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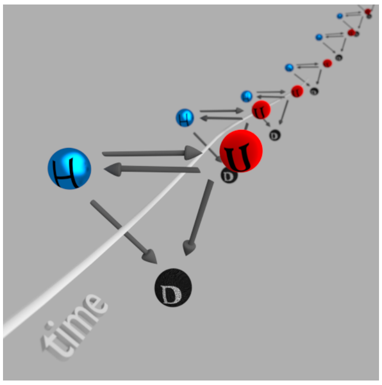


Longevity, Unhealthy Years And Burden On Different Sectors

by MOHAMED ISMAIL

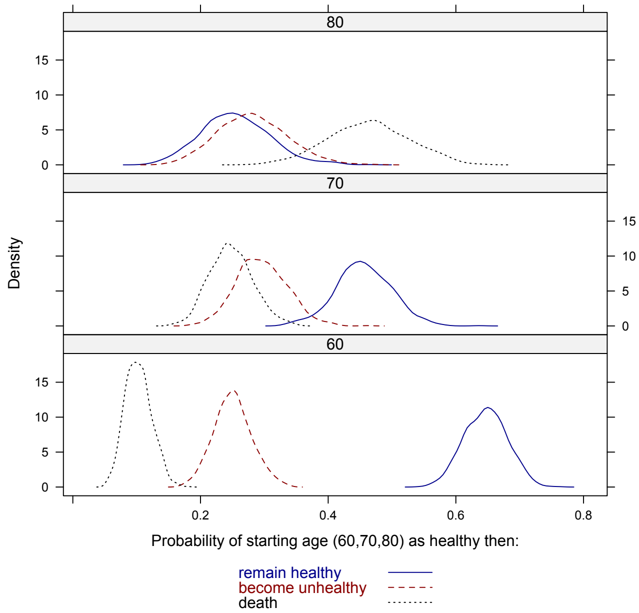
Thanks to many factors, more people are now expected to live longer than ever. This gives rise to research questions in relation to its impact on health, social care, work and pensions. Among questions that are getting popular is, how long people can work before retirement? And how long do we expect people to have an unhealthy life? The importance of accurately answering these questions is increasing in the current time. In the light of budgets' constraints, and calls for welfare reforms, improving the accuracy of estimates becomes more relevant than before. There are different methods for estimating age-related costs, however, an approach that looks over the whole life course of an individual modelling the movement in and out different states is likely to provide more accurate estimations. For example, people developing age-related conditions such as dementia, how do they move between different healthcare provisions over their life courses? This is directly linked to estimating cost across sectors. In this release we touch on a Bayesian approach that we used for this kind of analysis. This approach can answer many of the life course questions, it is flexible and not limited to just health related applications [1].

Opportunity Of New Panel Data

Several longitudinal datasets based on household surveys have recently became available for public access, most notably is Understanding Society in the United Kingdom. This allows for modelling processes such as the movement between employment, job-seeking and retirement. Other opportunities are arising from allowing access to patients' health records. For example, these datasets allow investigating the relationship between ethnicity, gender, age, education and expectancy of life with cognitive impairment.

Increment-Decrement Life Table With Multiple Covariates

Also known as Multi State Life Table, it is a powerful demographic tool for modelling transition between functional states over time intervals. For example, for estimating healthy life expectancy, a person can move between two transient states (healthy, unhealthy) or can move to an absorbing state (death). The probabilities of moving between these states over time can be estimated (transition probabilities) and active life expectancy can be calculated. A large volume of literature explains different methods of constructing such a table. Some are based on extending hazard models, others assume moving between states to follow a Markov process. The approach we explain here doesn't make these assumptions, can deal with censored data and is highly intuitive.



Transition Probabilities

Represents the chances that someone at particular age and functional status, will by next interval, experience improvement, decline, or stay in the same functional status. In increment decrement life table this is represented by a matrix of parameters reflecting the rates of movement between functioning states. Following is an example for transition probabilities matrix for moving between 3 states, healthy, unhealthy and death:

$$P(t, t+c) = \begin{pmatrix} p_{hh}(t, t+c) & p_{hu}(t, t+c) & p_{hd}(t, t+c) \\ p_{uh}(t, t+c) & p_{uu}(t, t+c) & p_{ud}(t, t+c) \\ 0 & 0 & 1 \end{pmatrix}$$

Last row is already known because death is an absorbing state, and it follows that:

$$p_{dh} = p_{du} = 0, p_{dd} = 1$$

A Bayesian Estimation

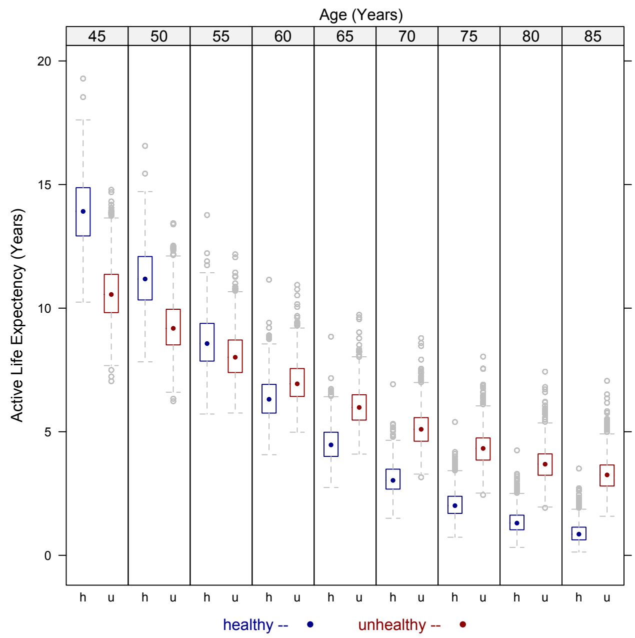
This method [2] is based on fitting a bivariate hazard model to a person-event history data; posterior distributions of coefficients are estimated using a Gibbs sampler. Distributions of transition probabilities are calculated for a particular person profile using bivariate normal integration, and calculations of active life expectancy; the average number of years that one can expect to spend in a functioning state, is attainable using exact methods.

We obtain a distribution of coefficients followed by distribution of transition probabilities for all table intervals, leading to full distributions of all life table quantities, with confidence intervals directly included. This is the major benefit of doing the estimation within a Bayesian framework. Since the data always represent a sample, we should be able to report the uncertainty over the estimations. This is in contrast with point estimation obtained from a maximum likelihood method (MLH) where it is not straightforward to report errors for the estimated life table quantities. It should be noted that there are other existing techniques that use an MLH estimation for estimating probabilities, followed by bootstrapping for calculating standard errors.

This Bayesian approach doesn't impose restrictions over time between survey interviews. Thus, the time between interviews' dates can vary considerably within the sample. Cohorts may change during the study period, the only requirement is to have two records per subject to be considered by the model. In effect, all cohorts turn into one synthetic cohort.

Example output

The top left graph is a realization for the first row of the transition probabilities matrix for a person of particular profile at ages 60, 70 and 80. The graph below shows an example summary for the distributions of healthy and unhealthy life expectancies for an individual with the same profile across ages 45 to 85.



We produced these graphs as an example to visualise real output, but the outcome of this kind of analysis and it's applications goes far beyond this.

[1] Mohamed Ismail is grateful to prof. Scott Lynch, Princeton University, for granting him access to the original code and algorithms.

[2] Lynch, S.M. and J.S. Brown. (2005), "A New Approach to Estimating Life Tables with Covariates and Constructing Interval Estimates of Life Table Quantities." *Journal of Sociological Methodology*, 35, 177-225.