Kaplan-Meier Curve

Ranstam J, Cook JA

Analysis of time-to-event ("survival") data requires two pieces of data that are taken into account simultaneously: i) the time period for which follow-up was available, and ii) the status at the end of the follow-up. The former variable is continuous (time) and the latter categorical, specifying whether the endpoint was the event under study, such as death or relapse had occurred, or if whether it had yet to occur when follow-up end. Follow-up times often varies between individuals in a study due to recruitment over time and also due to withdrawal from follow-up, loss-to-follow-up or the occurrence of another event (e.g. death from an unrelated cause), often referred to as a competing risk, which precludes the occurrence of the event of interest (e.g. recurrence of the disease of interest).

A Kaplan-Meier curve, is often used to visually summarise time to event data (e.g. time from diagnosis to death or time from treatment to relapse). Censored patients contribute information that no event occurred up to the point of censoring avoiding discarding this useful information. The time period is broken down into intervals and the survival rate estimated (by calculating the Kaplan-Meier estimate) based upon those at risk during each interval (those who had not had the event by start of internal and were not censored before or during the time interval). The estimates are presented as a curve where the y-axis indicates the proportion of individuals under risk of an event, and an x-axis indicating time. The curve is characterised by steps, each representing the occurrence of one or more events.

Kaplan-Meier curves are often presented with 95% confidence intervals and a difference between curves can be statistically tested, most commonly using the log-rank test. The curve can be presented upside down (by swapping the event and non-event) to focus more on the non-occurrence of the event than when it occur.

Two issues are particularly important when interpreting Kaplan-Meier curves. First, the validity of the Kaplan-Meier curve depends on the assumption that all participants in the analysis (including censored and uncensored) run the same risk of an event. This assumption is not fulfilled when censoring occurs due to an external event which precludes the event of interest. The Kaplan-Meier curve will then be, to some degree, a biased representation of the true survival curve. For example, the use of Kaplan-Meier analysis of implant survival in arthroplasty registry, will tend to overestimate the revision risk, because death precludes the revision of an implant thereby artificially inflating the apparent event risk. Methods which seek to account for such competing risks are available though not without additional assumptions.

Second, the statistical precision diminishes as follow up increases as the number of individuals contribution reduces due to either the event occurring or censoring. The impact of this can be dramatic. A single event therefore producing a much greater step in the curve the later during follow up it occurs. This is usually also reflected by the width of the curves confidence intervals. It is therefore vitally important for interpreting a curve that the number at risk is reported at key time point over the follow-up period.

References

1. Gillam MH, Ryan P, Graves SE, Miller LN, de Steiger RN, Salter A. Competing risks survival analysis applied to data from the Australian Orthopaedic Association National Joint Replacement Registry.Acta Orthop. 2010;81:548-555.

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