treatments are assigned to influence a certain outcome of interest, and there exist time-dependent covariates between treatments. When covariates are plentiful and/or continuous, statistical modeling is needed to reduce the huge dimensionality of the problem and allow for the estimation of causal effects. Recently, Wang and Yin (Annals of statistics, 2020) derived a new general formula, which expresses these causal effects in terms of the point effects of treatments in single-point causal inference. As a result, it is possible to conduct the modeling via point effects. The purpose of the work is to study the modeling of these causal effects via point effects. Challenges and solutions: The time-dependent covariates often have influences from earlier treatments as well as on subsequent treatments. Consequently, the standard parameters – i.e., the mean of the outcome given all treatments and covariates-- are essentially all different (null paradox). Furthermore, the dimension of the parameters is huge (curse of dimensionality). Therefore, it can be difficult to conduct the modeling in terms of standard parameters. Instead of standard parameters, we have use point effects of treatments to develop likelihood-based parametric approach to the modeling of these causal effects and are able to model the causal effects of a sequence of treatments by modeling a small number of point effects of individual treatment Achievements: We are able to conduct the modeling of the causal effects from a sequence of treatments in the familiar framework of single-point causal inference. The simulation shows that our method achieves not only an unbiased estimate for the causal effect but also the nominal level of type I error and a low level of type II error for the hypothesis testing. We have applied this method to a longitudinal study of COVID-19 mortality among Scandinavian countries and found that the Swedish approach performed far worse than the other countries' approach for COVID-19 mortality and the poor performance was largely due to its early measure during the initial period of the pandemic.

Keywords : causal effect, point effect, statistical modelling, sequential causal inference
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