A Bayesian illness-death model: life expectancies with and without dementia for individuals with Parkinson's disease

Ardo van den Hout and Fiona E. Matthews

MRC Biostatistics Unit, Institute of Public Health, University of Cambridge, UK

Longitudinal data taken from a Norwegian study of individuals with Parkinson's disease are investigated with respect to the onset of dementia. Of interest is the subdivision of total life expectancy into life expectancy with and without dementia. A three-state illness-death Markov model is presented in a Bayesian framework. In state one individuals with Parkinson's disease are dementia free, whereas state two indicates the presence of dementia. State three is the death state. The Bayesian framework is well suited to allow for individual heterogeneity via random effects, and to investigate transformations of the parameters of the model. The latter is of importance since life expectancies can be computed using the parameters of the Markov model. Markov Chain Monte Carlo methods as implemented in OpenBUGS are used to estimate the model.

The model can be seen as an extension to the Bayesian model in Pan et al. [1]. In our model, intensities of moving between the states are allowed to change in a piecewise-constant fashion by linking them to age as a time-dependent covariate. Relaxing the assumption of constant intensities makes the model applicable in many situations where individuals are followed over a long time period - especially in the case of elderly people where, for instance, the probability of dying increases with time. Our parametric model for the time-dependent intensities makes it possible to extrapolate the model beyond the follow-up time, and to estimate how many years of total life expectancy will be spent in a disease state and what factors are of influence. In describing how a disease develops over time, the model can help to predict future need for health care.

In the application, the number of individuals with Parkinson's disease at baseline is 233. Measurements were taken in the period 1993 - 2002 and are interval-censored, except for the death times which are exact. The three-state model that we use does not allow for recovery from dementia. To take into account heterogeneity with respect to susceptibility to ill-health, a shared random effect is included in the loglinear model for the intensities. For the prior of this random effect we use a half-normal distribution instead of the usual inverse gamma distribution. The Deviance Information Criterion is used to select between models.

A small simulation study was conducted to investigate the possibility of detecting a shared random effect in settings comparable to our setting. Conditions that we vary are sample size and variance of the assumed normal distribution of the random effect.

References

[1] Pan SL, Wu HM, Yen AMF, Chen THH (2007) A Markov regression random-effects model for remission of functional disability in patients following a first stroke: A Bayesian approach. Statistics in Medicine: Published Online.