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

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Outline

1. Introduction
   - Background
   - Objectives and Data Overview
2. Multistate model for Fertility Multiprocesses
   - Model Plausibility
   - Model specification
3. Analysis and Results
   - Data Sources
   - Results
4. Summary and Further Work
5. Selected References

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Fertility transitions in Africa

- 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.
- A more promising fertility transition is being experienced in South Africa, Namibia, Swaziland and Lesotho.

Fertility Transition and Development

- As countries develop, fertility generally falls and there is a strong inverse correlation between development indicators and fertility in contemporary societies.
- In 1980 Caldwell hypothesized that the time of the onset of the fertility transition in developing countries would be linked with the achievement of "mass formal schooling".
- Divergent views have been raised explaining stalling fertility as a new type of transition [Kabagenyi et al 2015].
- Much remains to be studied for better understanding the fertility transition in Africa.

Multiprocesses of Fertility Transition

- However, several pathways exist that may explain lower fertility rates.
- Early sexual debut, delayed entry into marriage and or delayed first birth may be important contributing factors.
- Marriage is a primary indication of the exposure of women to the risk of pregnancy and, therefore, is important for an understanding of fertility.
- In particular, Garenne and Joseph (2002) considered new patterns of marriages and unions, new forms of family life, new contraceptives.
- The transitions into marriage, first birth may be equally important.

The Processes-Proximate Determinants

- *AGE AT MARRIAGE*: Age at first marriage has a major effect on childbearing. Women who marry early will, on average, have longer exposure to pregnancy and a greater number of lifetime births.
- *AGE AT SEXUAL DEBUT*: The age at which women initiate sexual intercourse more precisely marks the beginning of their exposure to reproductive risks.
- *AGE AT BIRTH*: The age at which childbearing commences is an important determinant of the overall level of fertility as well as the health of the mother/child.
- Caltabiano and Castiglioni (2008) suggests that the sequence of these events and the intervals between them may are related to fertility patterns.

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Objectives

- Examining pathways of falling fertility patterns and associated factors in Namibia, Swaziland and Malawi.
- Apply multistate models (MSM) to explore time to the event [**FIRST BIRTH**] through multiple stages.

Case Study Countries

Map showing Namibia, Swaziland and Malawi

Fertility Patterns in Case Countries

Total Fertility Rates

Period	Namibia	Swaziland	Malawi‡
1985–1990	5.4	6.4	6.7
1991–1995	4.2	5.6	6.3
1995–2004	3.6	4.5	6.0
2005–2010	3.2	3.5	5.5

‡A comparison country as TFR is still high

Birth Interval (BI) and Children Ever Born (CEB) per woman

	Namibia	Swaziland	Malawi
BI (Median months)	45.1	37.9	36.1
CEB (All women)	1.73	2.28	2.57
CEB (Currently married)	2.78	3.58	3.20

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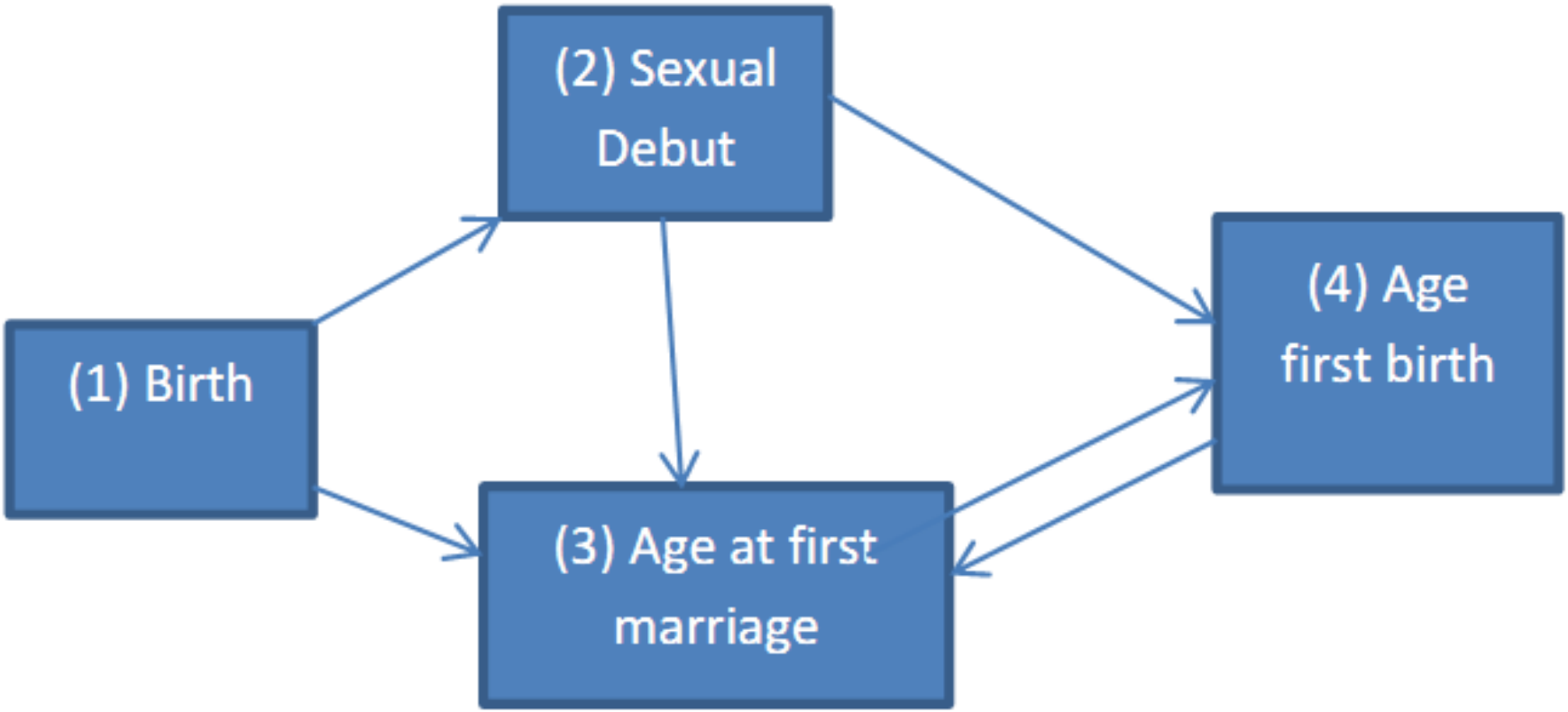
Model Plausibility

- The sequence of these events and the intervals between them were explored for reproductive age women.
- Interested in whether these events occurred simultaneously or sequentially, and if the latter, the order in which they occurred and the duration of intervals between events.
- Three multiprocesses:
  1. *A*: birth[1]–first sex[2]–first marriage[3]–first birth[4]; or
  2. *B*: birth[1]–first sex[2]–first birth[4]–first marriage[3]; or
  3. *C*: birth[1]–first marriage[3]–first sex[2]–first birth[4].
- Interest is in the order and intervals between events.
- Hazard models were used to identify transitions and factors associated with behavioral changes over time.

Schema for Sequence of Events



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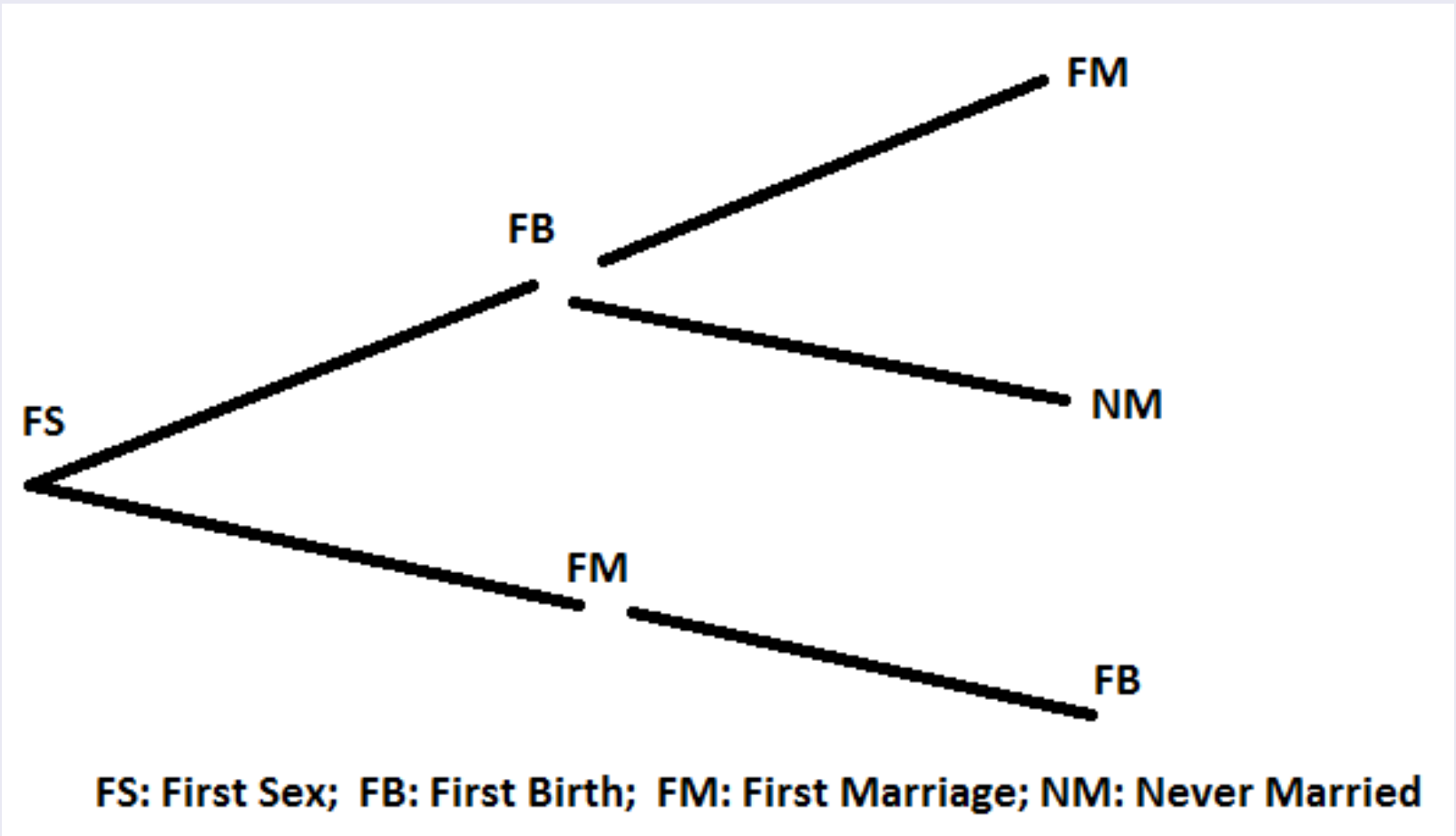
Possible Transitions in First Sequence [Steele et al. (2005) and Caltabiano and Castiglioni (2008)]



Model for Transitions Between First Sex and Single States

- Transitions from FS to FB (may be multiple transitions (j) per individual (i)):
  $logit[h_{ij}^{FS}] = \alpha^{FS}(t) + \beta^{FS} x_{ij} + u_j^{FS}$
- Transitions from FS to FM (actually fit separate eq. for first S-P transition):
  $logit[h_{ij}^{FM}] = \alpha^{FM}(t) + \beta^{FM} x_{ij} + u_j^{FM}$
- Fit the models simultaneously.
- Allow correlation between u_j^{FS} and u_j^{FM}:
  u_j^{FS} and $u_j^{FM}, i.e. Cov(u_j^{FS}, u_j^{FM}) = \sigma_U^{FS,FM}$

Model specification: Dealing with Discrete-Time [Steele et al. 2005]

- First Approach:
  - Specify a single equation model with dummy variables for each state. Interact dummies with duration and covariates to obtain state-specific duration and covariate effects.
  - Allow coefficient of each dummy to vary and covary randomly across individuals.
- Second approach-Competing Risks approach:
  - Model the cause-specific hazards simultaneously using a multinomial logistic model.
  - E.g. for Sequence 1, estimate 2 contrasts: marriage vs. single ("no event"), cohabitation vs. single.
  - Another competing risks approach: Model each competing risk separately, treating all other events as censored.

Multinomial Approach to Multi-State Models

- 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 is written:
  $\log\left(\frac{h_{itk}^{(r_i)}}{h_{itk}^{(0)}}\right) = \alpha_i^{(r_i)T} + \beta_i^{(r_i)T} X_{itk}^{(r_i)} + U_{ik}^{(r_i)}, \quad r_i = 1, \cdots, R_i; i = 1, \cdots s$, where $(u_j^{(1)}, u_j^{(2)}, \cdots, u_j^{(R)}) \sim MVN(0, \Sigma)$.
- In eqn. above, 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.

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Demographic and Health Surveys (DHS)

- 2013 Namibia DHS
- 2006/07 Swaziland DHS
- 2010 Malawi DHS
- Covariates for the 3 countries:
  1. Education level
  2. Wealth Index
  3. Region
  4. Type of Place of Residence
  5. Working status

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Descriptive Summaries [1]

Age at First Sex

	Namibia	Swaziland	Malawi
Median Age	19.0	18.0	17.3
By exact age (%)			
18 yrs	34.8	50.1	59.9
20 yrs	59.0	71.5	79.8
22 yrs	92.0‡	81.6	87.9
25 yrs	95.0‡	85.5	91.4

‡ Approximated

Age at First Marriage

Period	Namibia	Swaziland	Malawi
Median Age	22‡	20.0	17.8
By exact age (%)			
18 yrs	8.1	14.9	52.2
20 yrs	14.3	26.3	75.6
22 yrs	21.1	36.2	87.1
25 yrs	32.1	48.5	94.5
Percent Never Married	41.5	23.2	1.5

‡ Age at cohabitation. Actual marriage much later

Descriptive Summaries [2]

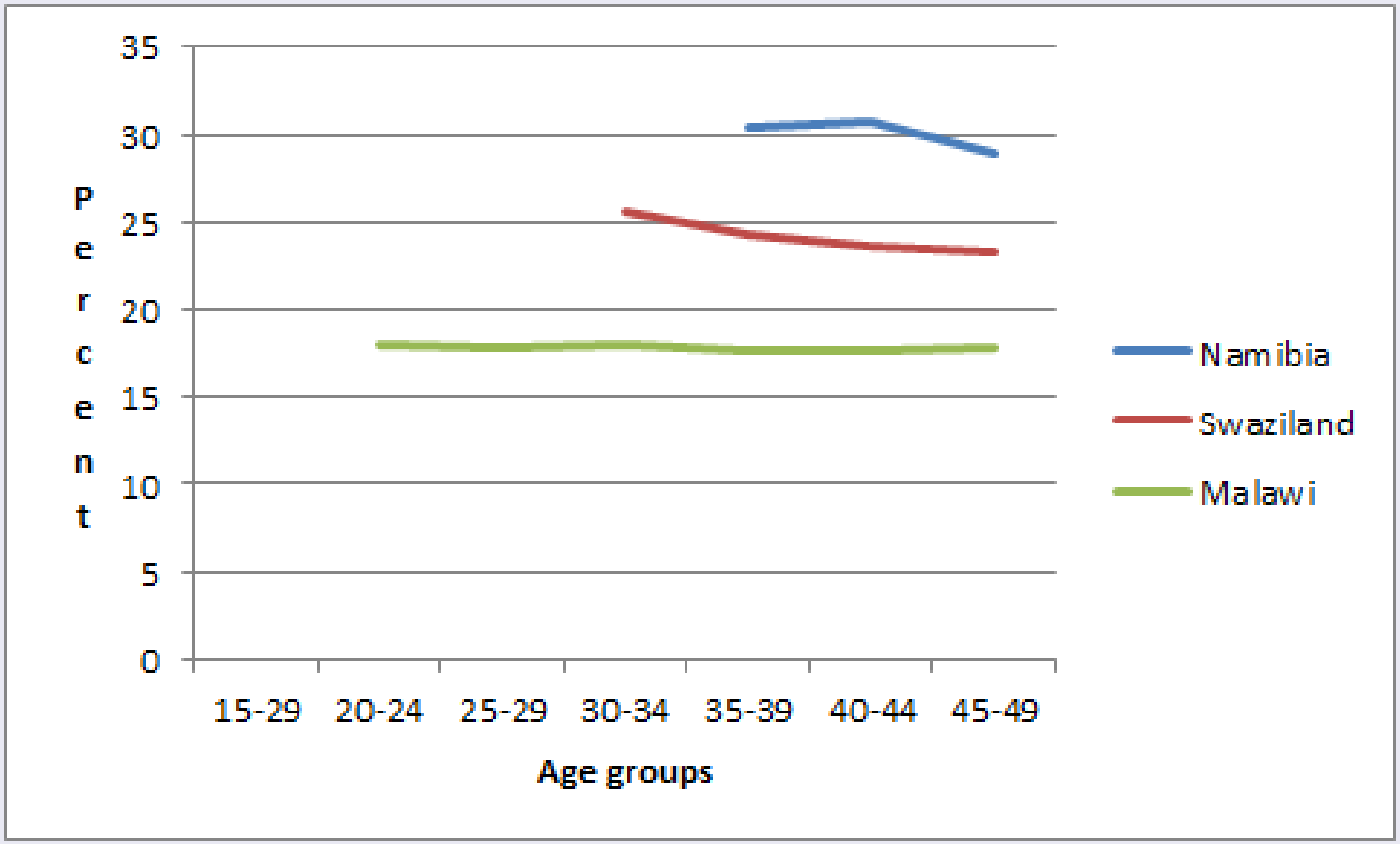
Marriage to First birth (in Months)

	Namibia	Swaziland	Malawi
Median months	21.6	19.2	18.9
By exact months (%)			
0-8 months	22.0	33.3	20.8
9-11 months	11.6	13.6	20.4
12+ months	63.2	53.1	48.8

Age at First Birth

	Namibia	Swaziland	Malawi
Median Age	21.6	19.2	18.9
By exact age (%)			
18 yrs	16.8	33.7	35.6
20 yrs	35.2	58.7	64.5
22 yrs	53.3	74.9	82.6
25 yrs	73.0	86.9	93.0

Cohort Patterns On Entry Into Marriage

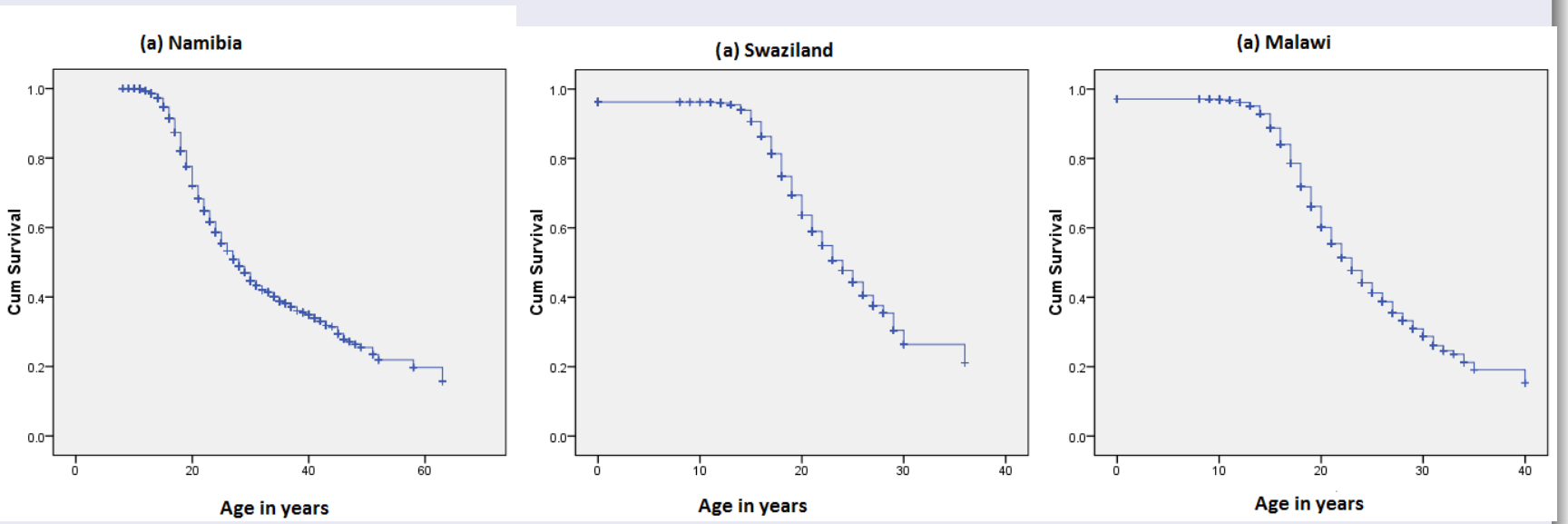


Observations on Descriptive Summaries

- Sexual debut is below 20 years in all 3 countries
- Only Malawi has birth after marriage
- Early birth in Malawi
- Early marital conception in Swaziland
- High coital frequency in Malawi couples
- Sequence 1: birth[1]–first sex[2]–first marriage[3]–first birth[4]

Survival curves

Age at first sex



Median survival times

Namibia–28 yrs; Swaziland–24 yrs; Malawi–23 yrs

Survival curves

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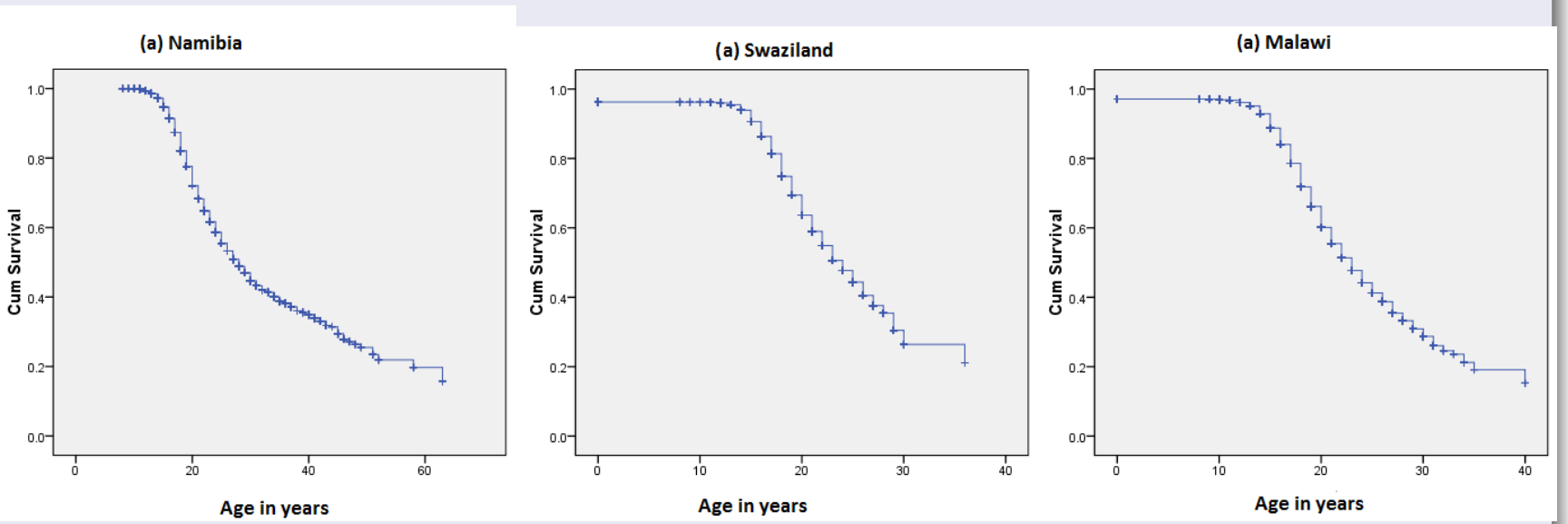

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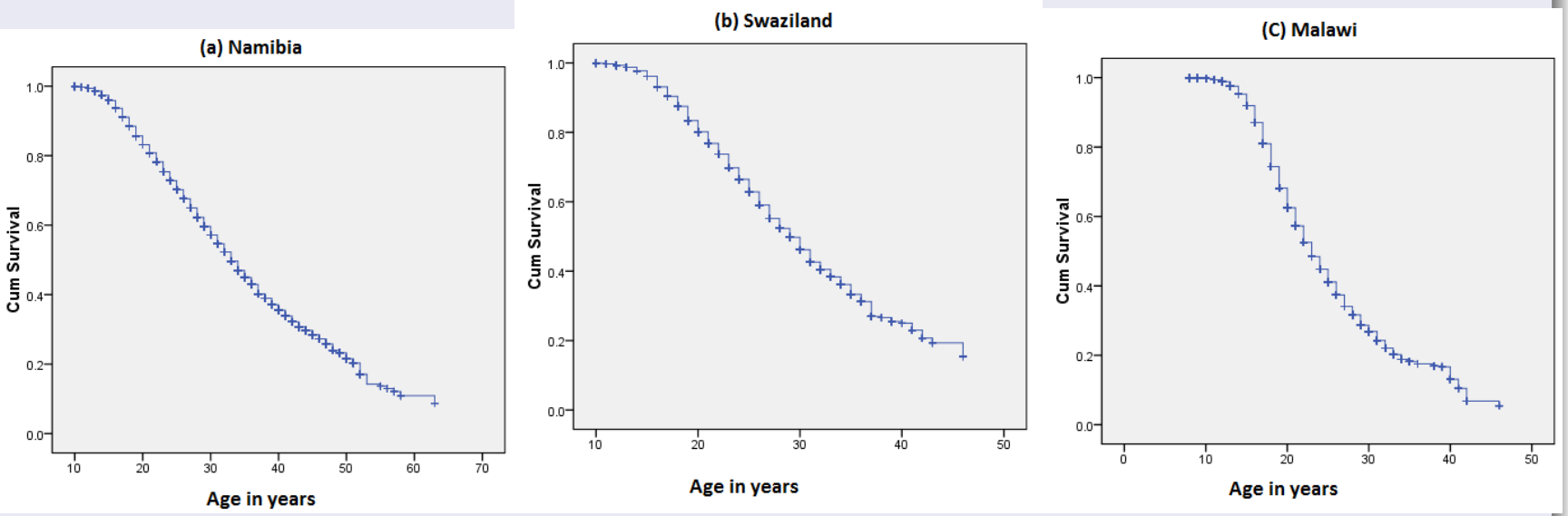

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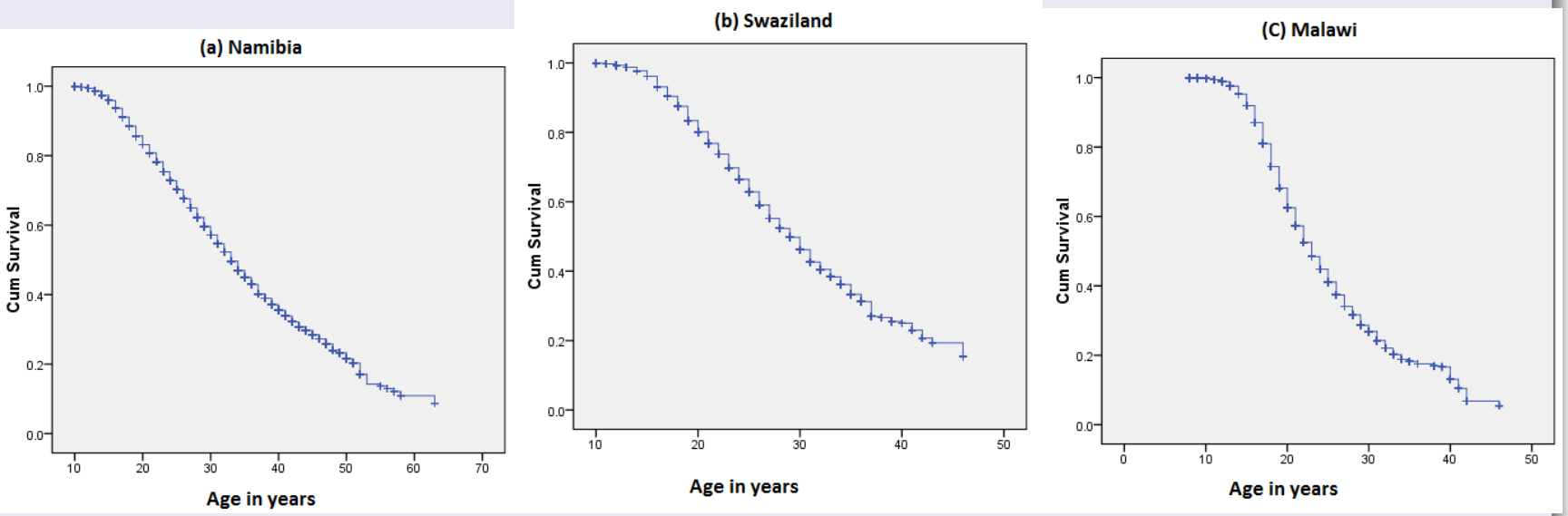

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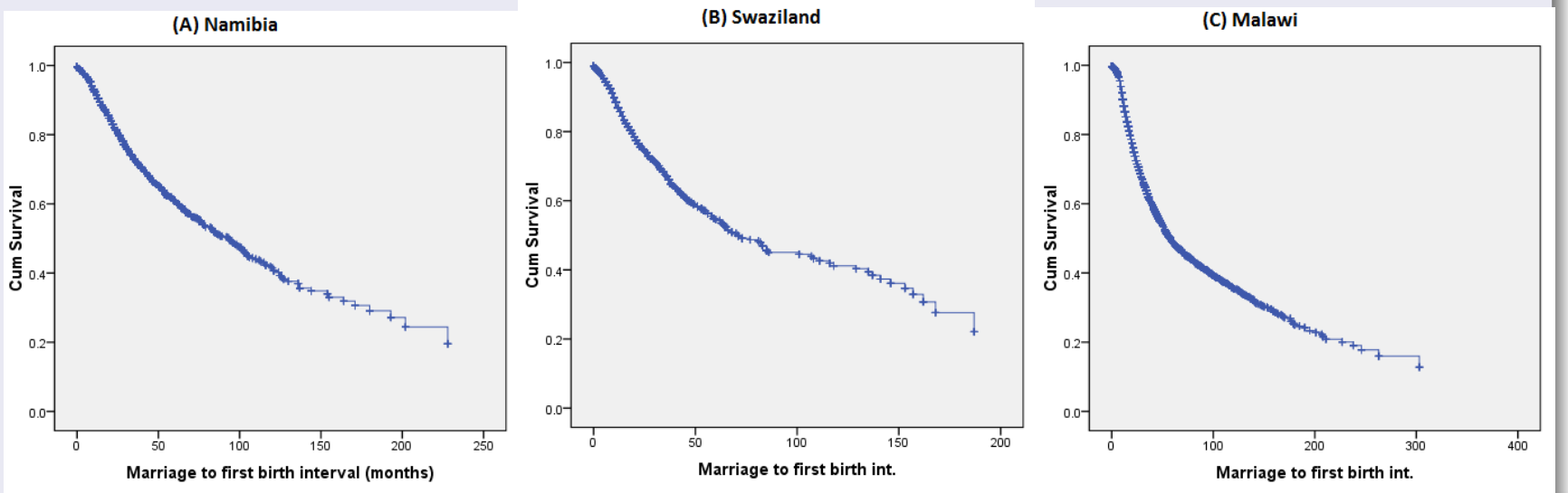

Median survival times

Namibia–94 months; Swaziland–71 months; Malawi–58 months

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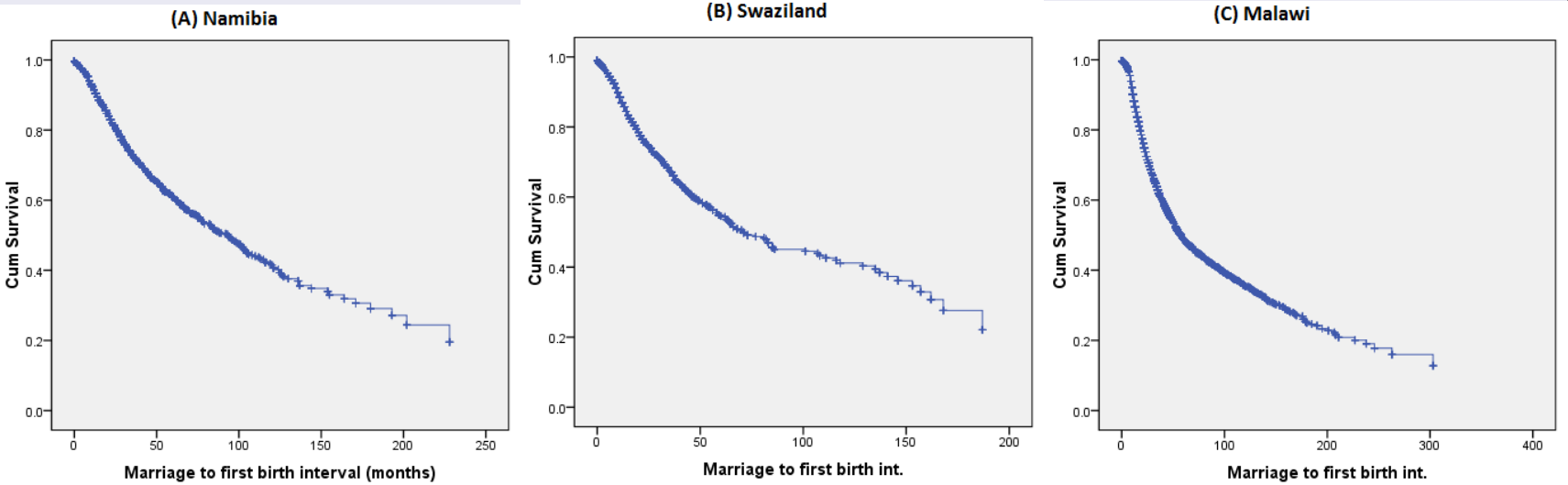

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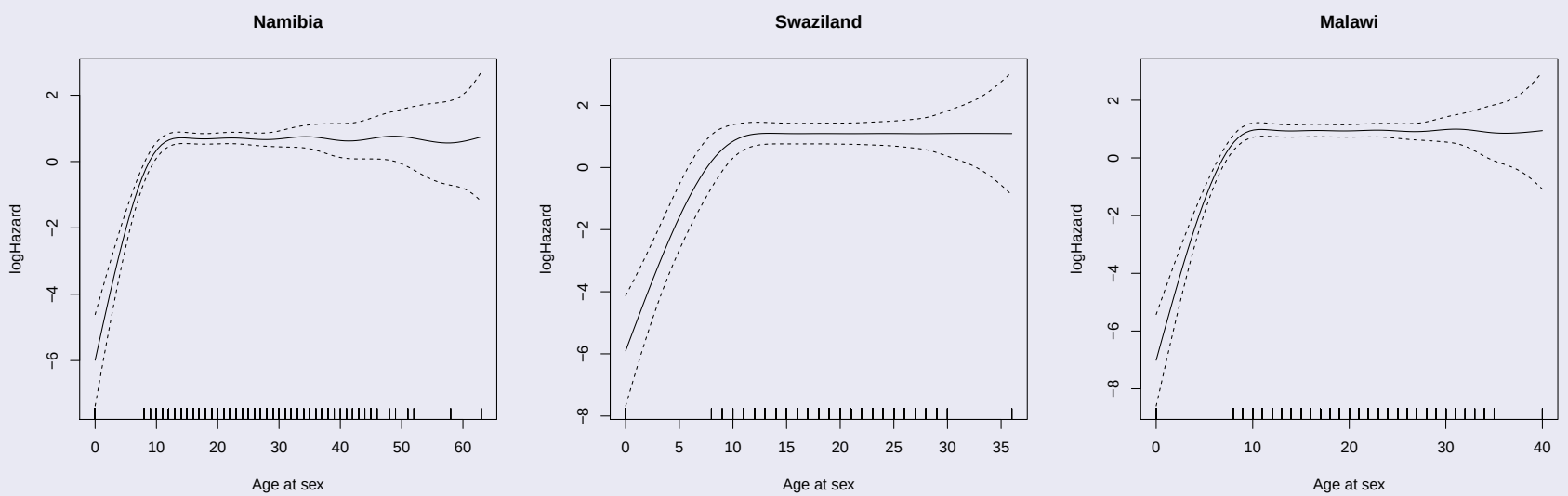
Hazards of First Sex



Hazards for Age to First Sex

Covariate	Namibia		Swaziland		Malawi	
	Coef	SE	Coef	SE	Coef	SE
working	-0.083	0.024	-0.065	0.034‡	-0.008	0.014‡
urban	0.009	0.022‡	0.044	0.033‡	-0.045	0.021
noeduc	0.747	0.057	0.998	0.078	0.841	0.061
primary	0.688	0.046	0.529	0.06	0.407	0.059
secondary	0.293	0.04	0.779	0.064	0.809	0.059
agelt20	1.047	0.038	0.791	0.05	0.882	0.043
age2529	-0.117	0.056	-0.175	0.069	-0.13	0.023
age3034	-0.176	0.06	-0.14	0.096‡	-0.088	0.046‡
agemt35	-0.314	0.088	-0.167	0.116‡	-0.134	0.054
per1970to79	0.345	0.036	-0.041	0.083‡	0.044	0.027‡
per1980to89	0.426	0.077	-0.021	0.115‡	0.134	0.055
per1990toAbove	0.65	0.096	1.01	0.131‡	0.318	0.07

‡Not significant at 5% level

Hazards for First Sex to Marriage

Covariate	Namibia		Swaziland		Malawi	
	Coef	SE	Coef	SE	Coef	SE
working	-0.049	0.035‡	0.038	0.048	-0.01	0.017
urban	0.085	0.035	0.186	0.05	0.091	0.026
noeduc	-0.393	0.08	-0.225	0.098	0.319	0.082
primary	-0.203	0.067	-0.103	0.083	0.307	0.08
secondary	-0.172	0.061	-0.199	0.079	0.11	0.081‡
agelt20	0.31	0.118	0.543	0.131	0.042	0.056‡
age2529	-0.302	0.105	-0.325	0.105	-0.082	0.025
age3034	-0.61	0.108	-0.404	0.135	-0.116	0.049
agemt35	-0.813	0.137	-0.62	0.152	-0.154	0.057
per1970to79	0.03	0.044‡	0.117	0.093‡	-0.035	0.028‡
per1980to89	0.006	0.1‡	0.212	0.144‡	0.002	0.057‡
per1990toAbove	0.099	0.153‡	0.502	0.354‡	0.1	0.077

‡Not significant at 5% level.

Hazards for Marriage to First Birth

Covariate	Namibia		Swaziland		Malawi	
	Coef	SE	Coef	SE	Coef	SE
working	-0.007	0.053‡	0.024	0.069‡	-0.002	0.017‡
urban	0.076	0.051	0.026	0.081‡	0.014	0.026
noeduc	-0.188	0.116	-0.006	0.139‡	-0.304	0.09
primary	0.155	0.097	0.011	0.12‡	-0.231	0.088
secondary	-0.007	0.088‡	0.044	0.116‡	0.042	0.09
agelt20	0.087	0.16‡	0.105	0.178‡	0.257	0.061
age2529	-0.028	0.131‡	-0.102	0.161	-0.056	0.025
age3034	-0.064	0.139‡	-0.271	0.204	-0.108	0.049
agemt35	-0.243	0.181	-0.006	0.23	-0.218	0.057
per1970to79	-0.153	0.07	0.249	0.14	0.013	0.028
per1980to89	-0.198	0.146‡	0.389	0.219	0.019	0.057
per1990toAbove	-0.007	0.203‡	0.978	0.759	0.027	0.078

‡Not significant at 5% level.

Summary

- Our analysis reveals several important differences in reproductive behavior between African countries.
- Later age at marriage has also been invoked to explain fertility decline in countries such as Senegal [Garenne and Joseph, 2002].
- Urbanization is obviously playing a major role in inducing fertility decline. Many countries have now reachedââor are close toââthe 50% threshold of urbanization.
- Increased use of contraceptives, both in calendar and out of calendar, in urban areas.
- The transitions in Malawi are quite short- probably hence high fertility
- Period effect seems not critical in the three countries.

Literature

- Steele, F., Goldstein, H. and Browne, W. (2004). A general multistate competing risks model for event history data, with an application to a study of contraceptive use dynamics. Journal of Statistical Modelling, 4: 145-159.
- Steele, F., Kallis, C., Goldstein, H. and Joshi, H. (2005). The relationship between childbearing and transitions from marriage and cohabitation in Britain. Demography, 42: 647-673.