Multistate model of life course events: analysis of transition to family formation and first birth with application in southern Africa

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Abstract

Fertility patterns in Southern African countries including Namibia, South Africa, Lesotho and Swaziland, have been falling to an average of TFR of 3.2 children per woman from 4.5 in the early 2000s. Changing marriage patterns, increased education level among women, and improved socio-economic status have been some of the factors associated with the declining fertility patterns. However, several pathways exist that may explain lower fertility rates, for instance sexual debut, delayed entry into marriage and or delayed first birth. Examining such pathways and associated factors may help understand the falling fertility patterns.

In this study, we use multistate models (MSM) to explore time to the event - first birth, through multiple stages. Multistate models (MSM) are useful to analyze life course events, in a situation where transitions to intermediate states are equally important, apart from the ultimate event (first birth). We extend MSM to examine factors associated with transition from birth to the woman's first birth, through intermediate stages such as sexual debut and marriage. MSM are fitted, through multiple survival models, to analyze four stages: birth[1]-first sex[2]-marriage[3]-birth[4]; or birth[1]-first sex[2]-birth[4]-marriage[3]; or birth[1]-marriage[3]-birth[4].

We apply the MSM models to study fertility patterns in Namibia, Malawi, and Swaziland using the recent Demographic and Health Surveys (2005-2013). In our model we adjusted for education level, place of residence, modern contraceptive use and other socio-demographic variables. Models were implemented using the Bayesian Inference. The sensitivity of the model to prior assumptions is explored.

1. Introduction

The sub-Saharan Africa is a region associated with a slower rate of decline in fertility compared to other regions. On average the total fertility rate (TFR) is above 5 children per woman, in 2012 (UN Statistics Division, 2014). The UN population growth projections have predicted that the rate will steadily fall to TFR of 3.2. Intra-regional variations are evident. Some countries such as Burundi, Chad, Niger, and Mali have TFR over 6. Others countries, among others, Zambia, Zimbabwe, Nigeria and Benin started a fertility transition but have now stalled. Many more have started experiencing a decline, after a stalled transition, and include countries in Ethiopia, Senegal, and Rwanda.

The decline in TFR seems to be an established trend in the region. A more promising fertility transition is being experienced in the southern countries, viz: South Africa, Namibia, Swaziland and Lesotho. Changing marriage patterns, increased education level among women, and improved socio-economic status have been some of the factors associated with the declining fertility patterns. However, several pathways exist that may explain lower fertility rates, for instance sexual debut, delayed entry into marriage and or delayed first birth. Examining such pathways and associated factors may help understand the falling fertility patterns.

In this study, we use multistate models (MSM) to explore time to the event - first birth, through multiple stages. Multistate models (MSM) are useful to analyze life course events, in a situation where transitions to intermediate states are equally important, apart from the ultimate event (first birth).

2. Methodology

We extend MSM to examine factors associated with transition from birth to the woman's first birth, through intermediate stages such as sexual debut and marriage. MSM are fitted, through multiple survival models, to analyze four stages: birth[1]-first sex[2]-marriage[3]-birth[4]; or birth[1]-first sex[2]-birth[4]-marriage[3]; or birth[1]-marriage[3]-birth[4]. Figure 1 illustrates the 4 states or stages and possible routes to the ultimate event.

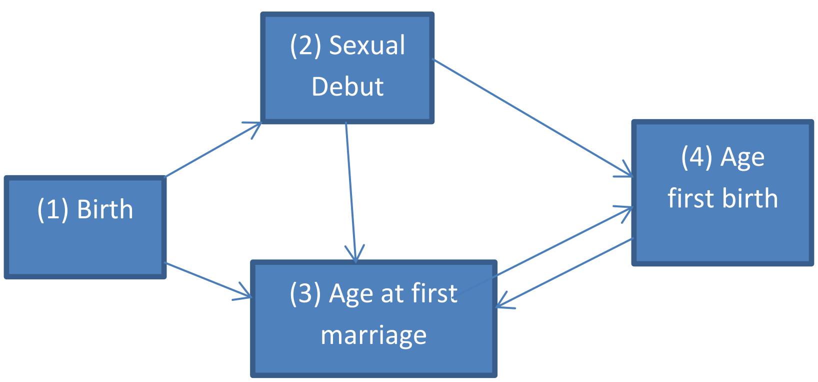

Figure 1: Illustration of multistate model from birth to the ultimate event – first birth and all intermediate states.

We define the MS model as follows. Suppose that there are R_i ways in which an episode in state i $(i = 1, \cdots s)$ can end. Denote by $h_{itk}^{(r_i)}$ the hazard of making a transition of type $r_i(r_i = 1, \cdots, R_i)$ from origin state i in time interval t for individual k. The hazard of no transition is denoted by $h_{itk}^{(0)}$. A discrete-time model for multiple states may be written

$$\log\left(\frac{h_{itk}^{(r_i)}}{h_{itk}^{(0)}}\right) = \alpha_i^{(r_i)T} + \beta_i^{(r_i)T} X_{itk}^{(r_i)} + U_{ik}^{(r_i)}, \quad r_i = 1, \cdots, R_i; i = 1, \cdots s \qquad (1)$$

In (1) duration and covariate effects may depend both on the origin state i and on the type of transition r_i. Unobserved factors, represented by $U_{ik}^{(r_i)}$, may also vary according to state and transition.

3. Data and Analysis

We apply the MSM models to study fertility patterns in Namibia, Malawi, and Swaziland. Malawi is used as a comparison country since the TFR is still high. Data are from the Demographic and Health Surveys, using the recent period (2005-2013). In order to estimate a discrete-time event history model, the data must first be restructured to what is often called a person-period format. This involves expanding the data so that there is a record for each time interval in each episode and state. In our model we adjusted for education level, place of residence, modern contraceptive use and other socio-demographic variables. Inference in our Bayesian multi state model is based on Markov chain Monte Carlo simulation algorithms that repeatedly draw random numbers from the full conditional distributions of all parameters. More specifically, we apply a Metropolis-Hastings sampler developed for semi-parametric multistate models and implemented in the software BayesX [13]. To determine the multistate model described previously, we carried out 10,000 iterations for the Markov chain Monte Carlo sample rejecting the first 5,000 as burn in and thinning the rest of the chain by a factor of 20. The sensitivity of the model to prior assumptions is explored.

References

Anderson, P.K. and N. Keiding. 2002. Multistate Models for Event History Analysis. Statistical Methods in Medical Research 11:91–115.

Lindeboom, M. and Kerkhofs, M. 2000. Multistate models for clustered duration data – an application to workplace effects on individual sickness absenteeism. The Review of Economics and Statistics, 82, 668-684.

Sneeringer, Stacy E. 2009. Fertility transitions in sub-Saharan Africa: a comparative analysis of cohort trends in 30 countries. DHS comparative reports No. 23. Calverton, Maryland USA. ICF Macro.

Steele F., Goldstein H. 2001. A General Multilevel Multistate Competing Risks Model for Event History Data, with an Application to a Study of Contraceptive Use Dynamics. Statistical Modelling, 2001.