New approaches for the modeling of competing risks in discrete time

Moritz Berger

(Vertretungsprofessur Institut für Statistik, LMU München)

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The purpose of time-to-event analysis is to model the time span T until the occurrence of an event of interest. In many studies there is not only one single type of event but $J > 1$ possible events, called competing events. A multitude of examples are found in clinical and epidemiological studies, where competing events such as cause-specific death, the progression of a disease, or the occurrence of an infection are often strongly related and therefore need to be analyzed together. The objective is often to build a regression model that links the occurrence of the event(s) of interest to a set of explanatory variables $\boldsymbol{x} = (x_1, \ldots, x_p)^\top$.

Commonly used approaches for competing risks analysis are: (i) The modeling of the cause-specific hazard functions $\xi_j(t) = \lim_{\Delta t \to 0}\{P(t < T \leq t + \Delta t, \varepsilon = j | T > t, \boldsymbol{x}) \,/\Delta t\}$, $j = 1, \ldots, J$, where $\varepsilon \in \{1, \ldots, J\}$ is a random variable indicating the type of event at T. (ii) The modeling of the cumulative incidence function $F_j(t) = P(T \leq t, \varepsilon = j | \boldsymbol{x})$, of one specific event of interest.

Traditional methods usually assume that the event times are measured on a continuous scale. In clinical and epidemiological studies, however, the exact (continuous) event times are often not observed, but only intervals (i.e., pairs of fixed consecutive points in time) at which the events of interest took place. Thus, time is measured on a discrete scale.

To address this issue, we propose: (i) A novel approach for the modeling of discrete cause-specific hazard functions. We introduce a tree-based model, which is particularly appropriate when higher-order interactions between the explanatory variables are present. (ii) A novel approach for the direct modeling of discrete cumulative incidence functions. The model is specified in terms of a discrete subdistribution hazard function for the event of interest.

The usefulness of both approaches is demonstrated by the analysis of age-related macular degeneration (AMD) among elderly people that were monitored by annual study visits.