



# Semiparametric methods for left-truncated and right-censored survival data with covariate measurement error

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## Abstract

Many methods have been developed for analyzing survival data which are commonly right-censored. These methods, however, are challenged by complex features pertinent to the data collection as well as the nature of data themselves. Typically, biased samples caused by left-truncation (or length-biased sampling) and measurement error often accompany survival analysis. While such data frequently arise in practice, little work has been available to simultaneously address these features. In this paper, we explore valid inference methods for handling left-truncated and right-censored survival data with measurement error under the widely used Cox model. We first exploit a flexible estimator for the survival model parameters which does not require specification of the baseline hazard function. To improve the efficiency, we further develop an augmented nonparametric maximum likelihood estimator. We establish asymptotic results and examine the efficiency and robustness issues for the proposed estimators. The proposed methods enjoy appealing features that the distributions of the covariates and of the truncation times are left unspecified. Numerical studies are reported to assess the finite sample performance of the proposed methods.

**Keywords** Cox model · Efficiency · Left-truncation · Measurement error · Right censoring

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