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Medical cost analysis: Application to colorectal cancer data from the SEER Medicare database

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Abstract

Incompleteness is a key feature of most survival data. Numerous well established statistical methodologies and algorithms exist for analyzing life or failure time data. However, induced censorship invalidates the use of those standard analytic tools for some survival-type data such as medical costs. In this paper, some valid methods currently available for analyzing censored medical cost data are reviewed. Some cautionary findings under different assumptions are envisioned through application to medical costs from colorectal cancer patients. Cost analysis should be suitably planned and carefully interpreted under various meaningful scenarios even with judiciously selected statistical methods. This approach would be greatly helpful to policy makers who seek to prioritize health care expenditures and to assess the elements of resource use.

Keywords: Censoring; Colorectal cancer; Composite endpoints; Inverse probability weighting; Median regression; Medical cost

1. Introduction

Until the late 1970s, the so-called "open checkbook era", medical cost meant money to be spent on doctors' services and brand new medical facilities, and there was no notion of competition, management or opportunity. Thus, medical expenses were not treated or controlled economically. In

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the late 1980s, an aggressive, concerted voice started to ask for control of health care costs and fiscal accountability in medicine. A host of complex decisions and debates concerning trade-offs between costs and patient benefits arose [1]. Practitioners and economists' roles in collection, analysis and interpretation of medical costs started to be emphasized in health economic studies. It is unlikely that physicians would advise an intervention over another strictly on economic grounds. Nonetheless, there is no doubt that the cost is becoming a more influential factor that drives a choice of treatment in the patient side.

Since the effectiveness of a clinical practice in medical outcome(s) almost always has a higher priority, costs are conventionally evaluated in a substudy so as to assess its economic implication in an ancillary manner. The mean as a population quantity is popular among policy makers and health care providers because the total cost can be derived from the mean. It also serves an essential part in determining cost-effectiveness (CE). However, other measures for the central tendency such as the median, which is guaranteed to be less sensitive and, equivalently, more robust to outliers, may be more appropriate because a small percentage of patients invariably incur extremely high costs relative to most patients. The notion of least absolute deviation (e.g., median or quantile) has been widely adopted in econometrics, but it is comparatively new in biostatistics and related biomedical areas.

It is also important to establish the patient's characteristics, treatment procedure, and other risk factors that affect medical costs. Regression is useful to this end. The type of regression model should depend on the research goal and the scientific problem that a researcher is trying to solve (mean vs. median; linear vs. nonlinear; and fixed vs. time varying regression coefficients).

Next we turn to CE, which is normally measured by the increase in mean medical cost divided by the increase in mean lifetime between two treatment programs. There are a few variants of CE, so-called, cost-utility and cost-benefit, depending on how to translate "life" saved [2,3]. As noted before, mean cost is a key component in all these measures.

Although many acknowledge that medical costs are important health economic data and that some caution should be taken for potential survivorship bias, it has been less than a decade since growing attention was generated by two key papers in the statistical society [4,5]. The authors pointed out that most standard analysis techniques are problematic for censored cost data. Examples are numerous but to name a few: the simple mean and variance, the two sample t-test, the ordinary least squares (OLS) estimator, the Kaplan–Meier (K–M) curve, the Log-rank test and the Cox proportional hazards regression [6]. To be more explicit, the simple arithmetic mean of medical costs regardless of censoring status, which is often called "full sample estimator", is severely underestimated because potential cost expenditures to be spent after censoring are not counted. Another naive average among uncensored costs, "(unweighted) complete case estimator", is destined to be biased toward the costs of the patients with shorter survival.

The futility of most traditional survival analyses is due to, namely, informative censoring induced by the positive correlation between total cost at event and total cost at censoring. In other words, even when the survival time and the censoring time are independent (actually, censoring is independent of all other random variables), the corresponding costs are not in general despite the analogy. The behavior of bias using traditional approaches inappropriately to cost data is extensively explored through simulation and is well documented, along with the associated literature review, in the papers referenced above [4,5]. In spite of this limitation, standard survival analyses are still applied to cost data in medical and marketing fields. Even to date, two sample (testing) problems are conducted mostly for uncensored costs either parametrically or nonparametrically [7–9]. Various statistical