Wild Bootstrapping Nelson-Aalen Estimators within a Multistate Model with Application in Health Insurance Data

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Based on a huge Bavarian health insurance data set, we investigate the impact of a preceding non-femoral (osteoporotic) index fracture on the incidence of and mortality after a femoral fracture within an elderly population. In this medical context, risks are often expressed in terms of hazards as a function of 'time-on-study'. Incidence and mortality rates, commonly used for its estimation, are not suitable, since the required constant hazard assumption is often violated within medical data [1]. We present an alternative approach based on a complex fracture-death multistate model allowing for non-constant hazards. We include 'long-term' care as a time-dependent variable. 'Age' is taken into account by its consideration as underlying time-scale leading to left-truncated data. Therefore, classical Kaplan-Meier estimation is also not appropriate. In our setting, risks are non-parametrically estimated by means of Nelson-Aalen estimates and time-simultaneous statistical inference can be based on a flexible wild bootstrap approach. The idea is to keep the data fixed and to approximate the underlying limit processes by substitution of the unknown martingales with standard normal random variables. Repeated simulations enable the construction of confidence bands. Presented proofs are based on martingale limit theorems [2] and recent results on linear resampling statistics in martingale difference arrays [3]. We show that a prior index fracture increases the risk of a femoral fracture, but does not affect mortality after a femoral fracture.

[1] Grambauer, N., Schumacher, M., Dettenkofer, M., and Beyersmann, J. (2010). *Incidence densities in a competing event analysis.* American Journal of Epidemiology, 172(9):1077–1084.

[2] Andersen, P.K., Borgan, O., Gill, R.D. and Keiding, N.: *Statistical models based on counting processes*. Springer New York (1993).

[3] Pauly, M. (2011): *Weighted resampling of martingale difference arrays with applications.* Electronical Journal of Statistics. 5, 41-52.