MULTIVARIATE STATISTICAL MODELLING OF FAMILY FORMATION PROCESSES AMONG WOMEN IN NAMIBIA

A DISSERTATION SUBMITTED IN FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY IN APPLIED STATISTICS

OF

THE UNIVERSITY OF NAMIBIA

BY

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April 2015

ABSTRACT

Family formation is a significant event in life-course of individuals. Many studies have revealed shifts in demographic processes including child-bearing patterns, age at sexual debut and first marriage, and marital status over the years. While there have been numerous studies in demographic processes in specific populations, very few studies have focused on family formation processes, and little or no quantitative research has been conducted on the distribution and dynamics and determinants of family formation in Namibia. This study employed a cross-sectional retrospective mixed methods design to achieve various objectives namely: to examine emerging marital patterns and trends in Namibia since attaining its independence in 1990; to analyze the hazards of first marriage and sexual debut and determinants of age at first marriage and sexual debut ; to establish factors associated with non-marital fertility; to examine perceptions of women regarding key union principles and values on matters of divorce, cohabiting, widowhood, polygamy, sex before and outside marriage based on a qualitative study; and to come up with family formation recommendations to guide policy and also pave way for further research. The study used data from the Namibia 1992 to 2006/7 DHS and from focus group discussions, which gave in-depth understanding on perceptions on family formation processes. Trend analysis, binary and multinomial logistic regression models were used to model the patterns and determinants of marital status. Discrete time hazard models through Bayesian Structured Additive Regression (STAR) approach were used to estimate the hazards of a woman's sexual debut and first marriage. The Hurdle Logit Negative Binomial (HLNB) regression model was used to model non-marital fertility. Findings indicated a general change away from marriage, with a shift in mean age at marriage which rose from 21 years in 1992 to almost 23 years in 2006. Cohabitation was prevalent among those less than 30 years of age; the odds were higher in urban areas and increased since the year 1992. Be as it may marriage remained a persistent nuptiality pattern, and common among the less educated and employed, but had lower odds in urban areas. Multinomial regression results suggested that marital status was associated with age-at-first-marriage, total children born, region, place of residence, education level and religion. Marital patterns have undergone significant transformation over the past two decades in Namibia, with a coexistence of traditional marriage framework with co-habitation, and sizeable proportion of women remaining unmarried to the late 30s. An upward shift in the mean age is becoming distinctive in the Namibian society. Period and cohort effects in the timing of first sex were evident among women in Namibia. Efforts to discourage early sexual debut should be stepped up especially in North-Eastern Namibia. Results did not suggest a significant nonlinear pattern of age at first marriage with age, cohort and period. First marriage timing in Namibia was influenced by the woman's age, birth cohort, period, place of residence, highest educational level, socio-economic status and region. Intervention strategies should not only target schools and the wider community in isolation, but should involve the individual family units as they have a bigger role to play in this regard. Non-marital fertility was associated with the age, educational level, urbanity, and socio-economic status. Rural women had higher fertility propensity compared to their urban counterparts even though there was no significant difference in fertility intensity. Fertility intensity decreased as the women got richer. Intervention efforts should focus on promoting education among girls and women especially in rural areas to improve their socio-economic status, reduce teenage pregnancy and non-marital fertility. Qualitative findings supported the quantitative findings and gave an in-depth understanding of women's perceptions on family formation processes.

Key words: marital patterns, age-at-first marriage, sexual debut non-marital fertility, Namibia

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The study findings were published in 2 refereed journals, one conference proceeding and 5 research conference presentations as follows:

Publications

1. **Pazvakawambwa L**., Indongo N., and Kazembe L. (2014). A hurdle Negative Binomial Regression Model for Non-marital Fertility In Namibia, *Journal of mathematics and System Science* 4 497-507.

2. **Pazvakawambwa, L**. Indongo, N. and Kazembe L. (2013) Explaining marital patterns and trends in Namibia: A regression Analysis of 1992, 2000, and 2006 Demographic and Health Survey Data, *PloS ONE 8(8): e70394. Doi:10.1371/journal.pone.0070394*

3. **Pazvakawambwa L**., Kazembe L., and Indongo N., (2014). Discrete Time to Event Models for Age at First Marriage in Namibia, Proceedings of the Population Association of America (PAA) Annual Meeting Program, Marriot Copley Place, Boston, Massachusetts, USA, 1 – 3 May 2014. *http://paa2014.princeton.edu/papers/140555*

Conference Presentations

1. **Pazvakawambwa L**., Kazembe L., and Indongo N. A qualitative evaluation of Namibian women's perceptions regarding family formation processes, presented

at the University of Namibia, 6th Annual Humanities and Social Sciences Research Conference, Windhoek, 28-29 August 2014.

2. **Pazvakawambwa L**., Kazembe L., and Indongo N., (2014). Discrete Time to Event Models for Age at First Marriage, poster presented at the Population Association of America (PAA) Annual Meeting Program, Marriot Copley Place, Boston, Massachusetts, USA, 1–3 May 2014.

3. **Pazvakawambwa L**., Kazembe L., and Indongo N. Period-cohort effects Models for age at first sex in Namibia, presented at the 1st Annual Statistical Colloquium, Windhoek Namibia, 5 September 2013.

4. **Pazvakawambwa L**., Indongo N. and Kazembe L. A hurdle Negative Binomial Regression Model for Non Marital Fertility in Namibia, presented at the 8th Population Association of Southern Africa Conference (PASA), Mafikeng, South Africa, 10-12 July 2013.

5. **Pazvakawambwa, L**. Indongo, N. and Kazembe L. Explaining marital patterns and trends in Namibia, presented at the 7th Annual Population Association of Southern Africa (PASA) Conference, Thohoyandou, South Africa, 11-14 July 2012

ACKNOWLEDGEMENTS

This dissertation would not have been a success without the expert guidance of my supervisors, Dr. Nelago Indongo and Professor Lawrence Kazembe from the Multidisciplinary Research Centre (MRC) and the Department of Statistics and Population Studies at the University of Namibia respectively. Their patient guidance and encouragement was very helpful from the initial to the final level of my Ph.D. studies. I sincerely appreciate all their contribution; their positive criticism as they tirelessly went through my drafts; their time given their busy schedules; and ideas which enabled me to complete my dissertation.

I am also indebted to my colleagues in the Department of Statistics and Population Studies, Dr. I. Neema, Dr. N. Nickanor, Dr. M. Muller, Mr. W Tjipueja, Mr. K. Mutorwa, Mr. I. Kamwi, Mr. P Iiyambo, Mr. Mr. C. Mahindi, and Mr. L. Unandapo for a very supportive environment and encouragement.

I acknowledge the assistance given by the following in translation of research documents into local languages and facilitation of focus group discussion and key informant interviews: M. Chuma, D. Manungo, F. Muyenga, K.P. Tjituri, M. Muller, J. De Klerk, E. Zariro, V. Lushetile, S. L. Mwandingi, C. Muna, and R. Chakare. I do not take for granted, their commendable efforts to set aside days and nights to finish our work on time during field work and their willingness to go an extra mile.

I give special thanks to my family, especially my dear husband Godfrey Tichaona who supported me all the way through moral support as well as with his commendable editing skills, my son Joshua Tinotenda for the information and communications technology support and encouragement, and my two loving daughters Delight Shumirai and Tsitsi Nelia for the moral support and their ready help with the kitchen and house chores during the busy times. I am also indebted to my sister-in law Shupikai, who assisted in the transcribing and proof reading of the voice recordings in the evenings.

I am thankful to the Namibia Ministry of Health and Social Services and Measure DHS for allowing me to gain access to some of their online datasets from www.measure.dhs used in this research.

This dissertation would not have been a success without financial support from the University of Namibia's Research and Publication Office (RPO), Department of Statistics and Population Studies, and the United Nations Population Fund (UNFPA) who provided funding for travel and subsistence to national, regional and international conferences and workshops for both oral and poster presentations, as well as publication fees of research output.

Most important of all, I give thanks to the Lord God, the creator of the universe for His unconditional love and hope which does not disappoint us.

DEDICATION

To my beloved family

DECLARATIONS

I, Lillian Pazvakawambwa, hereby declare that this is a true reflection of my own research and that this work or part thereof has not been submitted for a degree in any other institution of higher learning.

I, Lillian Pazvakawambwa grant the University of Namibia the right to reproduce this dissertation in whole or in part, in any manner or format, which the University of Namibia may deem fit, for any person or institution requiring it for study and research; providing that the University of Namibia shall waive this right if the whole dissertation has been or is being published in a manner satisfactory to the University.

……………………………………..   Date: ………………………

Lillian Pazvakawambwa

ABBREVIATIONS

AIC	Akaike Information Criteria
AIDS	Acquired Immune Deficiency Syndrome
BIC	Bayesian Information Criteria
CI	Confidence Interval
CLASP	Centre for Law and Social Policy
DF	Degrees of Freedom
EA	Enumeration Area
FGD	Focus Group Discussion
HIV	Human Immunodeficiency Virus
HLNB	Hurdle Logit Negative Binomial
HR	Hazard Ratio
MRC	Multi-Disciplinary Research Centre
NDHS	Namibia Demographic and Health Survey
OR	Odds Ratio
RPO	Research and Publications Office
RR	Relative Risk
STAR	Structured Additive Regression Models
STD	Sexually Transmitted Diseases
STI	Sexually Transmitted Infections
UNAM	University of Namibia
UNESCO	United Nations Education Scientific and Cultural organization

UNFPA	United Nations Population Fund
USA	United State of America
WHO	World Health Organization
ZINB	Zero Inflated Negative Binomial
ZIP	Zero Inflated Poisson

CHAPTER 1

INTRODUCTION

1.1 Orientation of the Study

Family formation, which encompasses marital patterns and trends, the timing of marriage, and fertility choices, is a significant event in life-course of individuals, and at society level creates a unit of production, consumption, distribution, and exchange of goods and services (Abdelrahman, 1989). Family dynamics over the years have changed a lot, with delayed entry into first marriage, increased levels of singlehood, divorce, co-habitation, and non-marital fertility in developed countries (Elliot and Simmoons, 2011; Raymo et al, 2009; Wu, 2000; Kalmijn, 2007; Steele et al, 2006; Vignoli and Ferro, 2009). Although such changes have been reported in African societies (Rashad et al, 2005; Abdelrahman, 1989; Raymo et al; Ueyama and Yamauchi, 2009; Manda, 2005; Arnaldo, 2004, Mufune, 2003), they largely remain unexplained.

Decisions about whether and when to marry, remain unmarried or to divorce, and to have non-marital or marital children are faced by everyone during his or her lifetime with far reaching socio-economic implications for individuals and society as a whole. While in most societies, these decisions are made by individuals, hence determined by individual preferences, they are also significantly shaped by social norms that draw the boundaries of the pool of eligible mates, civil laws that govern these processes and economic environments that frame family formation possibilities (Howse et al, 1989). Family formation patterns vary considerably across countries and over time. Such dynamics are also being experienced in African societies including Namibia.

General Description of Namibia

Namibia is a country in Southern Africa whose western border is the Atlantic Ocean. It shares land borders with Zambia and Angola to the north, Botswana to the east, and South Africa to the south and east. Namibia gained its independence from South Africa in 1990. The country is divided into 14 administrative regions and its largest and capital city is Windhoek. Namibia covers a total land area of 825 615 km^2 with a population of 2 113 077 giving a population density of 2.54 people per square kilometre (Geo-Hive, 2013).

The economy of Namibia thrives on agriculture, livestock, tourism and mining (gem diamonds, uranium, gold, silver, and base metals) and has a Gross Domestic Product of USD 13 064 billion (IMF Report, 2013). The country has a Gini coefficient of 59.7 (Economic Policy and Poverty Unit Report, 2013). Although its per capita GDP is five times higher than that of the poorest African countries, most of Namibia's people live in the rural areas and mainly depend on subsistence agriculture. The country has one of the highest rates of income disparities in the world because of its urban economy and a more rural cashless economy (World Almanac Report, 2004).

There are a total of 12 ethnic groups in Namibia namely Ovambo (49.0%), Kavango (9.2%), Coloured (including Basters) (8.0%), Herero (7.0%), Damara (7.0%), whites

(7.0%), Nama (4.7%), Lozi (3.5%), San (3.0%), Tswana (0.6%), and others (0.5%). The official language of Namibia is English and the recognized regional languages are Oshiwambo, Herero, Damara/ Nama, Setswana, Silozi, Rukwangali, German, and Afrikaans. The most prevalent religion in the country is Christianity (80-90%) with at least 50% of the Christians being Lutheran. A sizeable percentage of the population hold indigenous beliefs (10-20%) (World Fact Book, 2009).

With regard to education, Namibia offers compulsory free education for 10 years between the ages of 6 and 16 where Grades 1 to 7 are primary level, and Grades 8 to 12 are secondary. Life expectancy is estimated at 52.2 years in 2012 mainly due to the adverse effects of the AIDS epidemic (World Fact Book, 2013).

1.2 Statement of the problem

Many studies, based on census and surveys, put emphasis on marital trends that have shifted, non-marital child-bearing that has increased and age at first marriage which has risen over the years. More important was to offer explanations to these shifts among individuals over time. Very few studies (Mufune, 2003; Shemeikka, Notkola &Siiskonen, 2005) have been done on family formation processes; and little or no quantitative research has been conducted on the distribution and dynamics and correlates of family formation processes in Namibia. For example, changes in family formation patterns can induce thorny issues (such as passion crimes, gender empowerment wrangles, submission in female-male relationships, custody of children, property rights, HIV/ AIDS transmission and reproductive health etc) that confront and challenge deeply rooted cultural values thereby raising legal and policy challenges (Rashad et al, 2005). It was necessary to model family formation processes to guide policy for the promotion of stability in family unions to have a positive impact on the socio-economic development of the country.

1.3 Objectives of the study

This study's aims were to examine patterns and trends in family formation processes and perceptions regarding these processes among women of reproductive age in Namibia society with the goal to guide policy on sustainable socio-economic development of Namibia. The specific objectives were to:

i. Examine emerging marital patterns and trends in Namibia since attaining its independence in 1990.
ii. Analyze the hazards of first marriage and determinants of age at first marriage in Namibia.
iii. Analyze the hazards of sexual debut and determinants of sexual debut in Namibia.
iv. Establish factors associated with non-marital fertility in Namibia.
v. Examine perceptions of women regarding key union principles and values on matters of divorce, cohabiting, widowhood, polygamy, sex before and outside marriage based on a qualitative study.

vi. To come up with family formation recommendations to guide policy and also pave way for further research.

1.4 Significance of the study

It was evident that not much research in family formation has been done to date, except in connection with fertility studies (Mufune, 2003; Indongo and Naidoo, 2008; Shemeikka et al, 2005, Chinsembu et al, 2008). Changes in pattern of unions, childbearing and interactions within households reflect and impact on societal roles and norms, as well as may shape public policy. Therefore findings from this study will add to new knowledge in the field of family demography and guide family legislation policy as this will have a positive impact on the health and socio-economic wellbeing of the Namibia. Findings and recommendations from this study will also pave way for further research.

1.5 Limitations of the Study

The study will be based on the cross-sectional design. Examination of marital patterns and trends, analysis of the hazard of first marriage, and non-marital fertility will use secondary quantitative data collected as part of the Namibia Demographic and Health survey (NDHS), while the examination of perceptions of women regarding principles of family formation will use primary qualitative data collected to fulfill this objective. The limitation of cross-sectional data is that it offers a fixed time perspective of the existing relationship, which has a short coming of not capturing the dynamics of family formation processes. Moreover, since the data was collected in 1992, 2000 and

2006 changes may have happened between now and then, thus the relationship obtained is valid for that period when the data was collected. Furthermore, the use of secondary data will imply inheritance of some errors which may have been made in the data collection process. The pooling together of the 3 DHS will enable comparisons are cross periods and the analysis of random effects but may introduce errors if strata and primary sampling units are not defined in the same way each year, if key variables are measured are stored in different formats or are missing in some data sets.

As of the qualitative component of the research, results will depend on the willingness of women to participate in focus group discussions, availability of resources for travel to various parts of the country. To address limitations of the proposed study, appropriate random effects models will be fitted to permit assessment of different measurement errors. Time dependent covariates will be introduced in the model to capture some of the dynamism limited by the cross-sectional design.

1.6 Structure of the Report

In this report, the first chapter gives an orientation of the study, problem statement, objectives of the study, its significance and limitations. The second chapter gives a review of related literature on family formation processes and an evaluation of statistical theory on the analysis of marital patterns, non-marital fertility, and sexual debut and transition to first marriage. The third chapter outlines the methodology of the study in terms of the research design, study population, sample, research instruments, ethical considerations and the data analysis procedures. Chapter 4 presents the analysis of marital patterns and trends in Namibia using generalized linear regression models. Chapter 5 presents the determinants of non-marital fertility based on the Hurdle Logit Negative Binomial regression model. Chapter 6 presents event history models for the timing of sexual debut and first marriage among women in Namibia. Chapter 7 presents a qualitative evaluation of Namibian women's perceptions regarding family formation processes. Lastly, Chapter 8 presents the conclusions and recommendations of the study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Research in understanding and modeling the formation and distribution of marriages and marital dissolutions has increased (Mucmu and Saglam, 2008). Nevertheless this area of research is old and global, and the procedures that define these processes are multifaceted with social, behavioural and demographic factors which simultaneously influence family formation (Indongo and Naidoo, 2008; Mucmu and Saglam, 2008). Adolescents' plan for family formation (marriage and parenthood) and the congruence between their plans and their mothers' expectations and behaviours within these spheres show that family factors best predict children's plans, although peer groups may also be important.

Global family formation patterns

Studies in the Arab world, America, and Europe showed that women are staying single longer, or not marrying at all because of high costs associated with marriage, improved gender roles, educational expansion and secularization (Rashad & Roudi-Fahimi, 2005; Burgess, Propper & Aassve, 2005; Kalmijn, 2007). Within the same context, the percentages of marriages where both husband and wife are uneducated are decreasing (Rashad & Roudi-Fahimi, 2005). An equivalent study in Norway reported that a large proportion of cohabiters indicated economic reasons for their hesitation to marry and in particular the costs of the wedding.

Entry into first marriage has a bearing on a woman's fertility, economic status, educational aspirations, career development and at times health status. In Malawi, Iran, and Mexico, both longitudinal and cross-sectional studies on the age at first marriage have been conducted using discrete time hazard models (Manda, 2005; Torabi, 2010). Findings from these studies revealed that the age at first marriage was determined by level of education, age (Manda, 2005), premarital work experience and ethnicity, religion, place of residence, economic status, employment status (Torabi, 2010) and parental modernity (Huschek, 2010).

Atienzo et al (2014) examined adolescents' perceptions and expectations regarding family formation and their link to sexual behaviour. They identified four types of aspirations namely:

a) Early plan: desire to marry at age 21 and have children at age 22.

b) Middle plan: desire to marry and have children at ages 25 and 26 respectively.

c) Late plan: desire for stable partner at age 29 and children at age 31

d) Non-traditional plan: adolescents that do not want to marry and/ or have children.

Their results indicated that adolescents that aspired to postpone family formation, particularly until age 29 years of age (late plan) were more likely to report condom use at first intercourse and to have fewer sexual relations all their life. Adolescents' expectations about their future life affected their present sexual and reproductive decisions.

Family formation patterns in the developed world

The shift to cohabitation as the dominant mode of first partnership played an important role in the delay of first marriage and motherhood. In Japan, cohabiting unions were best viewed as an emerging prelude to marriage rather than as an alternative to marriage or singlehood (Raymo, Iwasawa, & Bumpass, 2009). This phenomenon is equally being observed in conservative south-east Asian societies. Coltabiano and Castiglioni (2008), based on the 2001 Nepalese Demographic and Health Surveys described a significant shift in marriage, cohabitation, and age at first sex. Current age, cohort and period at marriage, education level and place of residence were some of the factors associated with the family formation process in the study. Because of similarities to African settings due it being a developing country, I postulate that the Nepalese study may display parallel patterns to that of Namibia (Indongo & Naidoo, 2008).

Various other factors affecting family formation have been explored. Steel et al. (2005; 2006) has examined the effect of parenthood on whether non-marital unions led to marriage or parting. Their findings showed that the proportion of cohabiting couples who married before a birth decreased and the risk of dissolution declined during pregnancy. Lehrer (2008) indicated that early age at first marriage is known to be associated with high risk of divorce. Another study in Britain established that education was a key factor influencing the age of entry into first partnership and whether or not the respondent would experience pregnancy before forming the partnership. Furthermore, religiosity, experience of parental separation, and the geographical region of residence were more important in affecting the decision to cohabit rather than to marry directly.

With regard to non-marital fertility, Dyer and Fairlie (2004) examined the impact of family cap policies on the birth rates of single and less educated women with children in the United States. Their regression results did not provide sufficient evidence that family cap policies reduce out of wedlock births among the single and less educated women. However, Curtis and Waldfogel (2009) established considerable variation in the time to next birth among comparable mothers who lived in different cities, partly due to variation in labour markets, housing costs and availability and welfare policies.

A study on the effects of child support enforcement and welfare in non-marital childbearing indicated that both stricter child support enforcement and declines in welfare benefits deterred non-marital births (Garfinkel et al, 2003). According to economic theory, stricter child support enforcement will increase the cost of children for unwed fathers, making them less likely to have children outside marriage. City variation was particularly important for unmarried women who had 2 or more children whose fertility was more sensitive to these contextual variables than married women or unmarried women with just one child. Von Barel (2007) revealed that illegitimate fertility fell together with marital fertility in a Belgian town between 1850 and 1910 and suggested that during this period, non-marital child bearing may have reflected a liberal attitude towards reproduction for some women.

Lesthaeghe (2011) found strong similarities in second demographic transition patterns at both the macro-level (national trends in postponement of marriage and parenthood, rise of cohabitation) and micro-level (connection between individual values orientation and postponement of parenthood) in Southern Europe except for the fact that parenthood was still very rare among Asian cohabiting partners. In Romania and the Russian Federation, Potarca et al (2013) established that post-communist cohorts were significantly more likely to engage in long term cohabitation, child-bearing within cohabitation or lone parenthood. Non-marital cohabitation with children was associated with lower education in all countries. Strong differences emerged between the shape and stages of the second demographic transition in the two countries, with Russians having higher probability to experience child-bearing within cohabitation, as opposed to Romanians who followed childless marriage patterns or adopted postponement or singlehood.

Kondo (2012) showed that despite the significant effect on marriage timing, labour market conditions experienced in youth did not affect the probability that a woman will marry by the age of 30. The author further established that labour market conditions at the time of marriage were uncorrelated with the probability of divorce, spouse's characteristics, or the number of children.

Dominguez-Folgueras et al (2013) revealed that in Spain, cohabitation has spread significantly among younger cohorts and hence could no longer be considered as playing a marginal role in family formation processes.

Cuthbert and Fronek (2014) noted the increasing numbers of Australians moving to commercial off-shore surrogacy arrangements to satisfy their desire to become parents as a model of family formation. The authors underlined practice issues of concern to researchers, lawyers and social workers with regard to such arrangements. Fasang and Raab (2014) established salient intergenerational family formation patterns among middle-class American families namely: a strong transmission; a moderated transmission; and an intergenerational contrast pattern. For these families, educational upward mobility was a strong predictor of moderated intergenerational transmission, whereas strong emotional bonds between parents and children fostered strong intergenerational transmission of family behaviour.

Holland and de Valk (2015) found that in Europe the time since arrival in the country of residence and immigrant generation were consistent predictors of ideal ages for family formation, differentiating migrants from each other and from their majority counterparts. They found that the contextual influence of the country of residence matters for family formation ideals. There was a positive association between dominant family formation patterns across countries of residence and ideal ages. These results suggest that immigrant populations are influenced by their sociocultural and sociopolitical residential contexts, like all members of a society.

Family formation patterns in the developing world

In Ethiopia, Markos (2003) analyzed factors associated with marriage arrangements, family formation patterns, determinants and differentials in entry into first marriage, stability of first marriages, mate selection criteria for daughters, and factors associated with polygamous marriages. Results indicated that marriage dissolution was associated with early age at marriage, extended family structure, and poor economic status. Polygamous marriages were strongly associated with economic status and religious affiliation.

Censuses and surveys analyses conducted in a number of African countries indicated increased postponement of marriage and growing number of singles (Marston et al. 2009). Population changes brought about by HIV and AIDS pandemic and increased urbanization are purported to contribute to structural effects on marriage patterns. A longitudinal study in Malawi reported marital behaviour has changed in the wake of HIV (Ueyama & Yamauchi, 2009). Marston et al. (2009) further reveal that trends in marriage and time spent single in five sub-Saharan countries showed an upward shift in age at first marriage and age at first sex. A number of African countries have seen an increase in its urban population. A case in point is Namibia, which has 43% of its population living in urban areas. Although the impact of HIV/AIDS and urbanization on marriage and family institution is complex and long term, we hypothesize that their impact will be reflected in changing trends in marital patterns.

Posel et al (2011) found racial differences in marriage rates in South Africa between Africans and whites and related the differences to the traditional practice of *ilobolo* (payment of bride price) among African families. Golberg (2013) showed that changes in co-residence with parents are associated with following less advantageous pathways into adulthood, independent of particular family structure or orphan status. Overall, the findings suggested that family instability influences not only single transitions for youth, but also combinations of transitions.

Determinants of family formation patterns

Other factors impacting family formation were pre-marital work experience, country ethnicity, place of residence, birth cohort, years of schooling, and age at marriage (Mucmu and Saglam, 2008). Correlates of non-marital fertility, measured by the total children born to an unmarried woman, are best modelled by negative binomial regression analysis (Ramaswamy, Anderson & Dersarbo, 1994), which is an improvement on the Poisson regression model (Lawless, 1987) to address the problem of over-dispersion. Count data such as non-marital fertility often show high incidence of zero counts than would be expected if the data followed a Poisson distribution. In such cases, a zero inflated Negative Binomial distribution may be more appropriate (Ridout, Hinde & Demetrio, 2001). One may also consider the non-marital fertility births as a two-part process, with one part describing the incidence and the other prevalence. In such a situation, a hurdle negative binomial regression model, that permits covariates on both parts will be ideal to explore. The statistical models for binary and multiple responses, the modelling of count data, and event history outlined in the following sections were adapted from Tutz (2012); Kleiber and Zeileis (2008); Box-Steffensmeir and Jones (2004); Congdon (2010); Brezger and Kneib (2005); Lang et al (2014); Kneib and Fahrmeir (2007); Wackerly et al (2008); Hilbe (2011); Kleinbaum (2005); and Lawless (1987).

2.2 Modelling family formation processes

Binary and multinomial logistic regression models, count models and event history models have been used to examine formation processes. The binary logistic regression model can be used to analyze whether a woman has ever been in a marital union. Multinomial logistic regression can be employed to establish the determinants of a woman's marital status. Count models can be explored to model the correlates of non-marital fertility while event history models can be used to model a woman's transition to first sex and first marriage.

2.2.1 The binary logistic regression model

A binary logistic regression model is a generalized linear model which facilitates a workable representation of the link between independent variables and dichotomous dependent variables. The response only assumes 2 values usually coded as $y = 0$ and $y = 1$. Usually $y = 1$ is considered as a "success" and $y = 0$ as "failure". The distribution of a simple binary random variable $y \in \{0,1\}$ is completely characterized by the probability

$$\pi = P(y = 1) \text{ so that } P(y = 0) = 1 - \pi$$

The mean of y is $E[y] = \sum y.P(y) = 1(\pi) + 0(1-\pi) = \pi$

This means that the response probability π represents the mean of the binary distribution. In the same manner, the variance of y is given by

$Var(y) = E[y - E(y)]^2 = (1-\pi)^2\pi + (0-\pi)^2(1-\pi) = \pi(1-\pi)$

The value is determined by π and depends on π with minimal value at $\pi = 0$ and $\pi = 1$ and maximal value at $\pi = 1/2$. In most real life applications, a binary variable is repeatedly observed and of interest is the number of successes (the occurrence of $= 1$). Repeated trials could be about a sample of n women in which case the outcome of interest could be the number of women who were never married (success) at the time of a survey. The basic assumptions underlying the binomial distribution are that the random variables $y_1, y_2, \cdots, y_n$ with fixed n are binary $y \in \{0,1\}$ with the same response probability

$\pi = P(y_i = 1), \quad i = 1, 2, \cdots, n$ and are independent. Then the number of successes

$y = y_1 + y_2 + \cdots + y_n$ in n trials is called a binomial random variable $y \sim B(n, \pi)$ and has the distribution function

$$P(Y = r) = \binom{n}{r} \pi^r (1-\pi)^{n-r} \quad , r = 1, 2, \cdots n$$

The mean and variance of the binomial variable are given by $E[y] = n\pi$, $Var\ (y) = n\pi(1-\pi)$

A binary response variable is very different from a continuous response variable. While the important features of a continuous response variable are the mean, variance, skewness, kurtosis etc., which frequently may vary independently, in a binary response variable, all the characterized determined by a single value, which is often chosen as the probability of $y = 1$. Transformations of π that are usually useful are the odds and the log odds (logits) which are functions of π where

Odds: $\gamma(\pi) = \frac{\pi}{1-\pi}$ and

Log Odds (or logit): $logit(\pi) = \log(\ \gamma(\pi)) = \log\left(\frac{\pi}{1-\pi}\right)$.

The odds $\gamma(\pi) = \frac{\pi}{1-\pi}$ are a directed measure that compares the probability of the occurrence of $y = 1$ and the probability of occurrence of $y = 0$. If $y = 1$ is considered a success, and $y = 0$ a failure, a value $\gamma = \frac{1}{3}$ that failure is three times a likely as success. While γ compares $y = 1$ to $y = 0$, the inverse compares $y = 0$ to $y = 1$ giving

$$\gamma = \frac{P(y = 1)}{P(y = 0)}, \quad \frac{1}{\gamma} = \frac{P(y = 0)}{P(y = 1)}$$

Such that if the odds are considered as functions of π, one obtains

$\gamma(1 - \pi) = \frac{1-\pi}{\pi} = \frac{1}{\gamma(\pi)}$

because $\gamma(1 - \pi)$ corresponds to comparing $y = 0$ to $y = 1$.

When comparing two groups, the concept of odds and log odds can be illustrated by the case of comparing two groups on a binary response. For the two groups, one can be the treatment group while the other is a control group. A 2 x 2 cross-tabulation or contingency table usually summarizes the data with the underlying probabilities as given in **Table 1.**

Table 1: A contingency table for binary responses.

	y		
t	0	1	Total
1	π_1	$1-\pi_1$	1
2	π_2	$1-\pi_2$	1

where $\pi_t = P(y=1|T=t)$, $t = 1,2$ denotes the probability of response $y = 1$, corresponding to success. The probability of failure is then determined by $P(y=0|T=t) = 1 - P(y=1|T=t)$

A comparison measure of the two groups may be based on the relative risk (RR) or the odds ratio (OR). The relative risk is given by $r_{12} = \frac{\pi_1}{\pi_2}$. A relative risk of 3 means that the probability of success in group 1 is thrice the probability of success in group 2. If the relative risk is 1, it means that there is no difference between the groups. The odds ratio compares the odds rather than the probabilities. The odds ratio between groups 1and 2 is

$$\gamma_{12} = \frac{\pi_1 / 1 - \pi_1}{\pi_2 / 1 - \pi_2} = \frac{\gamma(\pi_1)}{\gamma(\pi_1)}$$

Groups are equivalent as far as the response is concerned if $\gamma_{21} = \gamma_{12} = 1$. The odds ratio also measures the association between rows and columns, which is the association between the grouping variable and the response (Tutz, 2012).

In structured regression models a distinction is made between two components, the structural component and the random component. A general form of the structural component is $\mu = h(\eta(x))$, where μ denotes the mean, h is a transformation function, and $\eta(x)$ denotes a structured predictor. In the case of a binary variable, the structural component that specifies the mean response has the form

$$\pi_i = F(\beta_0 + x_i^T \beta) = F(\eta(x_i)$$

With the linear predictor $\eta(x) = \beta_0 + x_i^T \beta$ and the distribution function F. An equivalent representation of the binary logit regression model is

$$\pi_x = \frac{exp\ (x^T \beta)}{1 + exp\ (x^T \beta)} \quad \text{or} \quad \frac{\pi_x}{1 - \pi_x} = exp\ (x^T \beta) \quad \text{or} \ log\left(\frac{\pi_x}{1 - \pi_x}\right) = x^T \beta$$

2.2.2 The Multinomial Logistic Regression Model

At times the response variable Y is only restricted to a set of possible values called polytomous or multi category responses which can be discrete numerical, nominal or ordinal. In business and social applications the response category may refer to the choice of different vehicle brand e.g. brand 1, brand 2, …, to brand *k*, socio-economic status e.g. poor, middle income, rich; or marital status e.g. married, never married, divorced, cohabiting, or widowed. Some rating scales have fixed response categories that have an implied order like work experience; which can be reported as none, little, moderate, or vast. There is need to distinguish between response categories whish are just labels from those which are ordered. If no order is implied, the response Y is measured on a nominal scale. If there is ordering in the categories and the corresponding numbers may be interpreted but not the distance or spacing between categories, then Y is measured on an ordinal scale. The other type of response category that contains more structure than the nominal case occurs in the form of nested or hierarchical response categories. A good example arise when the basic response is in the categories "no side effect", "side effect I", and "side effect II". Further, for the side effect type I, two further distinctions have to be made e.g. "side effect with available treatment", side effect without available treatment. In such cases, we have to split on the two levels, first the split into the basic categories and then a conditional split on the outcome side effects. In this study, the researcher focused on the response Y, the marital status of the woman which has nominal categories.

The multinomial distribution is an extension of the binomial distribution in that it allows for more than two possible outcomes. For example, in the NDHS survey, respondents are asked about their marital status. The number of outcomes depends on the number of mutually exclusive and exhaustive marital status categories.

Let the possible outcomes be denoted by *1,.., k* which can occur with probabilities $\pi_1..,\pi_k$ so that $P(Y=r)=\pi_r$. The categories of the random variable Y obscure the fact that the response is purely multivariate, since each response category refers to a dimension of its own. The general form of the multinomial distribution considers Y as a vector-valued random variable with m responses. The components of the vector $y^T=(y_1,..y_k)$ give the cell counts in the categories $1,..,k$ and have the probability mass function.

$$f(y_1,..y_k)=\begin{cases}\frac{m!}{y_1!..y_k!}\pi_1^{y_1}..\pi_k^{y_k} & ,y_i\in\{0,..m\},\ \sum y_i=m\\ \\ \text{o} & \text{otherwise}\end{cases}$$

Which is called the multinomial distribution with parameter *m* and

π^T =$(\pi_1..,\pi_k)$,$\pi_i\in$ [0,1]. Because $\sum\ y_i=m$ causes some redundancy in the presentation, a shorter version of the representation is used $y^T=(y_1,..y_q)$, $q=k-1$ giving

$$f(y_1,..y_q)=\frac{m!}{y_1!..y_q!\,(m-y_1-..-y_q)!}\pi_1^{y_1}..\pi_q^{y_q}\,.\,(1-\pi_1-..-\pi_q)^{m-y_1-..-y_q}$$

and is abbreviated as $y\sim M(m,\pi)$

This form makes it clear that the binomial distribution is a special case of the multinomial distribution where k=2 (i.e. q=1) since

$$f(y_1) = \frac{m!}{y_1!..y_q!(m-y_1)!}\pi_1^{y_1}..\pi_q^{y_q}\,.(1-\pi_1)^{m-y_1} = \binom{m}{y_1}\pi_1{}^{y_1}(1-\pi_1)^{m-y_1}.$$

It can be shown that for the multinomial distribution components $y^T = (y_1,..y_q)$

$$E(y_i) = m\pi_i$$

$Var(y_i) = m\pi_i(1-\pi_i)$ and $Cov(y_i, y_j) = -m\pi_i\pi_j$

The multinomial logit model is the most widely used regression model that links a categorical response variable with nominal categories to explanatory variables.

Let $Y \in \{1,..,k\}$ be the response categories $1,..,k$ and $y^T = (y_1,..y_k)$ be the corresponding multinomial distribution for m =1. Let **x** be the vector of explanatory variables, then the binary logit model has the form

$$log\left(\frac{P(Y=1|\boldsymbol{x})}{P(Y=2|\boldsymbol{x})}\right) = \boldsymbol{x}^T\boldsymbol{\beta}$$

The multinomial logit form uses the same linear form of logits but takes inconsideration k-1 logits instead of only one logit such that

$$log\left(\frac{P(Y=r|\boldsymbol{x})}{P(Y=k|\boldsymbol{x})}\right) = \boldsymbol{x}^T\boldsymbol{\beta}_r, r = 1,..,q$$

where the log-odds compare $P(Y=r|\boldsymbol{x})$ to the probability $P(Y=k|\boldsymbol{x})$. In this representation, k serves as the reference category since all probabilities are compared to the last category. The vector $\boldsymbol{\beta}_r$ depends on r because comparison of $Y=r$ to $Y=k$ should be specific for *r* The q logits

$$log\left(\frac{P(Y=1|\boldsymbol{x})}{P(Y=k|\boldsymbol{x})}\right), \dots, log\left(\frac{P(Y=q|\boldsymbol{x})}{P(Y=k|\boldsymbol{x})}\right)$$

determine the response probabilities $P(Y = 1|\boldsymbol{x}), \dots, P(Y = k|\boldsymbol{x})$ uniquely.

From $P(Y = r|\boldsymbol{x}) = P(Y = k|\boldsymbol{x})exp(\boldsymbol{x}^T\boldsymbol{\beta}_r)$ one gets

$$\sum_{r=1}^{k-1} P(Y=r|\boldsymbol{x}) = P(Y=k|\boldsymbol{x}) \sum_{r=1}^{k-1} exp(\boldsymbol{x}^T\boldsymbol{\beta}_r)$$

Adding $P(Y = k|\boldsymbol{x})$ to the left and right hand sides of the equation gives

$$P(Y=k|\boldsymbol{x}) = \frac{1}{1+\sum_{r=1}^{k-1} exp(\boldsymbol{x}^T\boldsymbol{\beta}_r)}$$

The representation of the multinomial logit model depends on the choice of the reference category. Instead of k, any category from 1 , .., k could have been chosen as the reference category. The need to specify the reference category is due to the constraints $\sum_r P(Y = r|\boldsymbol{x}) = 1$. The effect of this constraint is that only $q = k - 1$ response categories may be specified. The remaining probability is implicitly determined (Tutz, 2012).

2.2.3 Regression Models for Count Data

In certain regression applications, the response variable may be given in the form of event counts, where an event count refers to the number of times an event occurs, for example, the number of medical insurance claims received by a medical aid society in a month, the number of traffic accidents per week at a certain road intersection, or even the total number of children ever born to a woman.

The response variable Y can be considered as a non-negative integer-valued random variable with $y \in \{0,1,2,3,\ldots\}$. At times an upper bound exists for the response because the number of occurrences may be finite e.g. potential medical aid claims but usually the number is often very large and therefore considered as irrelevant in modelling.

The basic model for count data is the Poisson distribution, which can be treated within the framework of a generalized linear model. The Poisson distribution was derived as a limiting case of the Binomial distribution. The discrete random variable Y is distributed with intensity parameter $\lambda, \lambda > 0$ if the probability density function is given by

$$P(Y = y) = \begin{cases} \frac{\lambda^y e^{-\lambda}}{y!} & y \in \{0,1,2,3,\ldots\} \\ 0 & \text{otherwise} \end{cases} \quad \text{abbreviated } Y \sim P(\lambda)$$

The mean and variance of the Poisson distribution are equal $E[Y] = Var[Y] = \lambda$ and this property is referred to as the equi-dispersion property of the Poisson distribution. Unlike the normal distribution, whereby the mean and the variance are not linked, the Poisson distribution implicitly models stronger variability for larger means, a property that is often found in real life data. However, with real life data the variance often exceeds the mean, an effect referred to as over-dispersion which calls for separate modelling.

The Poisson distribution has some important properties. Let $\{N(t)\}, t \geq 0)$ be a counting process with $N(t)$ denoting the event count up to time *t*. $N(t)$ is a non – negative integer valued random variable, and the process is a collection of these random variables satisfying the property that $N(s) \leq N(t)$ if $s < t$. The Poisson process is a specific counting process that has to fulfil several properties. With $N(t, t + \Delta t)$ denoting the number of counts in the interval $t + \Delta t$ then

a) For disjunctive time intervals $(s, s + \Delta s)$ and $(t, t + \Delta t)$, the increments $N(s, s + \Delta s)$ and $N(t, t + \Delta t)$ are independent.

b) The distribution of the counts in the interval $(t, t + \Delta t)$ depends only on the length of the interval Δt and not on t.

c) The probability of no or one event in the interval $(t, t + \Delta t)$is given by

$$P(N(t, t + \Delta t) = 1) = \lambda \Delta t + o(\Delta t)$$

$$P(N(t, t + \Delta t) = 0) = 1 - \lambda \Delta t + o(\Delta t)$$

Where *o(h)* denotes a remainder term with the property ${o(h)}/{h} \rightarrow 0 \; as \; h \rightarrow 0$.

From this process, the number of events occurring in the interval $(t, t + \Delta t)$ is Poisson distributed with mean $\lambda \Delta t$ i.e.

$$N(t, t + \Delta t) \sim P(\lambda \Delta t)$$

If the Poisson process is a valid model, the waiting time between events follows an exponential distribution. For the waiting time for the first event, W_1, the outcome $W_1 > t$ occurs if no events occur in the interval $(0, t)$.

$P(W_1 > t) = P\big(N(0,t)\big) = e^{-\lambda t}$ so that W_1 follows the exponential distribution with parameter λ.

Sums of independent Poisson distributed random variables are Poisson distributed i.e.

If $Y_i \sim P(\lambda_i),\ i = 1,2,3, \ldots$ are independent and $\sum_i \lambda_i < \infty$ then $\sum_i \lambda_i \sim P(\sum_i \lambda_i)$.

For large values of λ the Poisson distribution P(λ)may be approximated by a normal distribution $N(\lambda, \lambda)$.

Poisson Regression Model

Let (y_i, x_i) denote *n* independent observations and $\mu_i = E(y_i|x_i)$then $y_i|x_i \sim P(\mu_i)$ so that

that $\mu_i = h(\boldsymbol{x}_i^T \boldsymbol{\beta})$or $g(\mu_i) = \boldsymbol{x}_i^T \boldsymbol{\beta}$ where g is a known link function of $\mu = g^{-1}$denotes the response function. Since the Poisson distribution is from the exponential family, the model is a generalized linear model. The most widely used model uses the canonical link function by specifying

$\mu_i = \exp(\boldsymbol{x}^T\ \boldsymbol{\beta})$ or $\boldsymbol{x}^T\ \boldsymbol{\beta}$

called a log linear model since the logarithm of the conditional mean is linear in the parameters. This log-linear form makes interpretation of the parameters easy. The model implies that the conditional mean given $x_t = (x_1, x_2, \cdots, x_p)$ has a multiplicative form given by $h(\boldsymbol{x}) = \exp(\boldsymbol{x}^T\boldsymbol{\beta}) = e^{x_1\beta_1 \cdots x_p\beta_p}$

Thus e^{β_j}represents the multiplicative effect on $\mu(\boldsymbol{x})$ if the variable x_j changes by one unit to $x_j + 1$, (given that the rest of the variables are fixed) one obtains $\frac{\mu(x_1,\cdots x_{j+1},\cdots x_p)}{\mu(x_1,\cdots x_j,\cdots x_p)} = e^{\beta_j}$ or equivalently

$\log \mu\big(x_1, \cdots x_{j+1}, \cdots x_p\big) - log\mu\big(x_1, \cdots x_j, \cdots x_p\big) = \beta_j$ where β_j is the change in the log means if x_j increases by one unit, e^{β_j} is the multiplicative effect, which is easier to interpret because it directly effects upon the mean.

The model goodness of fit can be assessed through the deviance statistic. The deviance is a measure of the discrepancy between the fit and the data. It compares the log likelihood of the fitted value for observation y_i

Denoted by $l_i(\hat{\mu}_i) = y_i \log(\hat{\mu}_i) - \hat{\mu}_i - \log(y_i!)$ to the likelihood of the perfect fit

$l_i(y_i) = y_i \log(y_i) - \log(y_i!)$, yielding

$$D = -2\sum_i l_i(\hat{\mu}_i) - l_i(y_i) = 2\sum_i \left\{y_i log\left(\frac{y_i}{\hat{\mu}_i}\right) + [(\hat{\mu}_i - y_i)]\right\}$$

If an intercept term is included, the term in brackets $\hat{\mu}_i - y_i$, may be omitted.

With the scope of generalized linear models, the deviance is also used as a goodness of fit test with a known asymptotic distribution when the observations are grouped.

Let $y_{i1}, \cdots y_{in_i}, i = 1, \cdots, N$ denote independent observations at a fixed measurement about x_i with $Y_{it} \sim P(\tilde{\mu}_i), \tilde{\mu}_i = h(\boldsymbol{x}_i^T \boldsymbol{\beta})$.

Then $y_i = n_i \bar{y}_i = \sum_{t=1}^{n_i} y_{it} \sim P(n_i \tilde{\mu}\ \ )$ which may be written as

$y_i = P(\mu_i)$, where $\mu_i = n_i \tilde{\mu}$.

When using $\tilde{\mu}$, the deviance for the grouped data observations has the same form as for single observations.

$$D = 2 \sum_i \left\{ y_i log \left(\frac{y_i}{\hat{\mu}_i} \right) + [(\hat{\mu}_i - y_i)] \right\}$$

is asymptotically χ^2 distributed with $N - p$ degrees of freedom, where p is the dimension of the parameter vector.

Negative Binomial Model

A more flexible model than the Poisson model is the Negative Binomial distribution which is a two parameter distribution and can model over-dispersed counts. The negative binomial model can be derived as a mixture of Poisson distributions. If we consider the Gamma distribution $b_i = \Gamma(v, \alpha)$ with probability density

$$f(b_i) = \begin{cases} 0 & b_i \leq 0 \\ \frac{\alpha^v}{\Gamma(v)} b_i^{v-1} e^{-\alpha b_i} & b_i > 0 \end{cases}$$

The mean and variance are $E(b_i\ ) = {}^{v}/_{\alpha}\, , and\ Var(b_i) = {}^{v}/_{\alpha^2}$

If one assumes for the random parameter b_i the Gamma distribution $\Gamma(v, v)$, the mean fulfils $\mathrm{E}(b_i) = 1$ and obtains for the marginal probability

$$P(y_i) = \int f(y_i|b_i) f(b_i) db_i$$

$$= \int \left(e^{-b_i \mu_i} \frac{(b_i \mu_i)^{y_i}}{y_i!} \right) \left(\frac{v^v}{\Gamma(v)} b_i^{v-1} e^{-v b_i} \right) db_i$$

$$= \frac{\Gamma(y_i + v)}{\Gamma(v)\Gamma(y_i + v)} \left(\frac{\mu_i}{\mu_i + v} \right)^{y_i} \left(\frac{v}{\mu_i + v} \right)^{v}$$

which represents the Negative Binomial distribution $NB(v, \mu_i)$ with mean and variance given by

$E(y_i) = \mu_i = \exp(\boldsymbol{x}_i^T \boldsymbol{\beta})$ and $Var(y_i) = \mu_i + \frac{{\mu_i}^2}{v}$

The mean is the same as for the simple Poisson distribution but the variance is greater than the Poisson variance by $\frac{{\mu_i}^2}{v}$. The Poisson case may be seen as a limiting case $(v \to \infty)$. The scaling of v is such that small values signal strong over-dispersion when compared to the Poisson model while for large values of v the model is similar to the Poisson Model and $\frac{1}{v}$ is considered the dispersion parameter. The additional parameter makes the model more flexible than the simple Poisson model.

Zero-inflated Count Models

It often occurs that one observes more zeros than are consistent with the Poisson or Negative Binomial model. The data may exhibit over-dispersion through excess zeros.

The data could be from a mixture of distributions. For example, a question may be asked to a woman, “What is the total number of children ever born to you?” Zero responses will be recorded for many women who never had children due to infertility, and from those women who could have children but who happen not have had any children yet during the time interval in question.

Generally, zero inflated count models can be derived from a mixture of two sub-populations, one with the no-responders who are never at risk of the event and the responders, who are at risk. With C denoting the class indicator of the sub-populations ($C_i = 1$ for responders and $C_i = 0$ for non-responders), one obtains a mixture distribution

$$P(Y_i = y) = P(Y_i = y|C_i = 1)\pi_i + P(Y_i = y|C_i = 0)(1 - \pi_i)$$

Where $\pi_i = P(C_i = 1)$ are the mixing probabilities.

If one assumes that the counts within the responder sub-populations are Poisson distributed, one obtains

$$P(Y_i = 0|C_i = 0) = 1$$

$$P(Y_i = 0) = P(Y_i = 0|C_i = 1)\pi_i + (1 - \pi_i)$$

$$= \pi_i e^{-\mu_i} + 1 - \pi_i$$

And for $y > 0$

$$P(Y_i = y) = P(Y_i = y|C_i = 1)\pi_i + \pi_i e^{-\mu_i} \mu_i^y / y!$$

Where μ_i is the mean of the Poisson distribution of population $C_i = 1$ and one obtains

$E(y_i) = \pi_i\mu_i,\ Var(y_i) = \pi_i\mu_i + \pi_i(1-\pi_i)\mu_i^2 = \pi_i\mu_i(1+\mu_i(1-\pi_i)$

Since $Var(y_i) > E(y_i)$, excess zeros imply over-dispersion if $\pi_i < 1$. The Poisson model is included in the special case where all observations refer to responders and $\pi_i = 1$.

When covariates are present, one may specify a Poisson distribution model for $y|C_i = 1$ and a binary response model for $C_i \in \{0,1\}$ for example

$\log(\mu_i) = \boldsymbol{x}_i\ \boldsymbol{\beta},\ \log(\pi_i) = z_i^T\gamma$ where x_i and $z_i$may be different sets of covariates. The simplest mixture models assumes only an intercept in the binary model

$\text{logit}(\pi_i) = \gamma_0$. For increasing $\gamma_0$one obtains in the limit the Poisson distribution model without zero inflation. The joint log-likelihood function, after omitting constants is given by

$$l = \sum_{i=1}^{n} l_i(y_i)$$

$$= \sum_{i=1}^{n} I(y_i = 0)\, log\left\{1 + \frac{exp(\boldsymbol{z}_i^T\boldsymbol{\gamma})}{1+exp(\boldsymbol{z}_i^T\boldsymbol{\gamma})}\left(exp(-exp(\boldsymbol{x}^T\boldsymbol{\beta}) - 1)\right)\right\}$$

$$+\left(1 - I(y_i = 0)\right)\left\{\boldsymbol{z}_i^T\boldsymbol{\gamma} - log\left(1 + exp(\boldsymbol{z}_i^T\boldsymbol{\gamma})\right) - exp(\boldsymbol{x}^T\boldsymbol{\beta}) + y_i(\boldsymbol{x}^T\boldsymbol{\beta})\right\}$$

Where $I(y_i = 0)$ denotes an indicator variable that takes value 1 if $y_i = 0$ and 0 otherwise.

Hurdle models

Another model that is able to account for excess zeros is the hurdle model (Tutz, 2012), which allows one to model over-dispersion through excess zeros for baseline models such as the Poisson and the Negative Binomial model. The model specifies two processes that generate zeros and the positives. The combination of both models, a binary model that determines whether the outcome is a zero or positive and a truncated-at zero count model, gives the model.

Generally, if f_1 and f_2 are the probability mass functions with support $\{0,1,2,\cdots\}$. The hurdle model is given by

$$P(y = 0) = f_1(0)$$

$$P(y = r) = f_2(r)\frac{1 - f_1(0)}{1 - f_2(0)}, \quad r = 1,2,\cdots$$

The model can be viewed as a stage-wise decision model, which, at first stage, a binary variable C determines whether a count variable has a zero or a positive outcome. C=1 means that the “hurdle is crossed” and the outcome is positive, while C=0 means that will be observed.

The binary decision between zero and a positive outcome is determined by the f_1 distribution in the form

$$P(C=1) = 1 - f_1(0) \; and \; P(C=0) = f_1(0)$$

At the second stage the conditional distribution given c is specified. If the hurdle is crossed, the response is determined by the truncated count model with probability mass function

$$P(Y=r|C=1) = {f_2(r)}/{\left(1 - f_2(0)\right)} \qquad , \;\; r = 1,2,\cdots$$

If the hurdle is not crossed, the probability for zero outcome is 1, $P(Y=0|C=0) = 1$. One obtains the hurdle model from

$$P(Y=r) = P(Y=r|C=0)P(C=0) + P(Y=r|C=1)P(C=1)$$

Which yields

$$P(Y=0) = P(C=0) = f_1(0)$$

$$P(Y=r) = P(Y=r|C=1)P(C=1)$$

$$= \left\{ {f_2(r)}/{\left(1 - f_2(0)\right)} \right\} \left(1 - f_2(0)\right), \quad r = 1,2,\cdots$$

The derivation shows that the hurdle model is a finite mixture of truncated count model $P(Y=r|C=1)$ and the degenerate distribution $P(Y=r|C=0)$. In contrast to the zero-inflated count models, C is an observed random variable and not an unobservable mixture. The truncated count model is determined by the probability mass function f_2 which is referred to as the parent process. If $f_1 = f_2$ the model collapses to the parent model f_2. This model quite flexible as is handles both under and over-dispersion if we look at the mean and variance, with

$$\gamma = {(1 - f_1(0))}\Big/{(1 - f_2(0))} = P(Y > 0|(1 - f_2(0))$$

$E(y) = \sum_{r=1}^{\infty} r\, f_2(r)\gamma = P(Y > 0)E(y|y > 0)^2$ and the variance has the form

$$Var(Y) = P(Y > 0)Var(Y|Y > 0) + P(y > 0)(1 - P(Y > 0))\, E(y|y > 0)^2$$

Looking at a specific model like the Hurdle Poisson model, which assumes that f_2 is the probability mass function of a Poisson distribution with mean μ_2. Let y_2 denote the corresponding variable (Poisson with mean μ_2), then one has

$$E(y_2) = \gamma\mu_2$$

$$Var(Y) = \sum_{r=1}^{\infty} r^2\, f_2(r)\,\gamma - \left[\sum_{r=1}^{\infty} r\, f_2(r)\right]^2 = \mu_2(1 + \mu_2)\gamma - {\mu_2}^2\gamma^2$$

And therefore

$$\frac{Var(Y)}{E(Y)} = 1 + \mu_2(1 - \gamma)$$

This means that for the non-trivial case $\mu_2 > 0$ one obtains over-dispersion if $0 < \gamma < 1$ and under dispersion if $1 < \gamma < \frac{1+\mu_2}{\mu_2}$, where the upper threshold is determined by the restriction $Var(Y > 0)$. For $Y = 1$, the hurdle Poisson model becomes the Poisson model. The model is determined by the choice of $f_1$and f_2. There is a lot of flexibility because $f_1$and f_2 may be Poisson, or Negative Binomial distributions. One can also combine the binary logit model for the truncated right censured at $y = 1$ distribution of f_1, and a Poisson or Negative Binomial model for f_2. Concrete reparametrizations are obtained by linking the two distributions to explanatory variables. If we consider the Hurdle Poisson model where both $f_1$and f_2 correspond to Poisson distributions with means μ_1 and μ_2, then for observations (y_i, x_i)one may specify for

$\mu_{i1} = \exp(\boldsymbol{x}_i^T \boldsymbol{\beta_1}), \qquad \mu_{i2} = \exp(\boldsymbol{x}_i^T \boldsymbol{\beta_2})$

Yielding the model $P(y_i = 0) = \exp(-\mu_{i1})$

$$P(y_i = r) = \frac{{\mu_{i2}}^r}{r!} e^{-\mu_{i2}} \frac{1 - \exp(-\mu_{i1})}{1 - \exp(-\mu_{i1})}$$

The log likelihood is given by $l(\boldsymbol{\beta_1}, \boldsymbol{\beta_2}) = -\sum_{y_i=0} \mu_{i1} + \sum_{y_i>0} log\left(\frac{1-e^{-\mu_{i1}}}{1-e^{-\mu_{i2}}} \frac{{\mu_{i2}}^{y_i}}{y_i!} e^{-\mu_{i2}}\right),$

which decomposes into $l(\boldsymbol{\beta_1}, \boldsymbol{\beta_2}) = l_1(\boldsymbol{\beta_1}) + l_2(\boldsymbol{\beta_2})$ with

$$l_1(\boldsymbol{\beta_1}) = -\sum_{y_i=0} \mu_{i1} + \sum_{y_i>0} \log(1 - e^{-\mu_{i1}})$$

$$l_2(\boldsymbol{\beta_2}) = \sum_{y_i>0} \log(\mu_{i2}) - \mu_{i2} - \log(1 - e^{-\mu_{i2}}) - \log(y_i!)$$

In general, the regressors for the two model components do not have to be the same. Even though most hurdle models use the hurdle zero, the specification of more general models where the hurdle is some positive number can be readily developed. R packages have been developed to fit zero inflated and hurdle models using the MASS and pscl packages ((Kleiber and Zeileis, 2008).

2.2.4 Event History Models

In many business, health and social science applications, the response of interest is the time to a certain event. For example, survival time after being diagnosed with cancer, time to failure of a new component, or even the time to first sex or marriage.

In social sciences, the interest is usually focused on the effects of demographic or socio-economic covariates on human behaviours. It is usually impossible to observe the duration times for all subjects, either due to loss to follow up, or because the event never takes place (e.g. the person never marries). Some times are missing, or censored, and the missingness mechanism is generally assumed at random. There are two types of censoring. Right censoring is most common and this occurs when the event has not occurred by the end of the observation period. That means the unknown failure time is greater than the subject's survival time c when the observation period ended. On the other hand, a failure time is left-censored at c if its unobserved actual value is less than c. A failure time is interval-censored if it is known only that it lies in the interval (c_1, c_2).

Discrete time survival analysis

Event history data for discrete time purposes usually records the dependent variable as a series of binary outcomes denoting whether or not the event of interest has taken place has taken place at the observation point. The history is structured into discrete intervals where the random variable T denotes the time of occurrence of an event. We assume that events are both observable at specific, directly defined points, t_i. The probability mass function for a discrete random variable is $f(t) = P(T = t)$ and denotes the probability of an event occurring at time t_i. More than one failure can occur simultaneously. The survivor function for the discrete random variable T is given by $S(t) = P(T \geq t_i) = \sum_{j \geq i} f\left(t_j\right)$, where j is a failure time. The hazard rate for this discrete time case is given by

$$h(t) = \frac{f(t)}{S(t)}$$

which shows that the risk of an event occurrence is equivalent to the ratio of the probability of failure to the probability of survival (Box-Steffensmeier and Jones, 2004). This ratio can be expressed in terms of the conditional probability of failure, given survival, hence the hazard probability for the discrete time case can be written as

$P(T = t_i | T > t_i)$.

If we suppose that the conditional probability of survival is

$P(T > t_i|T \geq t_i) = 1 - h(t)$, then the probability of failure $f(t)$, can be expressed as

$P(T = t_i) = P(T = t_i|T \geq t_i)\ X\ P(T > t_{i-1}|T \geq t_i)\ X\ \ \ldots.\ X\ P(T > t_2\backslash T \geq$ 2) $X\ P(T > t_1\backslash T \geq t_1)$, where t_2 and t_1 represent the first and second time periods. Now if we express this in terms of the hazard probability and in terms of the conditional probability we have

$f(t) = h(t_i)\ X\ \left(1 - h(t_{i-1})\right) X \ldots.X \left(1 - h(t_2)\right) X \left(1 - h(t_1)\right) = \prod_{i=1}^{t} 1 - h(t_i)$,

This illustrates that the probability of survival beyond time *t* is equal to the conditional probability of surviving through each the *t* previous periods.

For an event history data set consisting of n cases observed over *t* periods, for each observation in the dataset, let y_{it} denote the dependent variable which is a binary indicator coded 1 if an event occurs and 0 if an event does not occur at time *t*. If the event never occurs, the observation is right censored and contributes to the data set a vector of zeros. The likelihood of such a dataset is given by

$$L = \prod_{i}^{n} \left[h(t_i) \prod_{i=1}^{t-1} (1 - h(t_i))\right]^{y_{it}} \left[\prod_{i=1}^{t} \left(1 - h(t_i)\right)\right]^{1-y_{it}}$$

$$= \prod_{i=1}^{n} \{f(t)\}^{y_{it}} \{S(t)\}^{1-y_{it}}$$

From this likelihood function, only cases experiencing an event contribute information regarding the probability of failure i.e. $f(t)$ and cases not experiencing the event contribute information only regarding the probability of survival i.e. $S(t)$.

Models for discrete time processes

With the discrete time data structure, correlates can be incorporated by treating the probability of failure as conditional on survival as well as covariates i.e.

$$h(t) = P(T = t_i | T \geq t_i, \boldsymbol{x})$$

Since for discrete time data the dependent variable is binary, a commonly applied function relating this variable to covariates involves the logistic distribution, which gives rise to the logit model.

The discrete time formulation of the event history model aims at modelling the risk, or the probability of occurrence of the event of interest. The hazard probability achieves this idea of risk as it reflects the probability of an event's occurrence, conditional on survival and covariates, to some time t_i. We denote the probality of an event's occurrence by $P(y_{it} = 1) = \lambda$ and the probability of non-occurrence $P(y_{it} = 0) = 1 - \lambda$. We assume that this probability is a function of covariates $\boldsymbol{x}$**.** To derive a discrete time model, we first specify a distribution function for the following model

$$\lambda_{it} = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_k x_{ki}$$

A commonly used function for this model is the logit function

$$\log\left(\frac{\lambda_i}{1-\lambda_i}\right) = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_k x_{ki}$$

which specifies λ in terms of the log-odds ratio of the probability of an event occurrence to the probability of a non-occurrence. The logit coefficients β_k are therefore interpreted in terms of their relationship to the log-odds of an event occurrence. When $\beta_k > 0$, the log of the odds ratio is increasing as the covariate increases, and decreasing when $\beta_k < 0$. Since the log odds ratio are generally awkward to interpret, the predicted probability of an event occurrence, λ_i, can be retrieved from the logit model by re-expressing

$$\log\left(\frac{\lambda_i}{1-\lambda_i}\right) = \beta_0 + \beta_1 x_{1i} + \beta_2 x_{2i} + \cdots + \beta_k x_{ki}$$

directly in terms of the probability $\lambda_i = \frac{e^{\beta' x}}{1+e^{\beta' x}}$ where $\exp(\beta' \boldsymbol{x})$ represents the exponential logit parameters for a given covariate profile.

Bayesian Event History models

If $Y_1, Y_2, \cdots, Y_n$ denote random variables associated with a sample of size n, the likelihood function of the sample $L(y_1, y_2, \cdots, y_n|\vartheta)$ is the joint density $P(Y_1 = y_1, Y_2 = y_2, \cdots Y_n = y_n|\vartheta)$. The parameter ϑ shows that this function depends explicitly on the value of some parameter ϑ. In the Bayesian approach, this unknown parameter ϑ is considered a random variable with probability distribution called the prior distribution of ϑ. The prior distribution is specified before any data is collected and provides a theoretical distribution of information about ϑ that was available before any data was collected. We assume that the parameter ϑ has a continuous distribution with density $g(\vartheta)$ that has no unknown parameters. Based on the likelihood and the prior on ϑ, it follows that the joint likelihood of $Y_1, Y_2, \cdots, Y_n, \vartheta$ is

$$f(y_1, y_2, \cdots, y_n, \vartheta) = L(y_1, y_2, \cdots, y_n | \vartheta) X \; g(\vartheta)$$

and the marginal density of $Y_1, Y_2, \cdots, Y_n$ is

$$m(y_1, y_2, \cdots, y_n) = \int_{-\infty}^{\infty} L(y_1, y_2, \cdots, y_n | \vartheta) \; X \; g(\vartheta) \; d(\vartheta)$$

The posterior density of $\vartheta | y_1, y_2, \cdots, y_n$ is

$$g * (\vartheta | y_1, y_2, \cdots, y_n) = \frac{L(y_1, y_2, \cdots, y_n | \vartheta) \; X \; g(\vartheta)}{\int_{-\infty}^{\infty} L(y_1, y_2, \cdots, y_n | \vartheta) \; X \; g(\vartheta) \; d(\vartheta)}$$

The posterior density summarizes all of the pertinent information, about the parameter ϑ by making use of the information contained in the prior for ϑ and the information in the data (Wackerly et al, 2008). Prior distributions that result in posterior distributions that are of the same functional form as the prior but with altered parameter values are called conjugate priors. For a number of distributions, there are conjugate prior families often considered to be broad enough to handle most practical situations, since the posterior will be a true probability density function, and some characteristics of this density provide an estimate of ϑ i.e. the mean, median and mode of the posterior density could be used as an estimator. To estimate some function of ϑ, say $t(\vartheta)$, the posterior expected value of $t(\vartheta)$ can be used as an estimator of this function of ϑ.

In the development of classical confidence intervals, the parameter of interest ϑ has a fixed but unknown value and the intervals are constructed by finding two random values $\hat{\vartheta}_L$ and $\hat{\vartheta}_U$, the lower and the upper confidence limits such that $\hat{\vartheta}_L < \hat{\vartheta}_U$ so that the interval $(\hat{\vartheta}_L, \hat{\vartheta}_U)$ encloses the fixed value of ϑ with probability $1 - \alpha$.

The parameter is fixed, the endpoints of the interval are random, and different samples will yield different realised intervals. With Bayesian inference, the parameter ϑ is a random variable with posterior density function $g * (\vartheta)$. If we consider the interval (a, b), the posterior probability that the random variable ϑ is in this interval is

$$P * (a \leq \vartheta \leq \mathrm{b}) = \int_a^b g * (\vartheta) \ d(\vartheta) ,$$

so that if the posterior probability $P * (a \leq \vartheta \leq \mathrm{b}) = 1 - \alpha)$, it means that the interval (a, b) is a credible interval for ϑ.

The Bayesian approach to estimation and inference dwells on the updating knowledge about unknown, ϑ , in a statistical model on the basis of observations, y, with the revised knowledge expressed in the posterior density $p(\vartheta \mid y)$. Hypothesis on parameters are also based on posterior probabilities conditional on the observed data. Markov Chain Monte Carlo (MCMC) can be used to provide an effective way to generate samples from the joint posterior distribution$p(\vartheta \mid y)$. The MCMC methods differ from the conventional Monte Carlo methods in that successive sampled parameters are dependent or auto correlated. The target density for the MCMC samples is especially relevant when the posterior cannot be stated exactly in analytical form, for example when the prior density assumed for ϑ is not conjugate with the likelihood $p(y|\vartheta)$ (Congdon, 2010).

Bayesian Structured Additive Regression

General linear models assume that given covariates, v and unknown parameters γ, the distribution of the response variable y belongs to an exponential family with mean, $\mu = E(y|\mu, \gamma)$ linked to a linear predictor η by

$\mu = h(\eta), \quad \eta = \mu'\gamma$ where h is a known response function and γ are the unknown regression parameters (Brezger and Kneib, 2005).

Recent years have seen fast advances in information and communications technology resulting in an increase in the availability and abundance of spatial geo-referenced regression data. Handling such special data appropriately called for more sophisticated regression analysis techniques.

In practical generalised linear regression situations, a number of challenges often arise as follows:

For continuous covariates in the dataset, the assumption of a strictly linear effect on the predictor may not be appropriate, i.e. some effects may be of unknown non-linear form.

Observations may be spatially correlated.

Observations may be temporally correlated.

Heterogeneity among individuals or units may not be sufficiently describe by covariates such that the unobserved unit or cluster specific heterogeneity must be handled appropriately.

Interactions between covariates may be of complex non-linear form.

To address these challenges, the strictly linear predictor is replaced by a semi-parametric structured additive predictor

$$\eta_i = f_i(v_{i1}) + \cdots f_p(v_{ip}) + \mu_i'\gamma$$

where i is the generic observation index, the v_j are the generic covariates of different type and dimension, and the f_j are functions of the covariates which are not necessarily smooth. These functions consist of non-linear effects of continuous covariates, time trends and seasonal effects, two dimensional surfaces, varying coefficient models, independent identically distributed random intercepts and slopes and temporally or spatially correlated effects. Covariates with parametric effects are subsumed in the term $\mu_i'\gamma$ (Lang et al, 2014; Brezger and Kneib, 2005)

Spatial effects are usually introduced in regression models to account for spatial correlation which is usually induced by unobserved, spatially varying covariates. Spatial locations are usually captured exactly in terms of latitude and longitude or observations are clustered in connected geographical regions and can be used to estimate spatial effects.

Another popular approach to estimate the smooth effects of continuous covariate is to employ penalised splines or p-slines. The basic assumption of this approach is that the unknown smooth function f_j of a covariate x_j can be approximated by a polynomial spline. A polynomial spline function is defined based on a set of M+1 (not necessarily equally spaced) knots $x_{min} = k_0 < k_1 < \cdots < k_{M-1} < k_M = x_{max}$ within the domain of the covariate x. A function $g: (a, b) \to IR$ is called a polynomial spline of degree $l, l \in IN_0$ based on knots $k_0, \cdots, k_m$ if it satisfies the following conditions:

g(x) is $l - 1$ times continuous differentiable and

g(x) is a polynomial of degree l for $x \in [k_m, k_M|\,]$, $m = 0, \cdots, M - 1$

The space of the polynomial splines can be shown to be an $(M + 1)$dimensional subspace of the space of the $(l - 1)$ times continuous differentiable functions. Therefore assuming that f(x) can be approximated by a polynomial spline leads to a representation in terms of a linear combination of $d = M + 1$ basis functions B_m i.e.

$$f(x) = \sum_{m=1}^{d} \xi_m B_m(x)$$

where $\boldsymbol{\xi} = (\xi_1, \cdots, \xi_d)'$ corresponds to the vector of unknown regression coefficients.

The standard procedure for examining the effects of covariates (v_i) on survival times is the Cox proportional hazard model where the multiplicative structure

$$\lambda_i = \lambda(t, v_i) = \lambda_0(t)\exp(v_i', \gamma)$$

is assumed for the hazard rate, γ is a vector of regression coefficients and $\lambda_0(t)$ is the baseline hazard rate. The baseline hazard rate is re-parameterized through $g_0 = \log\left(\lambda_0(t)\right)$ and the covariates are partitioned into groups of different types to extend the Cox model to a semi-parametric hazard rate model so that $\lambda_i(t) = \exp(\eta_i(t))$, $i = 1,2,\cdots,n$ is a geo-additive predictor of the form

$$\eta_i(t) = v_i'\Upsilon + g_o(t) + \sum_{j=1}^{J} f_j(x_{ij}) + f_{spat}(s_i) + b_{gi}$$

where $f_j(x_{ij})$ is the non-linear effect of continuous covariates x_j, and $f_{spat}(s)$ is the spatial effect. The vector of linear effects is denoted by γ while b_g, $g \in \{1,\cdots,G\}$ are uncorrelated individual or group specific frailties. An extended geo-additive Cox model that addresses arbitrary combinations of left , right and interval censoring schemes and relaxes the proportional hazards assumption by allowing all covariates to be piecewise constant i.e. time varying was further proposed by Kneib (2006). Extensions of geo-additive models have been widely developed and adopted (Adebayo and Farhmeir 2005; Hennerfeind et al,2006; Khatab and Fahrmeir, 2009;Wand, Whitaker and Ramjee,2011; Nkurunziza, Gerbhhardt and Pilz,2011; Claudio et al, 2012; Olubiyi and Olubusoye, 2013). The predictor, $\eta_i(t)$ can be expressed in matrix notation if we let $\boldsymbol{\eta} = (\eta_1, \eta_2, \cdots, \eta_n)'$ denote the prediction vector, and let $\boldsymbol{g_l} = (g_l(t_1), \cdots, \left(g_l(t_n)\right)'$ denote the evaluation of functions $g_l(t)$, $\boldsymbol{f_j} = (f_j\left(x_{1j}\right), \cdots f_j\left(x_{nj}\right))'$, the vector of evaluations of the functions $f_j(x_j)$, $\boldsymbol{f_{spat}} =$

$\left(f_{spat}(s_1), \cdots, f_{spat}(s_n)\right)'$, the vector of spatial effects and $\boldsymbol{b} = \left(b_{g1}, \cdots b_{gn}\right)'$ the vector of uncorrelated random effects. These vectors can be expressed as a matrix product of a design matrix **Z** and vector of parameters **B** to give

$\boldsymbol{\eta} = \boldsymbol{V\lambda} + \boldsymbol{Z_1 B_1} + \cdots \boldsymbol{Z_p B_p}.$

The likelihood of $\vartheta = (\boldsymbol{\lambda}', \boldsymbol{B_1}', \cdots, \boldsymbol{B_p}'$ for a n interval censored observation is given by

$$L_i(\vartheta) = exp\left(-\int_0^{T_j} \boldsymbol{\lambda(t)dt}\right)\left(1 - exp\left(-\int_{T_l}^{T_u} \boldsymbol{\lambda(t)dt}\right)\right)$$

The model is estimated using Bayesian inference. Priors for all parameters are assigned under the Bayesian approach (Lang and Brezger , 2004; Kneib and Fahrmeir, 2007). Diffuse priors are assumed for fixed parameters, while for the baseline effect $g_o(t)$ and the non-linear effects $f_j(x_{ij})$, Bayesian P-spline prior is assumed. These allow for nonparametric estimation of f as a linear combination of basis function (B-splines) $f(z) = \sum_{t=1}^{m} \alpha_t \beta_t(z)$, where $\beta_t(z)$ are B-splines and the coefficient of α_t are further defined to follow a second order Gaussian random walk smoothness priors

$$\alpha_2 = 2\alpha_{j-1} - \alpha_{j-2} + \epsilon_1$$

with independent and identically distributes errors $\epsilon_1 \sim N(0, \tau^2)$. The variance τ^2 controls the smoothness of f. Assigning a weakly informative inverse Gamma prior

$\tau^2 \sim IG(\boldsymbol{\epsilon}, \boldsymbol{\epsilon})$, with $\boldsymbol{\epsilon}$ very small, it is estimated jointly with the basis function coefficients.

Random effects (b_{gi}) are modelled by assuming exchangeable normal priors, $b_{ij} \sim N(0, \tau_b^2)$, where τ_b^2 is a variance component that incorporates over-dispersion and heterogeneity. For the spatial effects $f_{spat}(s)$, a Gaussian Markov random field prior can be chosen, which is commonly used in spatial statistics (Beag, York and Mollie, 1991), given as

$$\left[\boldsymbol{f_{spat}(s)} | \boldsymbol{f_{spat}(t)}; \boldsymbol{t} \neq \boldsymbol{s}, \boldsymbol{\tau^2}\right] \sim \boldsymbol{N}\left(\sum_{\boldsymbol{t} \in \boldsymbol{\partial_s}} \frac{\boldsymbol{f_{spat}(t)}}{\boldsymbol{N_s}}, \frac{\boldsymbol{\tau^2}}{\boldsymbol{N_s}}\right)$$

where $\boldsymbol{N_s}$ is the number of adjacent sites and $\boldsymbol{t} \in \boldsymbol{\partial_s}$ denotes that site t is a neighbour of site s. The prior defines areas as neighbours if they share a common boundary and neighbouring areas are assumed to have similar patterns. The conditional mean of $f_{spat}(s)$ is an average function of evaluations $f_{spat}(t)$ of neighbouring sites t, with τ^2 controlling the amount of spatial smoothness. In order to be able to estimate the smoothing parameters for non-linear and spatial effects, highly dispersed but proper hyper-priors are assigned to them. Hence, for all variance components, an inverse gamma distribution with hyper-parameters *a* and *b* is chosen e.g. $\tau^2 \sim IG(\boldsymbol{a}, \boldsymbol{b})$. Standard choices for the hyper parameters are *a=1* and *b=0.005* or *a=b=0.001*.

Evaluation of the posterior distribution of the model parameters is based on Empirical Bayesian inference. This uses a restricted maximum likelihood proposal which adopts a generalized mixed methodology approach (Kneib and Fahrmeir, 2007). Detailed numerical methods of implementing survival time models are described in the reference manual of BayesX (Belitz et al., 2009). Model diagnostics are based on the Akaike Information Criterion (AIC) and the Bayesian Information criteria (BIC). The best model is the one with the smallest AIC and BIC. AIC and BIC regulate the trade-off between the goodness of fit of the model and the complexity by imposing a penalty discourages over-fitting (increasing the number of free parameters in the data-generating process).

2.5 Conceptual framework

A number of authors have come up models and behavioral theories (Garfinkel et al, 2003; Manda, 2005; Rashad & Roudi-Fahimi, 2005; Burgess, Propper & Aassve, 2005; Kalmijn, 2007; Musau, 2008; Kim and Raley, 2014; Marston et al, 2013) suggesting various factors that impact on family formation processes. A conceptual framework for this study has been constructed by integrating factors from literature review such as socio-economic and cultural factors like family factors, peer pressure, economic status, religion, education level, geographical region, place of residence, employment status and ethnicity as correlates of family formation processes. Figure 1, shows the conceptual framework of demographic, socio-economic and cultural factors that might impact on family formation processes (Musau, 2008).

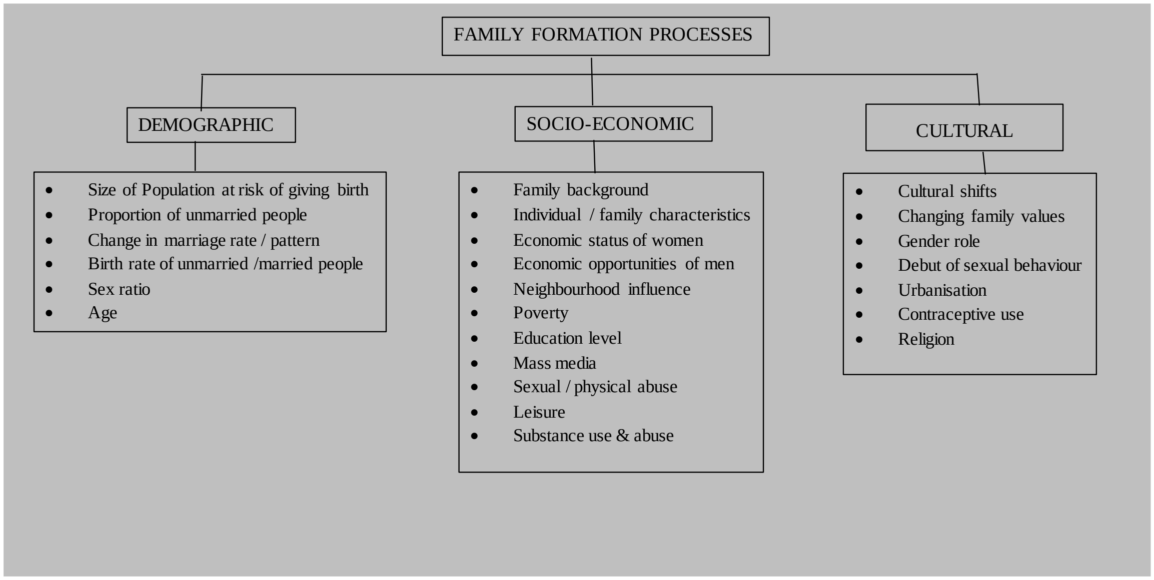


Figure 1: Conceptual framework for family formation processes

CHAPTER 3

METHODOLOGY

3.1 Research Design

The study used a cross-sectional design to give a snapshot of entire population and to allow investigation of potential risk factors and family formation process outcomes of interest. Both quantitative and qualitative approaches were used. For the first four objectives, the study was a cross-sectional retrospective design based on the NDHS of 1992, 2000 and 2006/7. The 3 DHS were pooled together. In the NDHS, a multi-stage cluster survey design was used, which at first stage a random sample of enumeration areas, which are the primary sampling units (PSU) were selected with probability proportional to size. From the selected PSU, a systematic sample of households was chosen. In the qualitative design, an interview guide was developed for focus group discussions to gain in-depth understanding on perceptions of Namibian women with regard to matters of marriage, divorce, cohabiting, polygamy, sex before and outside marriage.

3.2 Population

The target population was women of marriageable age who were in the fertility age-group (15-49) in Namibia. With regard to in-depth interviews and focus group discussions, the key informants targeted included among others, social sector heads/ workers, marriage counselors and officers, other community leaders and health workers.

3.3 Sample

In the NDHS, a representative household sample of reproductive age women was used. The samples drawn were 5421, 6755 and 9800 for 1992, 2000 and 2006 respectively, derived from women of reproductive age (15-49 years), in the selected households. The household and individual response rates were 96.2%, 97.8% and 94.7% respectively.

A focus group guide was developed for the qualitative study to look into family formation issues and was guided by Krueger (2009) and Ritchie et al (2013).

Focus group discussions were conducted to construct additional or supplementary information for a better understanding of women's feelings and attitudes towards marriage, divorce, and non-marital fertility until saturation was reached. In qualitative work, the law of large numbers does not always apply. It is possible to achieve saturation with small samples (O'Reilly and Parker, 2012). The focused group participants included among others, women, marriage counselors, marriage officers and traditional leaders separately. The data from these focus group discussions was supplementary to the survey data to further support or clarify statistical results. The group discussions were held in both urban and rural settings. The focus group discussions were conducted in convenience samples of 8 regions selected purposively namely Zambezi, Kavango West, Oshan, Kunene, Otjozonjupa, Khomas, Omaheke, and !Kara regions. Each focus group discussion was small, consisting of about 6 to 9 participants to allow full participation of all discussants and was selected using purposive sampling so that in-depth information that supports or substantiates findings could be gathered from individuals believed to be knowledgeable about the subject (Pathfinder International, 2006).

3.4 Research Instruments

For the quantitative data, a questionnaire that included variables on individual bio-demographic factors, household characteristics, history of marital unions and births was used to collect the data. In the qualitative approach, a semi-structured group interview format was adopted for focus group discussions to ensure that the same subject or scope was maintained in each group.

3.5 Procedure

For the qualitative analysis, the designed questionnaires were translated into six languages namely Afrikaans, Damara/Nama, Oshiwambo, Otjiherero, Kavango and Silozi. The research instruments were piloted in Khomas region. The questionnaires were pretested in both urban and rural areas and the results of the pilot survey were used to modify the research instruments as necessary.

The focus group discussions were professionally administered to allow space for exploration of any emerging issues not already catered for. The proceedings of the discussions were captured by audio media, and later transcribed and translated into English where necessary. These audio records were sufficiently reviewed to capture all sentiments and to come up with verbatim transcriptions in which other psycho-social indicators (e.g. anger, discomfort, enthusiasm, silence, and anxiety) could also be captured. These findings were then organized and summarized according to themes, to illustrate different beliefs, myths, attitudes and emotions related to the quantitative data (Indongo & Naidoo, 2008; Green, Mukuria, & Rubin, 2009). For use of secondary data permission to use the Namibia Demographic and Health Survey datasets was sought from www.measure.dhs and was granted (see APPENDIX II).

3.6 Data analysis

Descriptive statistics in form of charts, graphs and tables were used to profile the background characteristics of women. Trends were established and percentage changes in marital status were computed for the period between 1992 and 2006/7. Trends for the never married, married and living together categories by residence, age and education for the period 1992-2006 were also established. Further, regional patterns in marital status were investigated by computing and mapping proportions and percentage changes for each category.

The multinomial logistic regression model was used to establish the determinants of marital status. Potential predictors included current age, age at first birth, age at first intercourse, total children born, employment status, religion, and education level, region, place of residence and wealth index. Multinomial logistic models for the years 1992, 2000 and 2006 were fitted to establish predictors of marital union statuses of women. Bayesian structured geo-additive discrete time hazard models with both fixed and time dependent covariates were employed to establish factors associated with the women's transition into first marriage and transition to first sex.

For, non-marital fertility, measured by the total children born to the women, the Poisson, Quassi Poisson, Negative Binomial, Zero-inflated Poisson, Zero-inflated Negative Binomial, Hurdle Poisson, and Hurdle Negative Binomial models were explored to model non-marital fertility since the outcome variable (total children born) is a discrete quantitative random variable which had small number of counts, and had a considerable number of zero counts.

Based on the literature review, this study applied binary logistic regression, and multinomial logistics regression to model marital patterns and trends; hurdle logit negative binomial (HLNB) regression to model non-marital fertility; and discrete time structured additive regression to model the timing of sexual debut and first marriage among women in Namibia.

Analysis of the qualitative data was based on framework analysis and consisted of 5 key stages namely identifying a thematic framework, indexing, charting, mapping and interpretation. This was achieved through examining, categorizing, categorizing or combining the evidence and getting rid of redundant extra and irrelevant information, by carefully filtering through the maze of the large and complicated path of information (Rabiee, 2004).

More details of the analysis are presented in Chapter 4, Chapter 5, Chapter 6, and Chapter 7.

3.7. Research Ethics

A letter of introduction was developed for potential participants in focus group discussions, introducing them to the researcher, objectives and significance of the study. Respondents were free to accept or decline to participate in this study, and for those who would have initially accepted, it was made known to them that they were free to drop out at any point during the process if they no longer wished to continue. Written informed consent was sought from respondents and anonymity and confidentiality was guaranteed. Access to recorded information from the discussions was monitored and kept confidential. Some of the research findings and recommendations from the study were communicated through various appropriate publications and feedback workshops, colloquium and conferences.

CHAPTER 4

EXPLAINING MARITAL PATTERNS AND TRENDS IN NAMIBIA: A REGRESSION ANALYSIS OF 1992, 2000 AND 2006 DEMOGRAPHIC AND SURVEY DATA

4.1 Introduction

Marriage and family formation are the cornerstone of every society, but are based on individuals choice and preferences which are significantly shaped by societal norms (Howse et al, 1989). Marriage patterns vary considerably across countries and over time (Howse et al, 1989; Indongo and Naidoo, 2008; Shemeikka et al, 2005; Mumcu and Saglam, 2008; Marston et al, 2009; Rashad and Roudi-Fahimi, 2005; Burgess et al, 2003; Kalmijn, 2007; Kravdal, 1999; Ermisch and Francesconi, 2000). Such dynamics are also being experienced in African societies. Many studies, based on censuses and surveys, however, put emphasis on trends that have occurred (Marston et al, 2009; Rashad and Roudi-Fahimi, 2005; Burgess et al, 2003). However, more important is to offer explanations to differences among individuals and trends over time. This study aimed at examining marital trends and patterns in Namibia to offer explanations to what has emerged since attaining independence in 1990. Particularly, the study used national surveys based on the Namibia demographic and health surveys (NDHS) data of 1992, 2000 and 2006 to establish factors that explain marital status patterns and trends. It was hypothesized that there is considerable regional variation in marital status because of diverse cultural or ethnic differences in Namibia. It was further postulated that education, religiosity, socio-economic status and place of residence are such factors that explain differences in marriage patterns among individuals and trends over time (Mumcu and Saglam, 2008; Marston et al, 2009;Rashad and Roudi-Fahimi, 2005; Burgess et al, 2003; Kalmijn, 2007; Kravdal, 1999; Ermisch and Francesconi, 2000).

Research in understanding and modeling the formation of marriages and marital dissolutions has increased (Mumcu and Saglam, 2008). Nevertheless this area of research is old and global, and the processes that define nuptiality processes are multifaceted with social, behavioural and demographic factors which simultaneously influence marital status and trends (Indongo and Naidoo,2008; Shemeikka et al, 2005; Mumcu and Saglam, 2008). Studies in the sub-Saharan Africa, Arab world, America, and Europe showed that women are staying single longer, or not marrying at all because of high costs associated with marriage, improved gender roles, educational expansion and secularization (Marston et al, 2009;Rashad and Roudi-Fahimi, 2005; Burgess et al, 2003; Kalmijn, 2007; Kravdal, 1999). However, in many African societies, marriage is almost universal and early (Marston et al, 2009). Within the same context, the percentages of marriages where both husband and wife are uneducated are decreasing (Rashad and Roudi-Fahimi, 2005). An analysis of data on young American men and women from the National Longitudinal Survey of Youth from 1979 to 1992 showed that high earning capacity increased the probability of marriage and decreased the probability of divorce for young men (Burgess et al, 2003). In Europe, marriage patterns have mainly been explained by educational expansion, employment, secularization and changing gender roles (Kalmijn, 2007). An equivalent study in Norway reported that a large proportion of cohabiters indicated economic reasons for their hesitation to marry and in particular the costs of the wedding (Kravdal, 1999).

Recently, a considerable bulk of demographic research has reported increased cohabitation in Western and developed countries, with notable prevalence in developing countries. Ermisch and Francesconi (2000) examined the dramatic increase in cohabiting unions in Great Britain. They analyzed entry into first partnership, the stability of cohabiting unions and re-partnering after dissolution of cohabitation. The shift to cohabitation as the dominant mode of first partnership played an important role in the delay of first marriage and motherhood. In a study based on the 2001 Nepalese Demographic and Health Surveys, Coltabiano and Castiglioni (2008) described a significant downward shift in age at marriage, and delayed celebrated marriage in case of cohabitation. Cohabitation is also a common form of union in many southern African societies. For example in Botswana and South Africa, it is considered as a transitional stage before a bride price is paid, as such a consensual union may exist (Marston et al, 2009) In Namibia, national surveys indicate that one in five adults are in cohabitation, and the prevalence is increasing (Indongo and Naidoo, 2008; Shemeikka et al, 2005). However factors affecting such marital processes have not been examined.

Various other factors affecting marriage, singlehood, cohabitation or divorce have been explored. Steel et al.(2005) and Steel et al.(2006) have examined the effect of parenthood on whether non-marital unions led to marriage or parting. Their findings showed that the proportion of cohabiting couples who married before a birth decreased and the risk of dissolution declined during pregnancy. Lehrer (2008) indicated that early age at first marriage is known to be associated with high risk of divorce. Another study in Britain established that education was a key factor influencing the age of entry into first partnership and whether or not the respondent would experience pregnancy before forming the partnership. Furthermore, religiosity, experience of parental separation, and the geographical region of residence were more important in affecting the decision to cohabit rather than to marry directly (Berrington and Diamond, 2000).

With regard to marriage dissolution, Bracher et al. (1993) analyzed structural and temporal predictors of marriage dissolution. Their results indicated that the risk of marriage dissolution increased dramatically over the lives of the respondents. Year of birth, and age at marriage provided the most parsimonious characterization of the temporal correlates of marriage dissolution. Characteristics that were fixed by the time of marriage dissolution were related to characteristics of the unfolding marriage itself; namely patterns of employment, home-ownership, and region of residence. A review of research on the premarital factors associated with later marital quality and stability in first marriages was conducted by Larson and Holman (1994). Three major categories of factors were described including background and context, individual traits and behaviours, and couple interactional processes. They cited implications of their findings for family life education, premarital counseling and the need for further research.

The effect of such factors on the distribution and dynamics of intimate relationships in Namibia needs to be explored. The three survey data points spanning 1992 to 2006 present a unique opportunity to determine emerging trends and patterns in marital status. It is evident that not much research has been done to date, except in fertility studies (Indongo and Naidoo, 2008; Shemeikka et al, 2005), and in this study focus was exclusively on the association between different forms of unions and social-demographic variables. An attempt was also made to explore geographical variability in marital patterns in the country.

4.2 Methods

4.2.1 Data

This study was based on Namibian DHS of 1992, 2000 and 2006. DHS is a national survey drawn on using a multistage cluster sampling. At first stage, a random sample of enumeration areas (EA), which are primary sampling units, was chosen from the census sampling frame. From the selected EAs, households were systematically drawn. Only women of reproductive age (15-49 years), in the selected households, were interviewed using a face- to-face questionnaire. The questionnaire included variables on individual bio-demographic factors, household characteristics, history of marital unions and births. Final samples included in the analysis were respectively

5420 from the 1992 survey, 6755 from the 2000 survey and 9800 women, from the 2006/7 round of surveys. For this study, the outcome variable was *marital status.*

All women involved in the survey were asked questions about their current marital status. The response was a multi-categorical variable of four categories: 1) never married, 2) married, 3) living together (co-habitation), and 4) others (widowed, separated and others). Two binary outcomes: (i) coded 1 if ever married versus 0 if never married; and (ii) cohabiting versus married were also generated so that an assessment of the association between union formation, cohabitation and different socio-demographic covariates could be carried out.

Individual and household characteristics

Bio-demographic characteristics related to a woman included current age, age at first birth, age at first intercourse, total children born, employment status, religion and education level. Household characteristics consisted of region, place of residence (rural or urban) and wealth index. The region variable was recorded differently across the three surveys. The 1992 data recorded four broad geographic areas: northeast, northwest, central and south, while the 2000 and 2006 recorded 13 regions (Caprivi, Erongo, Hardap, Karas, Kavango, Khomas, Kunene, Ohangwena, Omaheke, Omusati, Oshana, Oshikoto, Otjozondjupa). To avoid errors introduced by aggregation/disaggregation the four regional groupings of 1992 in the subsequent analyses of all three waves of surveys were used. Again, 1992 data did not record a wealth index variable. A wealth index for 1992 was generated using the techniques as used for the 2000 and 2006 data. In brief, the wealth index was used as a proxy for the standard of living of the household. It was based on household ownership of consumer goods; dwelling characteristics; type of drinking water source; toilet facilities; and other characteristics related to household socioeconomic status (Arnaldo, 2004). To construct the index, each of the assets was assigned a weight (factor score) generated through principal component analysis and the resulting asset scores were standardized in relation to the standard normal distribution. Each household was then assigned a score for each asset and the scores were summed for each household. Individuals were ranked according to the total score of the household in which they reside. The sample was then divided into quintiles from one (lowest) to five (highest) (Filmer and Pritchett, 2001).

4.2.2 Statistical Analysis

Firstly, trends were analyzed and percentage changes in marital status between 1992 and 2006 were computed, particularly for the never married, married and living together categories by residence, age and education levels. Regional patterns in marital status were further investigated by computing and mapping percentages and percentage changes for each category (never married, married and living together) using 2000 and 2006 data. This provided an exploratory analysis of the changes that have happened between 2000 and 2006, since similar geographical divisions were not available in the 1992 data.

Secondly, the association between union formation (ever married) and socio-demographic variables were examined using a binary logistic regression. The study also explored if there was any shift towards cohabitation than marriage and investigated possible determinants by fitting a binary logistic regression. In a binary response, the variable $Y \sim$ Bernoulli $\left(p(v_i, \alpha)\right)$with

$$logit\left(p(v_i, \alpha)\right) = \eta_{ij} = v'\alpha_j ,$$

given some covariates $v = (v_1, \cdots, v_p)'$and corresponding parameter set α. Third, factors that explained marital status by fitting a multinomial logistic regression model were estimated. A multinomial random variable applies where an event, Y, ends up with three or more outcomes $1, \cdots, J$, (J > 2). Specifically suppose Y has unordered categories, we assume (Fahrmeir and Tutz, 1994)

$$Y \sim Multinomial(1, p(v_i, \alpha)) \text{ for } i = 1, \ldots n,$$

such that $p(v_i, \alpha) = (p_1(v_i, \alpha), \ldots, p_J(v_i, \alpha))^T$ and $P(y_i = j \mid \alpha) = p_j(v_i, \alpha)$, given some covariates $v = (v_1, \ldots, v_p)^T$ and corresponding parameter set α. The most common approach to estimate multinomial probabilities is through the logistic model

$$p(v_i, \alpha) = P(y_i = j|\alpha) = \begin{cases} \frac{\exp(\eta_{ij})}{1+\sum_{h=1}^{J-1} \exp(\eta_{ih})} & j = 1, \cdots, J-1 \\ \frac{1}{1+\sum_{h=1}^{J-1} \exp(\eta_{ih})} & j = J \end{cases}$$

where $\eta_{ij} = v^T \alpha_j$ is the linear predictor. The last category J is considered as a reference classification outcome. In this classical multinomial logit model all covariates are assumed to be independent of the category while effects are category-specific.

The binary logistic regression models for ever married (vs single) and cohabitation (vs marriage) were fitted by combining all the data between 1992 and 2006. For the multinomial logistic, three models for the years 1992, 2000 and 2006 were fitted respectively. The last multinomial category (others) was assigned as a reference category. Put differently, the study examined the likelihood of being: 1) never married versus others, 2) currently married versus others, and 3) currently living together (cohabitation) versus other forms of marital status. A p-value less than or equal to 0.05 was considered as significant. In all models, current age of the woman, age of the woman at first intercourse, age of the woman at first birth, and total number of children ever born to the woman were estimated as continuous variables, while region, education, religion, employment, wealth index and residence were estimated as categorical independent variables. Maximum likelihood estimation was applied for parameter estimation. All models were fitted in SPSS version 19.

4.3 Results

4.3.1 Trends in marital status

Over half of the women interviewed in all the years were never married (50.0% in 1992, 50.3% in 2000 and 56.6% in 2006). This showed an increase of 6.6% for the period 1992-2006. The proportion married which consisted of 29.0% in 1992, 23.4% in 2000 and 20.4% in 2006, declined by 8.4% in the same period. Women who were cohabiting with their partners were 13.4% in 1992 and this increased to 18.4% in the 2000 survey, but dropped 16.0% in 2006. The other forms of marital status showed a slight downward change between 1992 and 2006. A chi-square test for trend showed a significant change in marital patterns in Namibia between 1992 and 2006 (Chi square = 35.2,p = 0.0029).

Table 2 shows bivariate associations between never married, ever married, cohabitation and background characteristics. The percentage ever married shows a decline while cohabitation shows an increase in association with age (Chi-square = 250,p <0.05) and between 1992 and 2006 (p<0.05). There was also evidence of differences in proportion ever married and cohabiting by region, residence and education level (p<0.05).

Table 2: Bivariate associations of never married, ever married and cohabitation by background characteristics

Variable	Category	Never married	Ever married	Cohabiting	Total (*n*)
Year	1992	50.0	50.0	31.6	5421
	2000	50.3	49.7	44.0	6755
	2006	56.6	43.4	44.0	9804
Education	None	25.2	74.8	48.3	2370
	Primary	47.5	52.5	44.9	7462
	Sec/higher	61.8	38.2	34.5	12148
Religion	Protestant	54.2	45.8	38.6	16762
	Catholic	49.2	50.8	47.2	5218
Employment	Unemployed	58.8	41.2	43.6	12486
	Employed	45.4	54.6	37.8	9399
Residence	Rural	53.4	46.6	39.1	12588
	Urban	52.5	47.5	42.9	9398
Wealth index	Poorest	55.0	45.0	41.7	4139
	Poor	50.8	49.2	49.8	4526
	Medium	54.9	45.1	50.9	5054
	Rich	53.6	46.4	45.8	3857
	Richest	50.3	49.7	20.0	4044
Region	Northwest	66.5	33.5	35.1	8021
	Northeast	39.2	60.8	33.1	3878
	Central	45.7	54.3	52.0	5087
	South	49.5	50.5	40.7	4994
Age	15–19	92.5	7.5	68.7	4926
	20–24	70.1	29.9	62.8	4325
	25–29	49.9	50.1	51.4	3548
	30–34	33.4	66.6	38.8	3149
	35–39	24.8	75.2	33.2	2412
	40–44	19.7	80.3	27.4	2111
	45–49	15.1	84.9	22.7	1509

Next, the study explored changes in trends by residence, age and education. **Figures 2 to 4** give the results. Among the never married, the proportion in the urban areas was relatively lower than in the rural areas between 1992 and 2000, but this changed in 2006 (**Figure 2a**). A different trend was observed among the married (**Figure 2b**). For the living together, the proportion was higher in urban areas than rural areas, with increased trends for both areas between 1992 and 2000. This pattern changed in 2006, with relatively more partners living together in rural than urban areas (**Figure 2c**).

With regards to education level, the never married were relatively higher in proportion among those who attained secondary or higher education than among those with primary education or none. This higher trend persisted for all the years (**Figure 3a**).

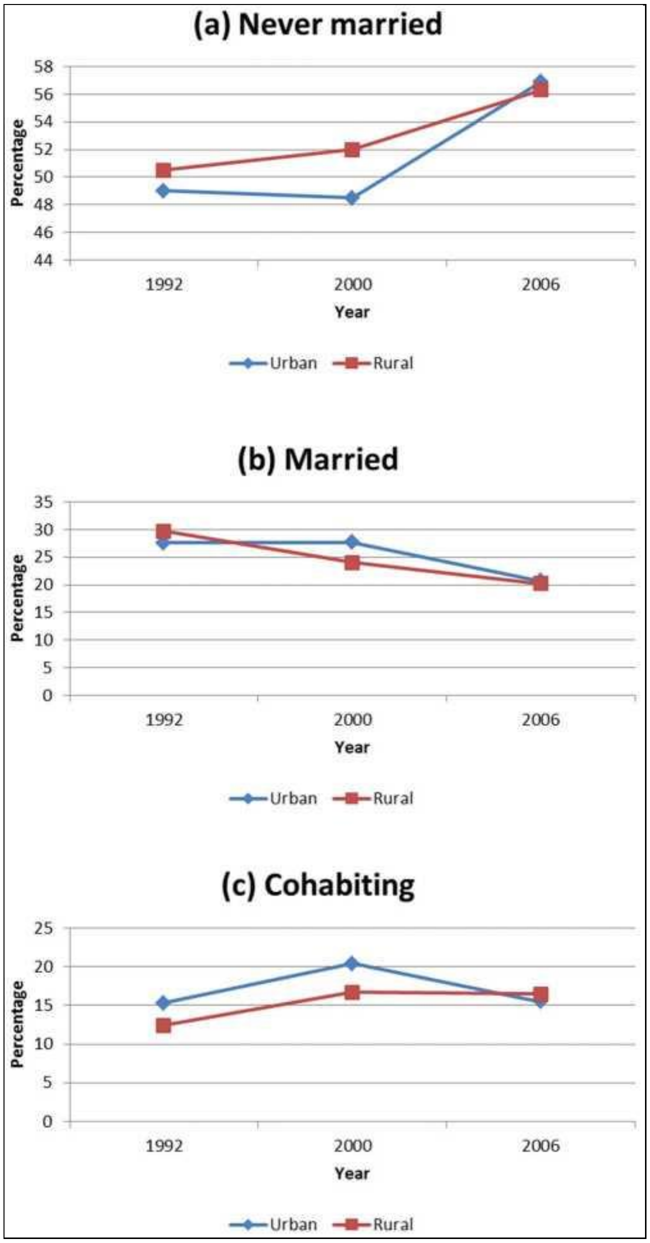


Figure 2: Trends in marital status. (a) never married; (b) married and (c) cohabiting between 1992 and 2006 by rural/urban place of residence.

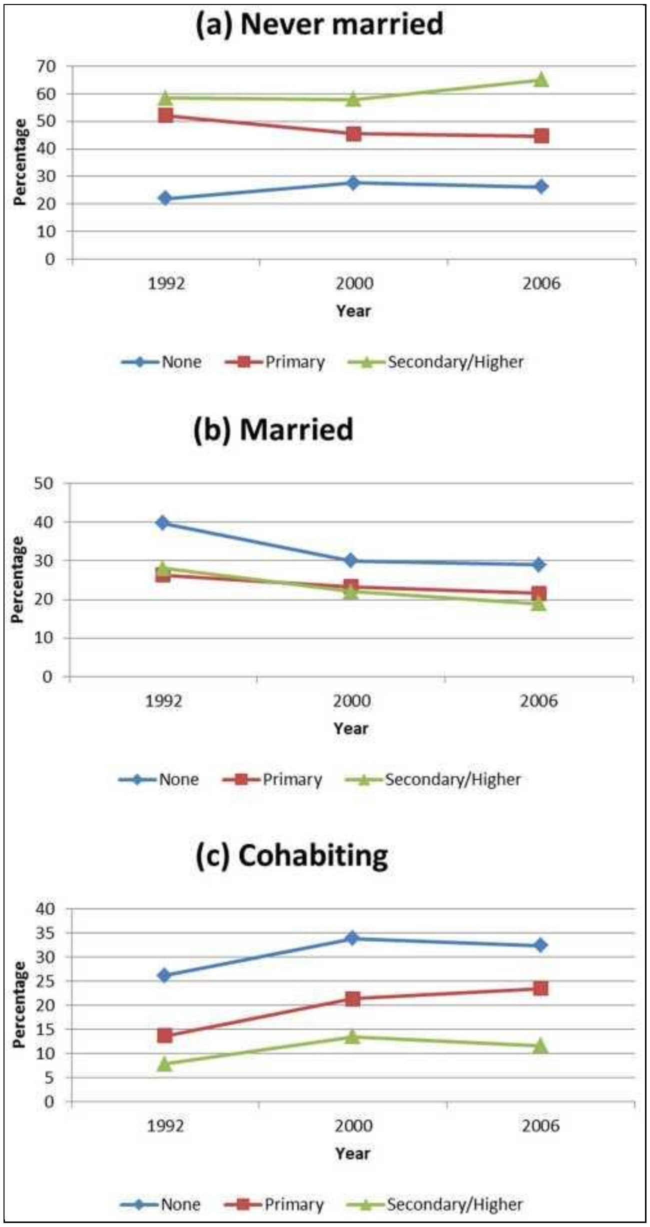


Figure 3: Trends in marital status. (a) never married; (b) married and (c) cohabiting between 1992 and 2006 by education level.

However, among the married women those with primary education were relatively more, followed by those without any formal education. Lower proportions of marriage were observed for those who achieved secondary or higher education levels and the trend was steady for the years (**Figure 3b**). The pattern observed among those living together was similar to those who were married (**Figure 3c**).

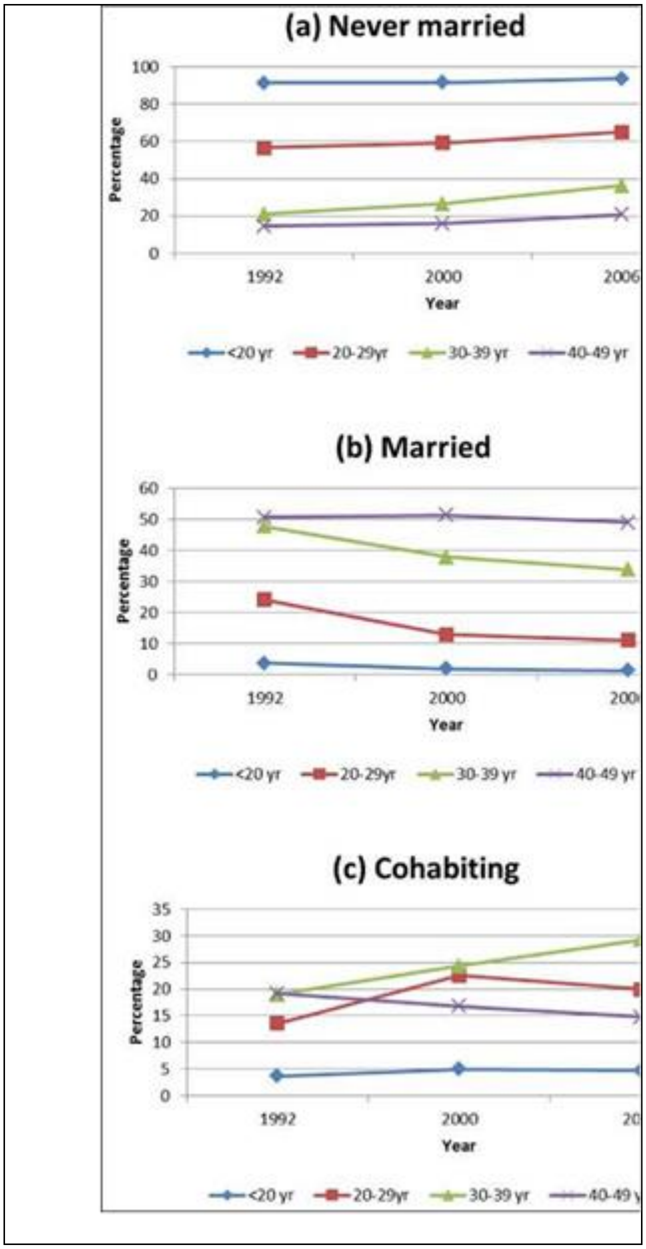


Figure 4: Trends in marital status. (a) never married; (b) married and (c) cohabiting between 1992 and 2006 by current age.

Turning to the effect of age on the trend of marriage patterns, it was observed as expected that those below age 20 mostly remaining unmarried with decreasing percentages as age increased (**Figure 4a**). In **Figure 4b**, as expected, there was a reverse in trends among the married, with increased rates as age increased persistently from 1992. A mixed pattern was notable among those living together, however, the proportion cohabitating with age below 20 years remained lower than 5% from 1992 (**Figure 4c**). However overall, there is a shift in modal age at marriage between 1992 and 2006 (**Figure 5**). In 1992, this was at 23 years, while in 2000 this shifted to 27 and as of 2006 this was at 29 years of age. This is in agreement with what has been discussed before (**Figures 2 to 4**).

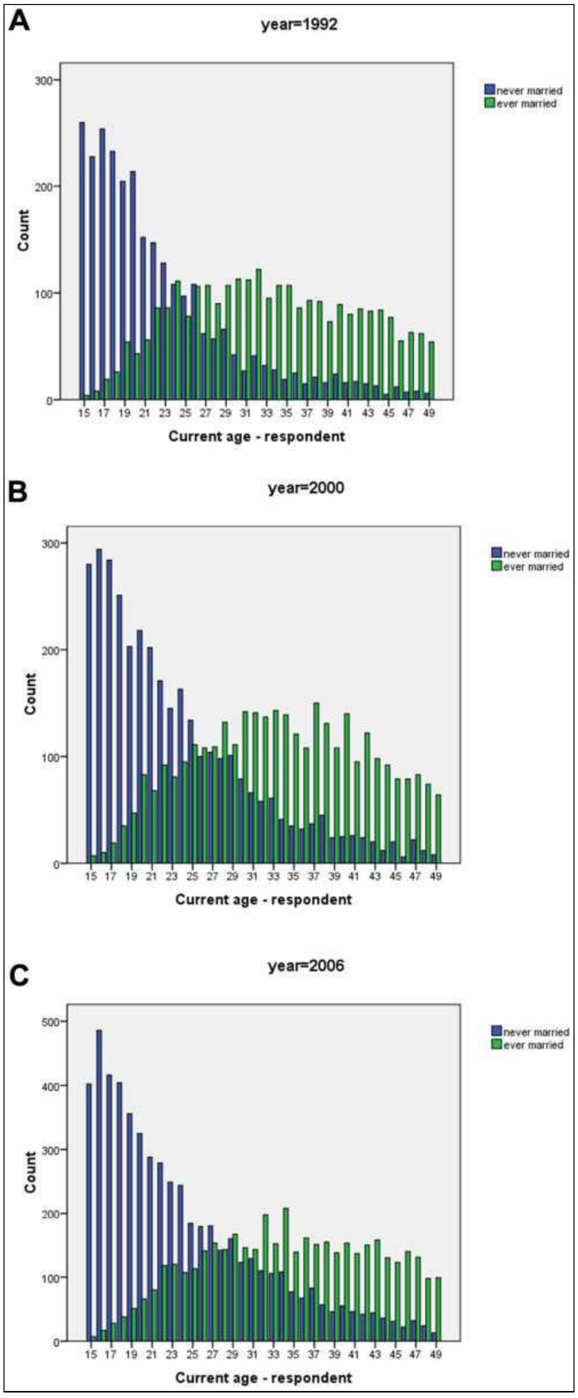


Figure 5: Cumulative number of women aged between 15-49 ever married or never married for: (a) year 1992; (b) year 2000 and (c) year 2006.

4.3.2 Geographical patterns in Marital Status

Figure 6 shows regional variation in marriage patterns. In 2000, a higher percentage living together was observed in the northern provinces of Kunene, Kavango, and Otjozondjupa, while in 2006 the highest rates were observed in central regions, particularly in Erongo, Khomas and Omaheke. For the married group, there were no significant differences across the regions for both 2000 and 2006 surveys, although Caprivi registered a relatively higher percentage married than other regions at both times. Significant regional differences were observed among the never married, particularly in the north and south (**Figure 6**, bottom panel).

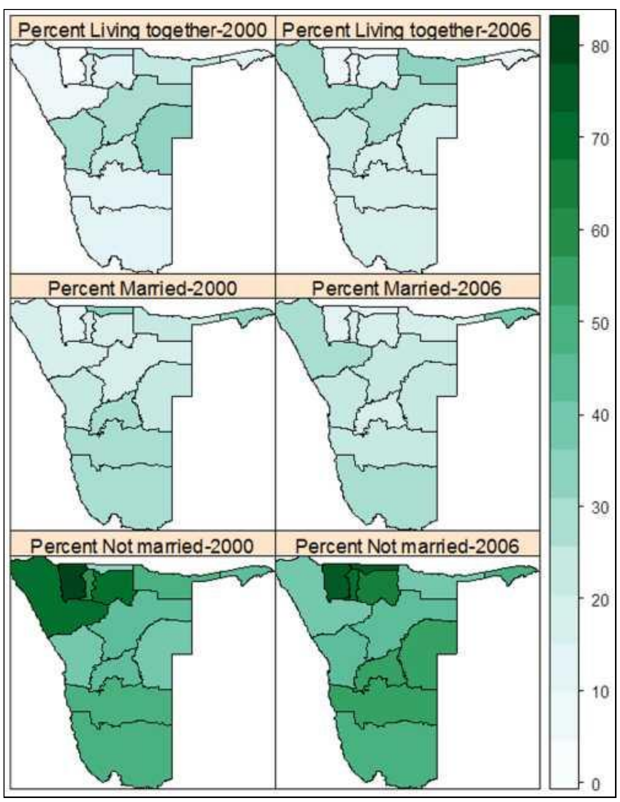


Figure 6: Regional proportions in marital status (never married, married and living together) in 2000 and 2006.

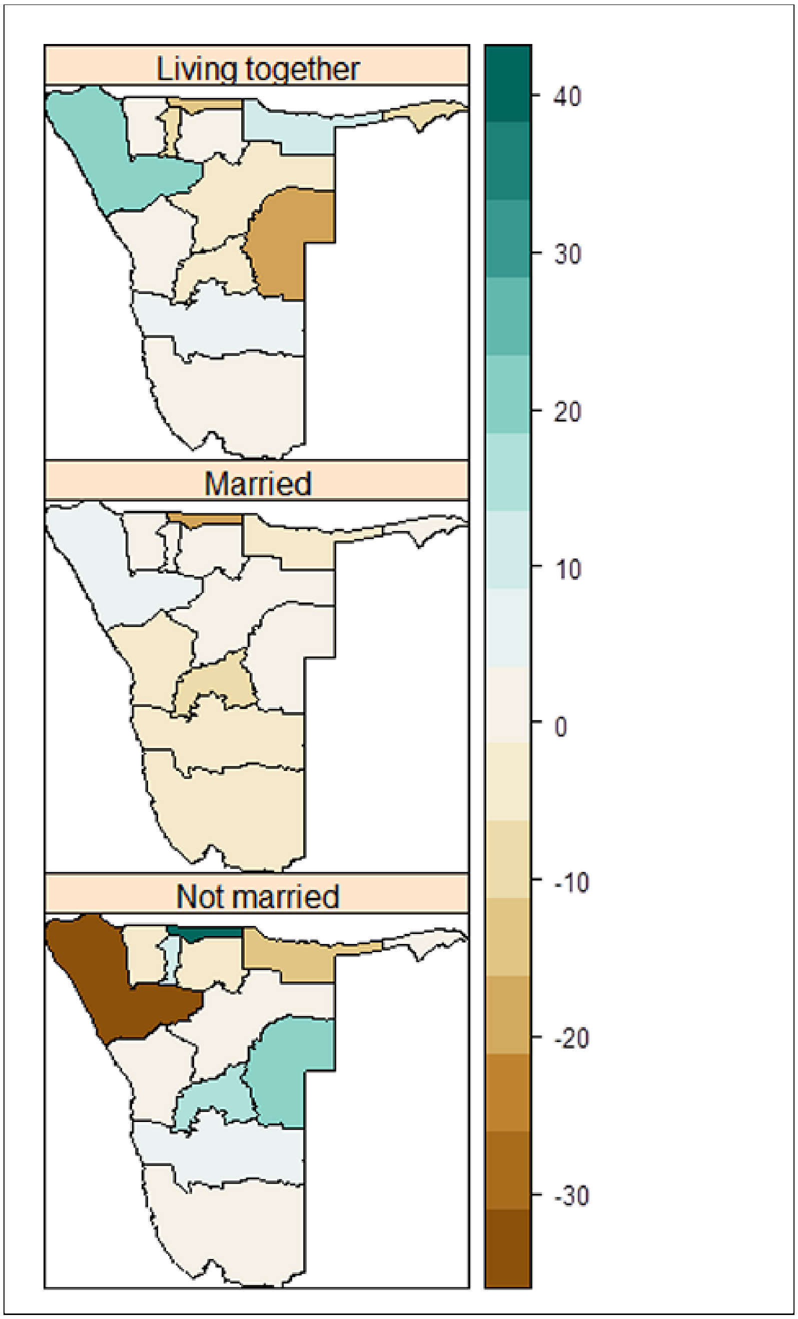


Figure 7: Percentage changes in marital status by region between 2000 and 2006 in Namibia**.**

An assessment of percentage change in marital patterns shows a decline among the never married in Kunene, while showing an increase among the living together in the same region (**Figure 7**). A relative decline in percent married was registered in many regions, especially in the central and southern regions. Among those living together, an increased change was notable in Kunene and Kavango whereas a corresponding decline was observed in Omaheke (**Figure 7**).

4.3.3 Ever in union and its determinants

Table 2 gives results of the model that predicts the probability of being in the union as a function of year, current age, region, education, religion, employment and residence. The probability of ever married was 33% higher in 1992 compared to 2006 but decreased to 29% in 2000. The proportion of women ever having been in a union increased with age, while the odds of ever been in a union was much higher in the North-east (OR = 2.31, 95% CI: 2.06, 2.59) and central (OR =1.17, 95% CI: 1.06, 1.29) regions of Namibia compared to the south, but much lower in Northwest (OR = 0.45, 95% CI: 0.41, 0.49). Results further showed that the chance of being married was much higher for those with no formal education or lower education level than those who attained secondary or higher (OR = 2.47 and 1.70 respectively). The effect of employment was marginal and that of wealth index was largely non-significant. Finally the effect of urban residence was lower, as expected, for the ever in union group compared to those in rural areas.

4.3.4 Cohabitation and its determinants

Table 2 again shows factors associated with cohabitation union versus being in traditional marriage. As one can observe, the propensity of cohabitation increased by 50% between 1992 and 2000, and 85-fold between 1992 and 2006 and at same time by 23% between 2000 and 2006. However, cohabiting decreased with increasing age. In other words, most cohabitation unions ended up in formal marriage. We also noted that cohabitation was much higher in the central region compared to the south (OR =1.21, 95% CI: 1.06, 1.39). This is the region where Windhoek, the capital city is located. What was surprising, though, from the findings is that being less educated was associated with increased probability of cohabitation compared to those who were of secondary or higher education levels (OR = 2.24 for no education and OR = 1.71 for primary education respectively). Furthermore, it was observed that living in urban areas increased the chance of cohabitation compared to living in rural areas (OR = 1.93, 95% CI: 1.70, 2.18).

4.3.5 Individual and household characteristics associated with never been married

Table 3 presents results from the multinomial regression model. Being single was significantly associated with current age, total children ever born, age at first birth and age at first sex.

Table 3: Logistic regression results for ever in union (vs single) and cohabitation (vs marriage).

		Ever married vs Never married		Cohabiting vs Married	
Variable	Category	OR	95% CI	OR	95% CI
Year	1992	1.33	(1.22, 1.45)	0.54	(0.47, 0.61)
	2000	1.29	(1.19, 1.39)	0.81	(0.73, 0.91)
	2006	1.00		1.00	
Education	None	2.47	(2.18, 2.79)	2.24	(1.92, 2.61)
	Primary	1.70	(1.57, 1.84)	1.71	(1.52, 1.93)
	Sec/higher	1.00		1.00	
Religion	Protestant	1.19	(1.01, 1.29)	1.39	(1.25, 1.56)
	Catholic	1.00		1.00	
Employment	Unemployed	1.00		1.00	
	Employed	1.08	(1.00, 1.16)	0.95	(0.85, 1.05)
Residence	Rural	1.00		1.00	
	Urban	0.78	(0.72, 0.85)	1.93	(1.70, 2.18)
Wealth index	Poorest	1.00		1.00	
	Poor	1.01	(0.91, 1.13)	1.01	(0.86, 1.18)
	Medium	1.10	(0.98, 1.23)	1.16	(0.99, 1.35)
	Rich	0.94	(0.83, 1.07)	1.05	(0.88, 1.26)
	Richest	1.27	(1.10, 1.47)	0.27	(0.22, 0.34)
Region	Northwest	0.45	(0.41, 0.49)	0.71	(0.61, 0.82)
	Northeast	2.31	(2.06, 2.59)	0.38	(0.32, 0.44)
	Central	1.17	(1.06, 1.29)	1.21	(1.06, 1.39)
	South	1.00		1.00	
Age	15–19	0.013	(0.011, 0.016)	9.53	(7.06, 12.86)
	20–24	0.08	(0.06, 0.09)	8.01	(6.49, 9.87)
	25–29	0.19	(0.16, 0.23)	4.65	(3.83, 5.65)
	30–34	0.39	(0.33, 0.46)	2.55	(2.11, 3.07)
	35–39	0.58	(0.49, 0.69)	1.88	(1.55, 2.29)
	40–44	0.78	(0.65, 0.94)	1.44	(1.18, 1.76)
	45–49	1.00		1.00	

The odds of remaining single decreased with increasing age, number of children the woman bore, and with increased age at first sex, while being single increased with increasing age at first birth. The effect of region varied in between the years. Between 1992 and 2006, women were likely to remain single in the northeast and south compared to the northwest. For those from the central region, the likelihood of being single was lower in 1992, but higher in the year 2000 and 2006 compared to those in the northwest region.

Education showed significant association with the never married in 2000, that is those with primary education were likely to remain single much longer than those with no education. No association with region was found, but being employed compared to being unemployed increased the likelihood of remaining single (RR= 1.38 in 1992, RR= 1.36 in 2000 and RR= 1.25 in 2006 respectively). Social status was also associated with decreased likelihood of remaining single. For instance in 2000, this decreased with increasing status (RR = 0.67, 0.64 and 0.63 for the medium status, rich and richest respectively compared to the poorest). A similar pattern was obtained for 2006, although this was not significant.

4.3.6 Individual and household characteristics associated with currently married

Among those women who were married compared to others, results indicated that current age, total children born, age at first birth and age at first intercourse were related to marriage. Increase in age was associated with lower probability of marriage in all the years (RR=0.94, 0.98 and 0.95 for 1992, 2000 and 2006 respectively), while total children born were positively associated with being married. Similarly association was obtained for age at first sex and birth (Table 3).

Significant regional differences for those married were observed in the northeast in 1992 (RR = 1.39, 95% CI = 1.01, 1.95) and in the central region again in 1992 (RR = 0.38, 95% CI: 0.19, 0.75). Having obtained secondary or higher education in 1992 showed a reduced chance of marriage (RR = 0.67, 95% CI: 0.45, 0.99), while results indicated an increased chance of marriage in 2000 (RR=1.54). Religiosity differences were noted in 2006, with Protestants less likely to be married. Being employed increased the chance of marriage for all the survey years. Similar to the never married, results indicated that social status was likely to reduce the odds of being married. In particular those in the upper social class were less likely to be married, and this was persistent in all survey years (RR = 0.37, 0.15 and 0.16 for the years 1992, 2000 and 2006 respectively). Women who were residing in urban areas compared to being in rural areas had a high probability of being married (RR= 1.59 [95% CI: 1.12, 2.26], 1.72 [95% CI: 1.31, 2.26] and 2.01 [95% CI: 1.57, 2.56] in the year 1992, 2000 and 2006 respectively).

4.3.7 Individual and household characteristics associated with living together

In the case of women cohabitating, current age significantly reduced the likelihood of cohabitation, whereas total children born, age at first birth, education level and employment status increased the chance of living together. Results indicated that women who attained primary education or secondary and higher education were at increased risk of living together. In fact the risk increased with increased education level. For instance in 1992 the risk increased from 1.45 to 2.44 as one moves from primary to secondary or higher levels of education, and in 2000 the risk changed from 2.19 to 2.68 for the same change in educational level, whereas in 2006 the risk varied between 1.15 and 1.68 for an increased educational level.

Table 4: Multinomial regression on marital status based on 1992, 2000, 2006 DHS data

		1992		2000		2006	
Variable	**Category**	**RR**	**95% CI**	**RR**	**95% CI**	**RR**	**95% CI**
NOT MARRIED							
Current Age		0.87	(0.85, 0.89)	0.91	(0.89, 0.93)	0.89	(0.88, 0.90)
Total children born		0.89	(0.82, 0.96)	0.85	(0.79, 0.92)	0.79	(0.74, 0.84)
Age at first birth		1.05	(1.01, 1.10)	1.03	(1.00, 1.06)	1.03	(1.00, 1.06)
Age at first intercourse		0.96	(0.95, 0.97)	0.98	(0.97, 0.99)	0.96	(0.95, 0.97)
Region	Northwest	1.00		1.00		1.00	
	Northeast	25.8	(17.33, 38.39)	1.72	(1.18, 2.51)	7.72	(5.84, 10.22)
	Central	0.74	(0.37, 1.48)	1.49	(1.11, 1.99)	2.27	(1.72, 3.01)
	South	3.05	(1.85, 5.02)	1.49	(1.08, 2.06)	1.71	(1.26, 2.32)
Education	None	1.00		1.00		1.00	
	Primary	0.82	(0.57, 1.20)	1.43	(1.00, 2.06)	0.89	(0.64, 1.23)
	Secondary or higher	0.77	(0.49, 1.20)	1.09	(0.74, 1.59)	0.71	(0.50, 1.01)
Religion	Catholic	1.00		1.00		1.00	
	Protestant	0.93	(0.69, 1.25)	0.83	(0.64, 1.06)	0.97	(0.78, 1.21)
Employment	Unemployed	1.00		1.00		1.00	
	Employed	1.38	(1.03, 1.85)	1.66	(1.31, 2.09)	1.25	(1.03, 1.53)
Wealth index	Least poor	1.00		1.00		1.00	
	Poor	0.99	(0.65, 1.50)	1.00	(0.72, 1.38)	0.95	(0.69, 1.29)
	Medium	1.18	(0.78, 1.78)	0.67	(0.47, 0.96)	0.86	(0.62, 1.20)
	Richer	1.37	(0.85, 2.22)	0.64	(0.44, 0.93)	0.79	(0.54, 1.16)
	Richest	1.19	(0.65, 2.17)	0.63	(0.39, 1.02)	0.81	(0.51, 1.30)
Residence	Rural	1.00		1.00		1.00	
	Urban	0.8	(0.54, 1.19)	1.29	(0.99, 1.70)	1.18	(0.92, 1.50)
MARRIED							
Current Age		0.94	(0.92, 0.96)	0.98	(0.97, 1.00)	0.95	(0.93, 0.96)
Total children born		1.23	(1.16, 1.32)	1.20	(1.12, 1.28)	1.25	(1.18, 1.32)
Age at first birth		1.09	(1.05, 1.13)	1.06	(1.03, 1.10)	1.10	(1.07, 1.12)
Age at first intercourse		1.00	(1.00, 1.00)	1.00	(1.00, 1.01)	1.00	(0.99, 1.00)
Region	Northwest	1.00		1.00		1.00	
	Northeast	1.39	(1.00, 1.94)	0.94	(0.65, 1.36)	1.01	(0.78, 1.31)
	Central	0.38	(0.19, 0.75)	1.27	(0.94, 1.70)	1.00	(0.75, 1.31)
	South	1.03	(0.64, 1.65)	1.01	(0.73, 1.39)	1.01	(0.75, 1.38)
Education	None	1.00		1.00		1.00	
	Primary	0.95	(0.70, 1.29)	1.54	(1.09, 2.17)	1.12	(0.83, 1.51)
	Secondary or higher	0.67	(0.45, 0.99)	1.17	(0.81, 1.69)	0.85	(0.61, 1.18)
Religion	Catholic	1.00		1.00		1.00	
	Protestant	1.08	(0.83, 1.41)	0.95	(0.74, 1.22)	0.62	(0.50, 0.77)
Employment	Unemployed	1.00		1.00		1.00	
	Employed	1.75	(1.35, 2.28)	1.55	(1.23, 1.95)	1.08	(0.89, 1.32)
Wealth index	Least poor	1.00		1.00		1.00	
	Poor	0.84	(0.58, 1.19)	1.00	(0.73, 1.37)	0.81	(0.60, 1.10)
	Medium	0.91	(0.64, 1.29)	0.78	(0.55, 1.11)	0.58	(0.42, 0.80)
	Richer	0.91	(0.59, 1.40)	0.78	(0.53, 1.14)	0.41	(0.28, 0.59)
	Richest	0.37	(0.21, 0.64)	0.15	(0.10, 0.24)	0.16	(0.10, 0.25)
Residence	Rural	1.00		1.00		1.00	
	Urban	1.59	(1.12, 2.26)	1.72	(1.31, 2.26)	2.01	(1.57, 2.56)
LIVING TOGETHER							
Current Age		0.91	(0.89, 0.93)	0.92	(0.90, 0.94)	0.89	(0.87, 0.90)

4.4 Discussion

There is a clear indication that in any society marriage is dynamic, and Namibia is not an exception (Table 2, Figures 2 to 4). The analysis revealed that marital patterns in a Namibian society is predominantly of never married women, and the rates are increasing, while the proportion of those getting married is falling, nevertheless, these proportions decline as age increases. The proportion of cohabitating couples has remained almost constant, below 20%, for the period 1992 to 2006, but persistently within the same range as those currently married. Comparison with other countries in the region show similarities with South Africa, while for Malawi, Mozambique and Zambia, marriage patterns are dominated by the married group (Larson and Holman, 1994; Arnaldo, 2004).

The inverse relationship of marriage patterns with current age is as expected (Figures 4a-4c, Table 1). As age increases, there is transition from singlehood to marriage or other forms of relationships.

Similarly, there is a transition from cohabitation to marriage as age increased. It remains to be explored if such transition differs by birth cohort or marriage cohort. What is clear from Figure 1 is that this transition is much slower in 2006 than earlier years suggesting a period effect. As Steel et al. (Steel et al, 2005) observed in the British study, patterns of cohabitation into marriage differed by cohort, with the 1950-60 cohort more likely to form marriages than much later cohorts. This was lacking in this study and may be worthwhile to investigate as further research. Their results further indicated that childbearing increased the probability of forming marital union. Since this analysis controlled for number of children ever-born, and the results display a positive association with marriage or cohabitation, one can argue that a similar effect as found in the British society are being observed in the Namibian society.

Now much as an increase in age is most likely to lead into marriage, notable, however, is that a plateau of this transition is at 30 to 39 years of age. This differs from other societies in the region, where marriage is entered at a relatively young age and the plateau occurs much early at 23-27 years. The policy of education for all introduced after independence meant more women became educated, thus delaying marriage (Government of the Republic of Namibia Report, 2001; Government of the Republic of Namibia, Second Millennium Development Goals Report, 2008). It is also during this time period that Namibia advocated more about gender equality and women empowerment, encouraging women to exercise their rights including rights to decide when to get married unlike in the past when women were forced into marriage (Government of the Republic of Namibia, Second Millennium Development Goals

Report, 2008). Evidently delayed transition to marriage has an effect of fertility rate (Indongo and Naidoo, 2008; Shemeikka et al, 2005; Steel et al, 2005; Steel et al, 2006), nevertheless, the positive relationship with total children born may indicate a catch-up phenomenon within the Namibian society. Be as it may, a total fertility rate of 3.22 shows that late entry into marriage has a big impact.

Results further revealed differences in marital status by place of residence, education level and age group. Interesting is a reversal of trends between 2000 and 2006 in all marriage categories. Between 2000 and 2006, there were more singles and fewer married in urban areas, a reverse of what was observed between 1992 and 2000. This is a clear indication that aspects of culture, marriage practices and customs change over time. It seems that this change is rapid in Namibia, especially after gaining stability brought about by attainment of independence in 1990. The effect of urbanization may explain the current trend, but a combined effect of increased educational level could moderate this change in patterns (Arnaldo, 2004; Chang and Jones, 1990). Historical family studies in Western European suggest that rapid urbanization, as that experienced in Namibia, does affect marriage patterns. There is a shift in the mean age at marriage, spouse choices change with educated men marrying educated women, and more also other forms of marital status, like cohabitation emerged and singlehood increased (Moreels and Matthijs, 2011). Perhaps, one can argue that the three survey data points: 1992, 2000 and 2006, spanning 14 years is not a long enough series of data to conclude that this is the transition being experienced in Namibia.

The binomial and multinomial analyses indicate that individual and household characteristics contribute significantly towards explaining marriage patterns. The effects of demographic and social differences emerged not only for a single year but were persistent over the years. For example, the effects of total number of children born and age at first intercourse on the singles remained the same, suggesting the non-changing societal attitude towards non-marital child bearing or early sexual interaction being seen as non-traditional behaviour (Vignoli and Ferro, 2009). Different perspectives have merged with regards the timing of first birth. Forms of sexual partnering have been positively related to timing of first birth. Van Roode et al (2012) showed that marriage and cohabitation were positively associated with birth timing, a finding which agrees with these results. Similar conclusions were drawn by Steel et al. (2005). However, among singles, early sexual initiation promotes protracted periods of singlehood, and in some cases cause relationship instability at younger age (van Roode et al ,2012).

Education level explains a large proportion of being in singlehood, or marriage or cohabitation. The trend and its effect are similar for the singles and married in that the risk is higher at lower level of education and lower at secondary and higher levels of education. However, the risk of cohabitation is increased with increased education level. Overall, there exists a transformative relationship between education and marital status, with decreasing likelihood of marriage among educated women than the less educated women (Torr, 2011; Musick et al, 2012). Along with gains in education, women’s employment more than doubled over the 10- year period (Government of the

Republic of Namibia, Second Millennium Development Goals Report, 2008). Employment status, however, has an opposing effect to that of education. Gainful employment solidifies marriage relationships. Being employed increased the chance of being single or marriage or in cohabitation. The effect is similar in all categories in that it generates economic independence, thus a woman can maintain her current status. According to a recent study by Sayer et al. (2011), a woman's employment status has no effect on the likelihood that her husband will opt to leave the marriage. An employed woman is more likely to initiate a divorce than a woman who is not employed, only when she reports being highly unsatisfied with the marriage.

With regards regional differences in marriage patterns, the findings suggest that marriage in Namibia is not universal, but display heterogeneity. These results agree with a study done in Mozambique (Arnaldo, 2004), and one can attribute such heterogeneous tendencies to variability in ethnic or cultural norms and socio-economic differences. For instance, the central region is more multicultural compounded with the effect of urbanization, while the northeast and northwest are more rural dominated, culture and traditional norms are vital (Shemeikka et al, 2005). These disparities may require a multilevel or random effects model that includes regional variables to capture contextual effects. Such models would be an interesting extension to the regression model fitted here and would be worth exploring.

Religiousness, as an indicator of social control, shows a varying effect among the married and those within cohabitation, and that its effect is changing with time (Vignoli and Ferro, 2009). Of interest is the fact that protestants were less likely to be married than Catholics, as evident in 2006, a fact that has been observed elsewhere, for example in Latin America and USA (Wolfinger, 2008). The liberal gospel and doctrines as purported by protestants may explain such an association. Vignoli and Ferro (2009) argued that Catholic values imposed on Italian society have a positive effect on marriage coherence, compared to north European countries and the USA which have seen rising marital disruption. The effect of religion should be interpreted to have the same effect on marriage patterns as culture has. Beliefs and norms do change over time, and religion has an influence on both of these, which in turn has an impact on marriage practices (Larson and Holman, 1994, Arnaldo, 2004).

4.6 Summary

In conclusion, the study demonstrated the fact that demographic and socio-economic characteristics have important and similar effects for all marriage patterns. The role played by these factors is important to inform policy. It should be noted that these explanatory factors are limited to explain the complex and dynamic processes that define marriage decisions and practices. However, literature persistently reports on these key factors, and this study has been defined within such general theoretical framework. Moreover, as pointed out by Vignoli and Ferro (2009), some of these variables may raise selection bias and endogeneity, and appropriate techniques are required to model the relationship that may exist between the response variable and the explanatory variables. For instance, a mixed regression model that incorporates random effects may be appropriate. Random effects may capture some of the unobserved and unmeasured population effects that influence marriage practices. Be as it may, there is an apparent social change in the Namibian society as reflected in the emerging marital patterns.

CHAPTER 5

A HURDLE NEGATIVE BINOMIAL REGRESSION MODEL FOR NON-MARITAL FERTILITY IN NAMIBIA

5.1 Introduction

The rise of non-marital fertility, which seems to defy the Bongaarts model (Moses and Kayizzi, 2007, Bongaarts, 1978) by decoupling marriage from fertility, has become a subject of interest in both the developed and developing world. Non-marital fertility can arise especially among young women who never have been married, or among older women who were previously married but who were widowed or divorced at the time of the birth. Though seemingly popular, consequences of non-marital fertility are mostly negative namely school abandonment especially for teenage girls, missed life opportunity, limited choice of future partners, higher health risks in terms of STIs and HIV/AIDS, stigmatization, exclusion, and at times subsequent deviant behavior (Zwang and Garenne, 2008).

The prevalence of non-marital births is mainly due to increasing diversity in marriage and family forms especially cohabiting unions, changing social and cultural norms including increased acceptance of pre-marital sex, out of wedlock childbearing, abortions, divorce, decisions never to marry, greater labour-force participation, and the availability and accessibility of contraceptives, in some cultures, non-marital child-bearing among adolescents is a means to prove fertility and might even be a pre-requisite to marriage (Miller, Park and Thomas, 2003).

Research suggests that non-marital childbearing is part of a global process of family change unlikely to disappear. Unlike the US, in Europe (except Britain), non-marital births were not generally seen as a problem (Kiernan, 2004). Non-marital childbearing is often associated with low income minority populations , a rejection of marriage institutions and an increase in independence and autonomy (Perrelli-Harris and Gerber, 2008), instability in family living arrangements due to parents' divorce, re-marriage, job loss, frequent migration, sexual abuse at childhood, highly concentrated, resource-deprived neighbourhoods, those who lack positive role models in their family and community, and those whose parents had lower educational and income levels (Miller, Park and Thomas, 2003).

In Southern Africa, family formation has undergone rapid transformation over the past few years with reduction in marriage rates, increasing prevalence of divorce, increase in cohabitation (Nzimande, 2007; Mturi et al, 2005, Moses and Kayizzi, 2007, Shemeikka, Notkola, Kuhanen and Siiskonen, 2008) and increase in non-marital childbearing. Among Africans living in rural settings predicted a more traditional pattern of family formation as evidenced by the higher risk of union entry and lower risk of non-marital child bearing. However, as marriage rates continued to decrease, non-marital child-bearing was increasingly becoming common in South Africa. Non-marital fertility is thought to be linked to demographic factors such as younger age, early age at first intercourse, age at menarche, and delayed age at marriage. Women who had a non-marital first birth were delaying both fertility and union entry. Rural residence during childhood marginally reduced the hazard of non-marital first birth but increased the hazard of entering a union by 44% (Amoateng, 2004). In Kenya, the unmarried women contributed 17% of the total fertility rate. Fertility was lowest in urban areas and higher in rural areas, although the urban areas contribution to non-marital fertility was highest (Chabeda, 2009). Elendou-Enyengue and Magazi (2011) attributed the high rates of non-marital teenage pregnancy to delayed and inconsistent contraceptive use, poverty, peer pressure and inequality. Stockard, Gray, O'brien and Stone (2009) found that cohorts with traditional family structures had higher non-marital fertility ratios (NFR). In Namibia, overall fertility levels have been decreasing over the past two decades. The decrease could be associated with an increased trend in the prevalence of use of modern contraceptives which doubled since 1992. Age at first birth has remained constant but age at first marriage continues to increase. As a result, postponement of marriage increases the probability that women remain childless or that they have fewer children than desired. Replacement level is projected to be attained much faster than expected and further research could focus on policy implications of family planning programmes once replacement level has been achieved to maintain it (Indongo and Pazvakawambwa,2012). In the US, variation in the time to next birth among comparable unmarried and married mothers who lived in different cities was partly due to variation in labour markets, housing costs, and availability and welfare policies (Curtis and Waldfogel, 2009). Dyer and Farlie (2004) examined the impact of family CAP policies (policies that seek to reduce fertility among welfare recipients by denying additional cash assistance to recipients that have children while on welfare) on the birth rates of single, less educated women with children in the US. Their regression results did not provide evidence that family CAP policies reduce non marital births among single, less educated women with children. Wildssmith and Paley (2006) established that employment deterred non-marital fertility more for women in lower economic backgrounds relative to those in higher economic backgrounds. Family structure had a significantly stronger effect on the risk of non-marital birth for higher socio-economic background women, in particular, being raised in a household with no parent present. The higher fertility in cohabiting unions suggested that these unions were viewed as more surrogate marriages, perhaps based on the history of informal unions in Mexico.

The increase in non-marital fertility in Europe and the US was mainly a result of increase in child bearing within cohabitation as couples postponed or 'forewent' marriage. The increasing cohabitation and child-bearing in cohabitation could be due to a shift in values towards individualization, autonomy, and secularization values that may have led to a rejection of the institution of marriage(Le sthaeghe, 2010; Klusener , Perelli-Harris, and Gassen , 2012); Wildssmith and Paley, 2006); Plotnick , 2004)). Cohabitation could be regarded as a step on the way to marriage for some, but an end in itself for others (Musick (2007). It was not clear whether non marital fertility would continue to increase across Europe and whether political and economic integration of Europe would trigger ideational and demographic harmonization on this issue.

In Russia, Perrelli-Harris and Gerber (2008) investigated the circumstances surrounding non-marital fertility which increased from 14.6% in 1990 to 29.8% in 2004. Their findings supported the assertion that legitimation of pre-marital pregnancies remained common throughout the 1990s. Women with vocational schooling had higher rates of non-marital child bearing. Lower vocational schooling had even higher non marital conception rates than those with secondary education. Women with higher education were more likely to marry once they conceived a child outside of marriage.

Musan, Kisovi, and Tonui (2012) established that low parental income and income instability during childhood significantly increased the risk of premarital birth. The respondent's occupation was significantly contributing to the increase in the rate of non-marital births in the district. The frequency of listening to music was significantly associated with non-marital births. Their results also indicated that most of the respondents' first intercourse experiences were with older boyfriends (73.3%) while 12.5% were with just a friend, and 12.9% were with either a younger boyfriend or a rape case. Their results suggested an increased acceptance of pre-marital sex in Kenya. However, most of the pregnancies (67.55%) were said to be accidental or unplanned. The authors stressed the need for integrated policy or programs to ameliorate the negative consequences associated with child-bearing outside of marriage and especially to mothers who did not desire to have children.

Zwang and Garenne (2008) associated non- marital fertility in South Africa with lack of contraception among young women, and refusal of abortion for religious reasons.

The number of non-marital births per woman is an example of an event count. An event count is a realization for a non-negative integer valued random variable. Various non-linear models based on the Poisson and negative binomial distributions have been developed to capture the behaviour of those events. Zero-inflated Poisson (ZIP) or Zero-inflated Negative Binomial (ZINB) models are used when there are many zeros in the data. Other models have also been developed to handle censored or truncated count data, for example, hurdle models. The Poisson model rarely fits to data because of over-dispersion. Zero-inflated models handle over-dispersion by changing the mean structure to explicitly model the production of zero counts, by assuming two latent groups. One is always the zero group, and the other is the not-always-zero or sometimes-zero group. That is to say, the zero counts emerge from the former group and some of the latter group with a certain probability (Park, 2005).

Gonzales-Barron, Kerr, Sheridan and Butler (2010) fitted the negative binomial and two zero-inflated parameterizations of the Poisson and negative binomial distributions (zero-inflated and hurdle) to bacteria data consisting of total coliforms present on beef carcasses sampled from nine Irish abattoirs. The pairwise Likelihood ratio tests applied to the nested models (negative binomial against Poisson, zero-inflated negative binomial against zero-inflated Poisson, and hurdle negative binomial against hurdle Poisson) indicated that in all cases, the negative binomial based distributions fitted the observed data far better than their simpler Poisson based counterparts. To model episodes of domestic violence data with too many zeros, Famoye and Singh (2006) proposed a zero-inflated generalized Poisson distribution and estimated the parameters using Maximum likelihood estimation. The major problems in these cases were that the iterative technique to estimate the parameters of the zero-inflated regression models failed to converge. The Zero-inflated Generalized Poisson model addressed the scenarios where the ZIP and the ZINB models were inadequate. Miranda (2010) allowed for low and high order parities to be determined by two different data generating mechanisms, and explicitly account for potential endogenous switching between regimes using a Poisson double hurdle count model was developed for the analysis. Chipeta, Ngwira and Kazembe (2013) also developed a two part model with one part for analysis of infection prevalence and the other to model infection intensity.

Correlates of non-marital fertility, measured by the total children born to an unmarried woman, can be modelled by negative binomial regression analysis, which is an improvement on the Poisson regression model to address the problem of over-dispersion. Count data such as non-marital fertility often show high incidence of zero counts than would be expected if the data followed a Poisson distribution. In such cases, a zero inflated Negative Binomial distribution may be more appropriate (Ridout, Hinde & Demetrio, 2001). One may also consider the non-marital fertility births as a two-part process, with one part describing the incidence and the other prevalence. In such a situation, a hurdle negative binomial regression model, that permits covariates on both parts will be ideal to explore.

5.2 Methods

5.2.1 Data and Sample

In Namibia, although non-marital childbearing has been reported to be high and increasing, no research has explicitly analyzed factors associated with or influencing non-marital fertility. This study was based on Namibian Demographic and Health

Survey (DHS) of 2006/7. DHS is a national survey drawn on using a multistage cluster sampling. At first stage, a random sample of enumeration areas (EA), which are primary sampling units, was chosen from the census sampling frame. From the selected EAs, households are systematically selected drawn. A total of 9804 women of reproductive age (15-49 years), in the selected households, were interviewed using a face-to-face questionnaire. The questionnaire included variables on individual bio-demographic factors, household characteristics, history of marital unions and births. Data included in this analysis comprised of 7117 non-married women who had either never married or were cohabiting at the time of the survey. The outcome variable was the total children ever born.

Each woman involved in the survey was asked how many children were ever born to her. The response was a non-negative integer valued count event. Bio-demographic characteristics related to a woman included current age, age at first birth, employment status, religion and education level and intimate relationship status. Household characteristics consisted of place of residence (rural or urban) and wealth index. The wealth index was used as a proxy for the standard of living of the household. It is based on household ownership of consumer goods; dwelling characteristics; type of drinking water source; toilet facilities; and other characteristics related to household socio-economic status. To construct the index, each of the assets was assigned a weight (factor score) generated through principal component analysis and the resulting asset scores were standardized in relation to the standard normal distribution. Each household was then assigned a score for each asset and the scores were summed for each household.

Individuals were ranked according to the total score of the household in which they reside. The sample was then divided into quintiles from one (poorest) to five (richest).

5.2.2 Statistical Analysis

Poisson, Negative Binomial, zero-inflated and hurdle models have all the flexibility and power of parametric models, handling repeated measures, multiple covariates, and various configurations of fixed and random effects, without assuming that the outcome is normally distributed (Hu, Pavlicova and Nunes, 2011), and were explored in this study. The purpose of this chapter is to explore the Poisson, Quasi-Poisson, Negative Binomial, Zero-Inflated Poisson, Zero-Inflated Negative Binomial, hurdle Poisson and hurdle Negative Binomial models using data from the NDHS on non-marital fertility.

The total children ever born to non-married women were assumed to follow two part process comprising of a point mass at zeros followed by truncated count data distribution for the non-zero observations. The model for the count can be either a Poisson or a negative binomial. These two-part models are also referred to as zero-hurdle models (Winkelmann, 2004, Winkelmann, 2008). For the Poisson hurdle model we have

$$P(Y_{ij} = 0) = 1 - p_{ij}, \quad 0 \le p_{ij} \le 1$$

$$P(Y_{ij} = k) = p_{ij} \frac{\lambda^k e^{-\lambda}}{k![1-e^{-\lambda}]}, \;\; k = 1, \cdots, \infty, \;\; 0 < \lambda < \infty$$

where Y_{ij} indicates the response for woman $j = 1, \cdots, n$ and λ is the mean for the truncated Poisson distribution. An alternative to the Poisson hurdle is a negative binomial which is given by

$$P(Y_{ij} = 0) = 1 - p_{ij}, \quad 0 \leq p_{ij} \leq 1$$

$$P(Y_{ij} = k) = p_{ij} \frac{\Gamma(k+1)}{k!\,\Gamma(\theta)} \left(1 + \frac{\lambda}{\theta}\right)^{-\theta} \left(1 + \frac{\lambda}{\theta}\right)^{-k}, \qquad k = 1, \cdots, \infty; \quad 0 < k < \infty$$

with parameters $\lambda \geq 0$ for the mean and $\theta > 0$ for over-dispersion. The component p is a fertility propensity, while the count part models the fertility intensity of the woman. A special case of the models above is the zero-inflated Poisson or zero-inflated Negative binomial. These models have a degenerate distribution at zero with untruncated Poisson or Negative binomial distribution. A zero-inflated Poisson is denoted by $Y_{ij}|\eta_{ij}, \lambda \sim ZIP(\eta_{ij}, \lambda)$. Combining zero inflation and over-dispersion gives a zero inflated negative binomial defined as $Y_{ij}|\eta_{ij}, \theta, \lambda \sim ZINB(\eta_{ij}, \theta, \lambda)$, where η and θ are the predictor and over-dispersion parameters respectively.

The zero-hurdle model can be extended to accommodate covariates and random effects. Since we have two parts, the prevalence component assumes a logit link while the severity component we proposed a log link:

$$\eta = \begin{pmatrix} logit(p_{ij}) \\ \log(\lambda_{ij}) \end{pmatrix} = \begin{pmatrix} \alpha_1 \\ \alpha_2 \end{pmatrix} + X_{ijl}^T \begin{pmatrix} \beta_1 \\ \beta_2 \end{pmatrix}$$

where α_l is the intercept for process l, the terms $\beta = (\beta_1, \beta_1)^T$ are vectors of regression parameters corresponding to the set of covariates, X_{ijl}. (Kazembe, 2013).

All the seven models were each fitted to non-marital fertility data using the pscl package (Zeileis, Kleiber and Jackman, 2009) in the R statistical software. The outcome variable was the total children ever born to non-married women between the ages of 15 and 49. The independent variables included age, place of residence, highest educational level, religion, economic status, age at first birth, contraceptive use, relationship status and employment status. The geographical region of the respondent was not included in the independent variable set as it was not significantly associated with the outcome variable (r = -0.016, p = 0.11). Over-dispersion in the data was evaluated using the Likelihood ratio test. Goodness of fit between pairs of competing models was assessed using the Voung statistic (Park, 2005).

5.3 Results

5.3.1 Descriptive Summary statistics

The average age of the sampled women was 25.48 years with a standard deviation of 8.43 years. The total number of children ever born to non-married women averaged 1.41 with a standard deviation of 1.81. The other sample characteristics are summarized in Table 5.

Table 5: Background characteristics of non-married women from the survey

Variable	Number	%
Age-group (years)		
15-19	2168	30.5
20-24	1719	24.2
25-29	1200	16.9
30-34	883	12.4
35-39	556	7.8
40-44	368	5.2
45-49	223	3.1
Type of place of residence		
Urban	3190	44.8
Rural	3927	55.2
Highest Educational level		
No Education	453	6.4
Primary	1782	25
Secondary	4619	64.9
Higher	263	3.7
Religion		
Roman Catholic	1644	23.2
Protestant and Others	5457	76.8
Wealth Index		
Poorest	1134	15.9
Poorer	1320	18.5
Middle	1670	23.5
Richer	1855	26.1
Richest	1138	16
Current Marital Status		
Never Married	5545	77.9
Living Together (Cohabiting)	1572	22.1
Employment Status		
Not Employed	4354	61.5
Employed	2720	38.5
Contraceptive Use		
Never Used	2313	61.5
Used Traditional or Modern Methods	4804	67.5

The distribution of the women by age group was 15-19 (30.5%), 20-24 (24.2%), 25-29 (16.9%), 30-34 (12.4%), 35-39 (7.8%), 40-44 (5.2%), and 45-49 (3.1%). The percentage of women residing in urban areas was 44.8% and the rest were residing in rural areas. The highest educational levels of the women ranged from no formal education (6.4%), primary education (25.0%), secondary education (64.9%) and higher education (3.7%). The majority of the women had attained secondary education but very few had higher education. In terms of religion, most of the women (76.8%) belonged to Protestant and other religions while the remainder (23.2%) were Roman Catholics. The women were almost evenly distributed among the wealth quintiles with 15.9% in the poorest category, 18.5% in the poorer category, 23.5% in the middle category, 26.1% in the richer category and 16.0% in the richest category. Most of the women had never married before (77.9%) and the rest were cohabiting (22.1%) at the time of the survey. The majority of the women were unemployed (61.5%). With regards to contraceptive use, most of the women used contraceptives (67.5%).

Of the 7117 women who were not married, a considerable percentage (42.8%) had never given birth, indicating a high occurrence of zero counts in the outcome variable. The histogram of the outcome variable also indicates a high frequency of zeros and long right tail giving evidence of over-dispersion in the data. The mean (1.41) and the variance (3.26) are also unequal as should be the case for an ideal Poisson random variable. The histogram of the total number of children ever born is presented in **Figure 8.**

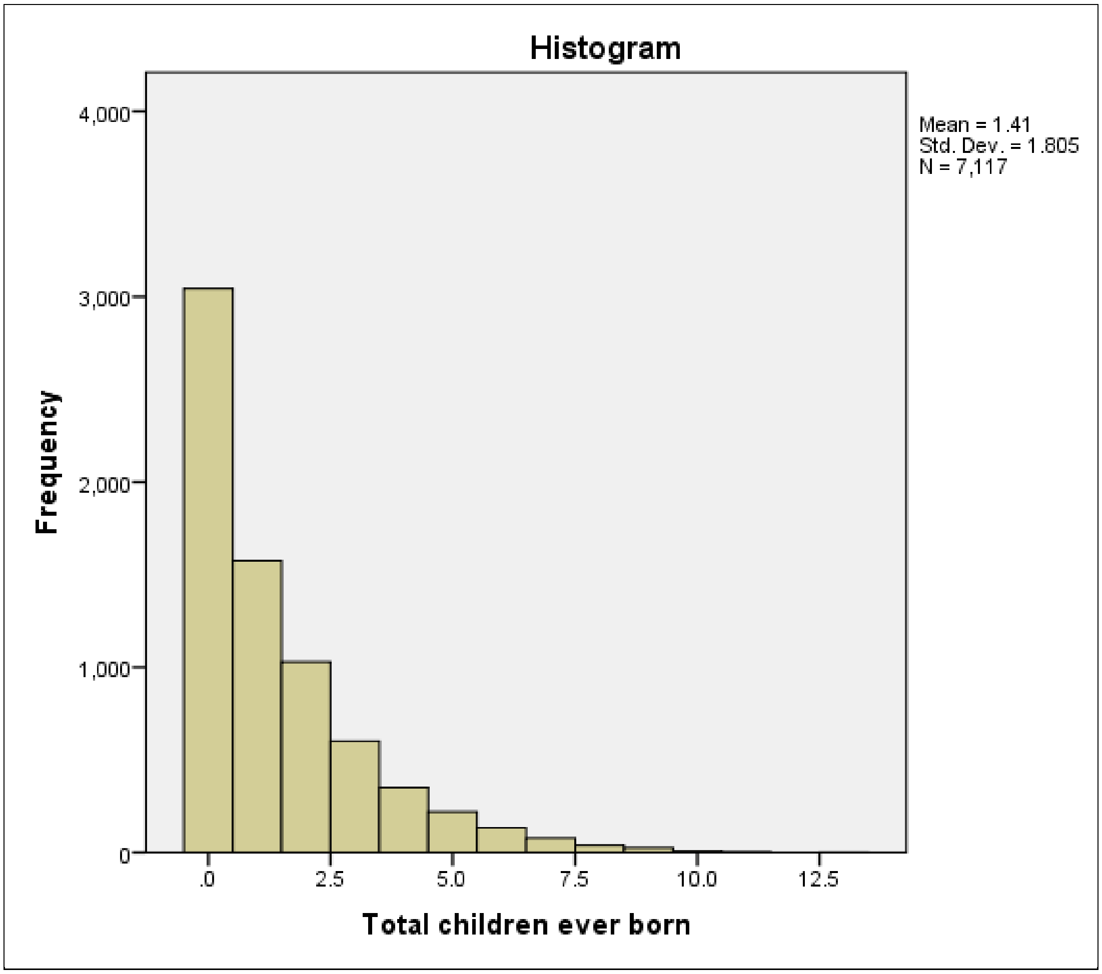


Figure 8: Histogram showing the distribution of the total children born per non-married woman

5.3.2 Regression analysis results

The seven candidate regression models explored were Poisson, Quasi Poisson, Negative Binomial, Zero-inflated Poisson, Zero-inflated Negative Binomial, Hurdle Poisson and Hurdle Negative Binomial Regression. Their corresponding Voung Statistics were used to test for goodness of fit and model comparison. Table 6 summarizes the model comparisons.

Table 6: Comparison of Poisson, Negative Binomial, Quasi-Poisson, Zero-inflated Poisson and negative binomial, and Hurdle Poisson and Negative Binomial Models

Comparison statistic	Poisson versus Quasi-Poisson	Poisson Versus Negative Binomial	Poisson Versus Zero –inflated Poisson	Poisson versus Negative Binomial Model	Poisson versus Hurdle Poisson	Poisson vs Hurdle Negative Binomial	Hurdle Poisson versus Hurdle Negative Binomial
Voung Statistic	na	0.7433	0.7188	0.7436	-11.022***	-12.808***	-4.933***
		P=0.2286	P=0.2377	P=0.2285	P<0.001	P<0.001	P<0.001

The goodness of fit tests showed that the hurdle regression models were overall superior to all other regression models according to the following ranking:

Poisson < Negative Binomial < Zero-Inflated Poisson < Zero-Inflated Negative Binomial <Hurdle Poisson <Hurdle Negative Binomial Regression.

In particular Hurdle Negative Binomial regression model offered the better fit compared to the Hurdle Poisson Regression model (Voung Statistic =-4.933, p<0.001). This best model was therefore chosen as the final model to fit to the non-marital fertility probability as well as determination of the factors influencing non-marital fertility counts, measured by the total children born. **Table 7** summarizes the results Hurdle negative Binomial regression.

Table 7: Regression Estimates from the Hurdle Negative Binomial Regression Model

Predictor	Hurdle Negative Binomial Regression model			
	Fertility Probability		Fertility Intensity	
	OR	95% CI	RR	95% CI
Intercept	0.166***	(0.099, 0.277)	0.461***	(0.366, 0.581)
Age of the Woman				
<=20	1.000		1.000	
21-30	12.079***	(8.526, 17.113)	3.915***	(3.160, 4.851)
31-40	59.145***	(30.902, 113.203)	8.268***	(6.684, 10.227)
41-49	162.476***	(60.431, 436.835)	10.883***	(8.778, 13.492)
Place of Residence				
Urban	1.000		1.000	
Rural	1.417**	(1.140, 1.761)	1.006	(0.948, 1.068)
Educational level				
No Education	1.000		1.000	
Primary	0.75	(0.474, 1.188)	0.935*	(0.875, 0.999)
Secondary	0.255***	(0.158, 0.4122	0.637***	(0.590, 0.688)
Higher	0.061***	(0.030, 0.123)	0.516***	(0.421, 0.633)
Wealth Index				
Poorest	1.000		1.000	
Poorer	0.645**	(0.484, 0.859)	0.942	(0.877, 1.012)
Middle	0.903	(0.681, 1.198)	0.891**	(0.829, 0.956)
Richer	0.634**	(0.466, 0.863)	0.817***	(0.751, 0.888)
Richest	0.417***	(0.287, 0.604)	0.699***	(0.620, 0.787)
Marital Status				
Never married	1.000		1.000	
LivingTogether (Cohabiting)	2.601***	(2.080, 3.253)	1.145***	(1.118, 1.174)
Employment Status				
Not Employed	1.000		1.000	
Employed	1.049	(0.878, 1.254)	0.978	(0.931, 1.028)
Contraceptive Use				
Never Used	1.000		1.000	
Used	8.579***	(6.268, 11.741)	1.027	(0.9648, 1.093)

5.3.3Estimated effects of non-marital fertility probability and intensity under the Hurdle Negative Binomial Model

The estimated effects of non-marital fertility probability are presented in Table 5. Non-marital fertility incidence was found to be associated with the age of the woman. Fertility generally increased with age for women aged between 41 and 49 (OR=162.48, 95% CI:60.43-436.85), those aged 31 to 40 (OR=59.15, 95% CI:30.90-113.20), and those aged 21 to 30 (OR=12.08,95% CI:8.53-17.11) having significantly higher fertility incidence compared to those women aged between 15 and 20 years of age. There was no significant difference in fertility incidence between those with primary education and those with no formal education (p=0.2203). Fertility probability generally decreased with increasing educational level of the woman. Those women with secondary education (OR=0.255, 95% CI:0.158-0.4122)or higher education (OR=0.06,95% CI:0.030-0.12) had lower probability of fertility compared to women with no formal education. Fertility probability was 1.4 times higher in rural compared to urban women. With regard to employment, there was no significant difference in fertility probability between employed and unemployed women (p=0.597). Based on the marital status of the women, cohabiting women had relatively higher fertility probability compared to never married women (OR=2.601, 95% CI:2.08-3.25). Results also indicated the those using either traditional or modern contraceptive methods had higher fertility probability than those who had never used contraceptives (OR=8.579, 95% CI:6.268-11.74).

Results of the Hurdle Negative Binomial regression showed that non-marital fertility increased with the age of the woman, with women aged 41-49 (RR=10.88, 95% CI:

8.78-13.4), women aged 31 to 40 (RR=8.23, 95% CI:6.68-10.23), and those aged 21 to 30 (RR=3.92, 95% CI:3.16-4.85) likely to have more children compared to those in the 15 to 20 years reference category. Unlike for fertility probability, the woman's place of residence (p=0.845) had no significant effect on the number of children born to the unmarried woman, even though rural women were likely to have more children compared to their urban counterparts. The fertility of the woman significantly decreased as her educational level increased. Women with primary education (RR=0.94, 95% CI:0.88-0.99), secondary education (RR=0.64, 95% CI:0.59-0.69), and those women with higher education level (RR=0.52, 95% CI:0.42-0.63) were likely to have fewer children compared to those with no formal education.

With regard to the economic status of the women, fertility intensity seemed to diminish from the poorest women to the richest women. There was no significant difference in fertility intensity between the poorer and the poorest women (p=0.1043). Women with middle economic status (RR=0.89, 95% CI: 0.83-0.96), richer women (RR=0.82, 95% CI: 0.75-0.89), and the richest women (RR=0.70, 95% CI:0.62-0.79) had fewer children compared to the poorest women. When it came to the intimate relationship status of the no-married women, cohabiting women were likely to have more children than their never married counterparts (RR=1.15, 95% CI:1.12-1.17). The employment status of the woman had no significant effect on the total children born to the woman (p=0.379).

5.4 Discussion

Findings from this study indicated that non-marital fertility was higher among cohabiting women compared to never married women. These findings are in agreement with Wildssmith (2006) explained that the higher fertility in cohabitating unions could be a suggestion that these unions are now being viewed as more surrogate marriages based on informal unions. In Namibia this could also be because of the effects of the disruption of traditional marriage settings during the apartheid era (Orieji, 1997). The popularity of child-bearing in cohabiting unions was also observed in many developed countries and some African countries (Klusener, Perelli-Harris and Garsen, 2012; Musick, 2007; Mturi et al, 2005). Non-marital fertility probability was higher in rural areas than urban areas but no significant differences in the total children born by unmarried women in rural and urban areas were observed in Namibia. These findings differ from those from South Africa where rural women had lower risk of non-marital childbearing compared to their urban counterparts (Nzimande, 2007) and findings from Kenya where the urban areas contribution to non-marital fertility was highest (Chabeda, 2009).

Results also indicated that in Namibia, non-marital fertility decreased with increasing educational level of the woman. Surprisingly in Russia, women with lower vocational schooling had even higher non-marital conception rates than those with secondary education because women with higher education were more likely to marry once they conceived a child outside of marriage (Perelli-Harris and Garber, 2008). In Kenya, women with secondary education contributed highly to non-marital fertility. Results also indicated that in Namibia, richer women had fewer children compared to their poorer counterparts. These findings are consistent with those from the developed world where women in highly concentrated, resource deprived neighbourhoods and those who lacked positive role models in their family and community, and those whose parents had lower educational and income levels were more likely to experience non-marital child-bearing (Miller, park and Thomas, 2003; Wildssmith and Paley, 2006; Musan, Kisovi, and Tinoui, 2012). The decrease in fertility levels in urban areas, and differentials in education can be explained by the fact that women delay child-bearing because of schooling and those in rural areas are out of school earlier and therefore more prone to teenage and non-marital pregnancies, and have limited access to contraceptives and other reproductive health services .

The employment status of the woman had no significant effect on non-marital fertility in Namibia. This is in contrast to study findings on Mexican American women which showed that employment deterred non-marital fertility more for women with lower economic backgrounds relative to those with higher economic backgrounds (Wildssmith and Paley, 2006). Again contraceptive use did not have a significant effect on non-marital fertility. This could be explained by study findings from the Kavango region of Namibia where rates of teenage pregnancy were high yet very little of the teenage fertility was wanted , and most probably non-marital, due to the risky nature of the sexual activities in that region. These sexual risks were due to delays and inconsistent contraceptive use (Elendou-Enyengue and magazi, 2011). The same pattern was also observed in Kenya where most of the non-marital pregnancies were reported to be accidental or unplanned (Musan, Kisovi and Tonui, 2012). In Rural South Africa, premarital fertility was ultimately due to lack of contraception among young women and was also associated with the risk of contracting sexually transmitted diseases (Zwang and Garenne, 2008).

5.5 Summary

Results indicate that, non-marital fertility in Namibia is associated with the age of the woman, her level of education, economic status, place of residence. Non- marital fertility was higher among cohabiting women compared to never married women. Fertility probability was higher in rural areas compared to urban areas even though there were no significant differences in fertility intensity between non-married women from rural and urban areas. Both Non marital fertility probability and intensity decreased with increased educational level. Intervention efforts should focus on promoting education among girls and women especially in rural areas to reduce teenage pregnancy and non-marital fertility.

CHAPTER 6

EVENT HISTORY MODELS FOR THE TIMING OF SEXUAL DEBUT AND FIRST MARRIAGE AMONG WOMEN IN NAMIBIA

6.1 Introduction

6.1.1Sexual Debut

Early first sexual intercourse is often associated with unplanned adolescent motherhood, unwanted pregnancies (Hallert et al,2007;Kaestle et al,2005; Rostosky, Regnerus and Wright, 2003), abortions and infanticide, school drop-outs, risk of sexually transmitted infections including HIV, maternal mortality (Zaba et al.,2012; Pettifor et al,2004; Mcgrath et al, 2012; Tilahun and Ayele,2013; Newell, 2008), and a general reduction of future life opportunities for the individual concerned (Hallert et al,2007). Early sexual intercourse may represent a life course transition that increases the chances of a longitudinal pattern of risky sexual activity, whose consequences may affect sexual functioning and relationship skills (Upadhyay and Hindin, 2007;Sandfort et al, 2008). Muharaj and Munthree (2007) found that in KwaZulu Natal, South Africa, nearly 46% of all sexually experienced young women reported that their first sexual encounter had been coerced. Those who had reported being coerced at first sex were significantly more likely to be black and living in an urban area , more likely to report having sexually transmitted infection (STI), and having experienced unintended pregnancy compared to those who had not been coerced at first sex. They noted that coercion at first sex is an important health problem that has a serious impact on the reproductive health and behaviour of young women.

Hallert et al. (2007) established that the median age at first sex had declined among males over the past 30 years but increased recently among females. A number of factors have been associated with sexual debut. Huschek et al (2010) established that characteristics of parent modernity were related to delayed entry into union. Having parents with lower human capital, coming from a larger family, and having a parent with certain backgrounds resulted in significantly different rates of union formation. The influence of parental human capital was at least partly mediated by the child's own educational attainment. When parents made household decisions jointly, sons reported delaying first sex. In households in which mothers had higher status, daughters reported delayed first sex. The results indicated that long-term positive effects on children, particularly delaying first sex, occur in families in which parental decision making is cooperative and in which women have higher status. Contact with non-co-ethnic peers resulted in postponement of starting a first union, and going to school with natives resulted in slower rates of entry into first union. Seiving etal (2006) revealed that the higher proportion of a youth's friends who were sexually experienced, the greater the odds of sexual debut . The odds were also elevated among youth who believed that they would gain their friends' respect by having sex.

Age at first sex is also associated with peri-urban residence (versus rural), ever use of alcohol, knowing at least one person who had HIV, while school attendance had a significant protective effect (Mcgrath et al,2012); employment, religion, religion (Zaba et al.,2012), and ethnicity(Mueller etal, 2008).

The time to first sex, is usually measured in years and is assumed to be continuous and usually modelled by classical parametric regression methods. The Cox proportional hazards function is well known for modelling event histories (Baschieri and Hinde, 2007). Unfortunately the time variable is measured on a continuous scale and is based on the proportional hazards assumption. This assumption is violated in most cross-sectional survey data which is based on retrospective studies, data is measured in discrete time, where there is recall bias and a lot of tied observations (Gayawan and Adebayo, 2013). Furthermore, this approach may not be suitable for estimating small area effects and at the same time adjusting for other covariates especially when the effects of the covariates are non-linear or time-varying (Manda and Meyer, 2005; Gayawan and Adebayo, 2013). Kneib (2006) proposed to address this challenge by assuming that an event occurs over an interval of time such that the heavily tied survival times are incorporated by introducing larger intervals for the heaped observations.

Moreover, there has been debate that sexual debut has recently declined (Dude, 2005;Guo et al., 2012; Martinez et al, 2011;Mmbaga, et al, 2012). However, the hazard and risk factors of changing pattern of age at first sex have not been fully explained. In addition, the actual pattern of risk factors of early sexual debut is largely unknown in Namibia. This chapter investigated the age- period-cohort effects by fitting a flexible, time-to-event models of age at first sex, using a case-study of data from Namibia. Study findings will aid the design strategies for delaying sexual debut.

6.1.2First marriage

Marriage can be viewed as a social union or legal covenant between two people, normally of opposite sex, in which intimate sexual relationships are acknowledged. Marriage is usually formalized by a wedding or celebration ceremony. People marry for various reasons ranging from social legal, love, emotional, financial, spiritual to religious reasons. There is a general call world-wide to delay marriage and to discourage premarital sex because early marriage, especially among girls, is often associated with adolescent motherhood, school dropouts, maternal morbidity and mortality, and forfeited future life opportunities for the affected individual (Pathfinder International Report, 2006; Green, Makuria and Rubin, 2009). The propensity to marry, the stability and duration of marriage have considerable implications for the organization of family life. The age at first marriage may also influence population growth, labour supply, consumption, wage rates, mortality, migration and to some extent fertility (Mensch, Singh and Casterline, 2005). According to the Namibia Marriage Act No. 25 of 1961, Section 26, no boy under the age of 18 and no girl under the age of 15 years may contract a civil marriage without the permission of a designated government (CRC/C/ADD 12, 1993). The 1992, 2000, and 2006/7 Namibia DHS report showed that mean age at marriage was 24 in 1992, 26.2 in 2000 and 28.6 in 2006/7. In 1992, the median age at first birth was 21 years and 56% of the births were premarital. In Namibia like in most of Southern Africa, premarital child-bearing is a concern especially in terms of the financial responsibility to support the children born.

Junya (2005) established that higher educational career, namely high school to college made one's hazard ratio of marriage drop to approximately 65%, and those with no experience of living apart from their parents tended to marry early. Later marriage for highly educated women primarily reflects longer enrollment in school that university education increasingly is associated with later as less marriage (Raymo, 2003, Mensch, Singh and Casterline, 2005). These findings are in line with the argument that higher education should be negatively associated with marriage only in the countries in which gender relations make it particularly difficult for women to balance work and family. In Nepal, Aryal (2007) established that the risk of getting married early decreased gradually with increasing year of birth cohort, and was higher among females of high socio economic status compared with those of low economic status. This could be explained by the fact that high socio-economic status families were motivated, for religious and prestige, to get their daughters married at an early age, preferably before menarche. Education, occupation and age at menarche were the most powerful factors in deciding the timing of first marriage in Nepal. Other social and family background characteristics were also important determinants of age at first marriage; including how strongly traditional values and ties to the natal family were held by women (Wong, 2005). In Malawi, rising age at marriage was a combination of birth cohort and education effects, depended on the family and to some extent on the community in which a woman resided. These results confirm a downward trend in teenage marriage and that raising women's education levels in sub-Saharan Africa have the beneficial effect of increasing age at marriage, and by implication reducing total fertility rates (Manda and Meyer, 2005).

For men, the decision whether to get married was strongly negatively affected by holding unstable contracts or not working relative to when an indefinite contract was held. However, for women, holding fixed term contracts was not a deterrent factor for the decision whether to get married (De La Rica and Iza, 2005). Discrete time to event models have been widely used (Manda and Meyer, 2005; Raymo, 2003; Mensch, Singh and Casterline, 2005; Aryal, 2005; Wong,2005) to analyze the timing of first marriage, first sex and first birth due to their flexibility and robustness .

This chapter explores the age- period-cohort effects on age at first marriage in Namibia by fitting discrete time-to-event models to retrospective cross-sectional data from the 2006-7 NDHS, to establish individual and structural effects that impact on the timing of first marriage among women in Namibia

6.2 Methods

6.2.1Data and Sample

This study was based on the 2000 and 2006/7 Namibia Demographic and Health Survey (DHS). DHS is a national survey drawn on using a multistage cluster sampling. At first stage, a random sample of enumeration areas (EA), which are primary sampling units, was chosen from the census sampling frame. In Namibia, the following procedure was used. From the selected EAs, households were systematically drawn. Only women of reproductive age (15–49 years), in the selected households, were interviewed using a face-to-face questionnaire. The questionnaire included variables on individual bio-demographic factors, household characteristics, history of marital unions and births. Final samples included in the analysis were respectively, 6755 from the 2000 survey and 9800 women, from the 2006/7 round of surveys.

6.2.2Statistical Modelling

The standard procedure for examining the effects of covariates (v_i) on survival times (T) is the Cox proportional hazard model where the multiplicative structure

$$\lambda_i = \lambda(t, v_i) = \lambda_0(t)\exp(v_i',\gamma)$$

is assumed for the hazard rate, γ is a vector of regression coefficients and $\lambda_0(t)$ is the baseline hazard rate at observed time (t). The baseline hazard rate is re-parameterized through $g_0 = \log\big(\lambda_0(t)\big)$ and covariates are partitioned into groups of different types to extend the Cox model to a semi-parametric hazard rate model so that $\lambda_i(t) = \exp(\eta_i(t)),\ i = 1,2,\cdots,n$ is a geo-additive predictor predictor of the form

$$\eta_i(t) = v_i'\Upsilon + g_o(t) + \sum_{j=1}^{J} f_j(x_{ij}) + f_{spat}(s_i) + b_{gi}$$

where $\eta_i(t)$ is the predictor, $f_j(x_{ij})$ is the non-linear effect of continuous covariates x_j, and $f_{spat}(s)$ is the spatial effect. The vector of linear effects is denoted by γ while $b_g,\quad g \in \{1,\cdots,G\}$ are uncorrelated individual or group specific frailties. A structured additive model for discrete time- to-event outcome was used to establish individual and structural effects, and simultaneously investigate non-linear effects of age, cohort and period on the timing of first sex among women. An extended geo-additive Cox model that addresses arbitrary combinations of left , right and interval censoring schemes and relaxes the proportional hazards assumption by allowing all covariates to be piecewise constant i.e. time varying was further proposed by Kneib (2006). Other extensions of geo-additive models have been widely developed and adopted (Adebayo and Farhmeir 2005; Hennerfeind et al,2006; Khatab and Fahrmeir, 2009;Wand, Whitaker and Ramjee,2011; Nkurunziza, Gerbhhardt and Pilz,2011; Claudio et al, 2012; Olubiyi and Olubusoye, 2013).

The predictor, $\eta_i(t)$ can be expressed in matrix notation if we let $\boldsymbol{\eta} = (\eta_1, \eta_2, \cdots, \eta_n)'$ denote the prediction vector, and let $\boldsymbol{g_l} = (g_l(t_1), \cdots, \left(g_l(t_n)\right)'$ denote the evaluation of functions $g_l(t)$, $\boldsymbol{f_j} = (f_j\left(x_{1j}\right), \cdots f_j\left(x_{nj}\right))'$, the vector of evaluations of the functions $f_j(x_j)$, $\boldsymbol{f_{spat}} = \left(f_{spat}(s_1), \cdots, f_{spat}(s_n)\right)'$, the vector of spatial effects and $\boldsymbol{b} = \left(b_{g1}, \cdots b_{gn}\right)'$the vector of uncorrelated random effects. These vectors can be expressed as a matrix product of a design matrix **Z** and vector of parameters **B** to give

$$\boldsymbol{\eta = V\lambda + Z_1B_1 + \cdots Z_pB_p.}$$

The likelihood of $\vartheta = (\boldsymbol{\lambda}', \boldsymbol{B_1}', \cdots, \boldsymbol{B_p}')$ for a n interval censored observation is given by

$$L_i(\vartheta) = exp\left(-\int_{0}^{T_j} \boldsymbol{\lambda(t)dt}\right)\left(1 - exp\left(-\int_{T_l}^{T_u} \boldsymbol{\lambda(t)dt}\right)\right)$$

The model was estimated using Bayesian inference. Priors for all parameters were assigned under the Bayesian approach (Lang and Brezger , 2004; Kneib and Fahrmeir, 2007). Diffuse priors were assumed for fixed parameters, while for the baseline effect $g_o(t)$ and the non-linear effects $f_j(x_{ij})$, Bayesian P-spline prior was assumed. These allowed for nonparametric estimation of f as a linear combination of basis function (B-splines) $f(z) = \sum_{t=1}^{m} \alpha_t \beta_t(z)$, where $\beta_t(z)$ are B-splines and the coefficient of α_t are further defined to follow a second order Gaussian random walk smoothness priors

$$\alpha_2 = 2\alpha_{j-1} - \alpha_{j-2} + \epsilon_1$$

with *i.i.d.* errors $\epsilon_1 \sim N(0, \tau^2)$. The variance τ^2 controls the smoothness of *f*. Assigning a weakly informative inverse Gamma prior $\tau^2 \sim IG(\boldsymbol{\epsilon}, \boldsymbol{\epsilon})$, with $\boldsymbol{\epsilon}$ very small , it is estimated jointly with the basis function coefficients.

Random effects (b_{gi}) were modelled by assuming exchangeable normal priors, $b_{ij} \sim N(0, \tau_b^2)$, where τ_b^2 is a variance component that incorporates over-dispersion and heterogeneity. For the spatial effects $f_{spat}(s)$, we chose a Gaussian Markov random field prior, which is commonly used in spatial statistics (Beag, York and Mollie, 1991), given as

$$\left[\boldsymbol{f_{spat}(s)}|\boldsymbol{f_{spat}(t)};\boldsymbol{t} \neq \boldsymbol{s},\boldsymbol{\tau^2}\right]\sim\boldsymbol{N}\left(\sum_{\boldsymbol{t}\in\boldsymbol{\partial_s}}\frac{\boldsymbol{f_{spat}(t)}}{\boldsymbol{N_s}},\frac{\boldsymbol{\tau^2}}{\boldsymbol{N_s}}\right)$$

where $\boldsymbol{N_s}$ is the number of adjacent sites and $\boldsymbol{t} \in \boldsymbol{\partial_s}$ denotes that site t is a neighbour of site s. The prior defines areas as neighbours if they share a common boundary and neighbouring areas are assumed to have similar patterns. The conditional mean of $f_{spat}(s)$ is an average function of evaluations $f_{spat}(t)$ of neighbouring sites t, with τ^2 controlling the amount of spatial smoothness. In order to be able to estimate the smoothing parameters for non-linear and spatial effects, highly dispersed but proper hyper-priors are assigned to them. Hence, for all variance components, an inverse gamma distribution with hyper-parameters *a* and *b* is chosen e.g. $\tau^2 \sim IG(\boldsymbol{a},\boldsymbol{b})$**.** Standard choices for the hyper parameters are *a=1* and *b=0.005* or *a=b=0.001.*

Evaluation of the posterior distribution of the model parameters was based on Empirical Bayesian inference. This used a restricted maximum likelihood proposal which adopts a generalized mixed methodology approach (Kneib and Fahrmeir, 2007). Detailed numerical methods of implementing survival time models are described in the reference manuals of BayesX (Fahrmeir and Tutz,2001; Belitz et al., 2009;). Model diagnostics were based on the Akaike Information Criterion (AIC) and the Bayesian Information criteria (BIC). The best model is the one with the smallest AIC or BIC. AIC and BIC regulate the trade-off between the goodness of fit of the model and the complexity by imposing a penalty discourages overfitting (increasing the number of free parameters in the data-generating process). All analyses were carried out in BayesX , a software for Bayesian inference in Structured Additive Regression models – version 2.0.1 (Berlitz et al., 2009).

6.3 Results of the analysis of the timing of sexual debut.

6.3.1Background characteristics of the sample

The background characteristics of the sample after data restructuring are presented in Table 8.

Table 8: Sample Characteristics of women (N=82795)

Variable	N	Percentage
Age-group		
15-19	18175	22
20-24	15970	19.3
25-29	13350	16.1
30-34	12150	14.7
35-39	9325	11.3
40-44	8025	9.7
45-49	5800	7
Period		
2000	33775	40.8
2006/7	49020	59.2
Cohort		
1950-1964	15100	18.3
1965-1974	21770	26.3
1975-1984	29575	35.7
1985-1992	16350	19.7
Region		
Zambezi	4860	5.9
Erongo	5985	7.2
Hardap	5220	6.3
!Karas	4890	5.9
Kavango(East and West)	7525	9.1
Khomas	7730	9.3
Kunene	8105	9.8
Ohangwena	4660	5.6
Omaheke	5420	6.5
Omusati	6905	8.3
Oshana	7920	9.6
Oshikoto	7010	8.5
Otjozonjupa	6565	7.9
Place of Residence		
Rural	45260	54.7
Urban	37537	45.3
Level of education		
Primary or No Formal	31795	38.4
Secondary or Higher	51000	61.6
Religion		
Protestant	61985	74.9
Catholic	18835	22.8
No religion	1150	1.4
Other	475	0.6
Missing	350	0.4
Wealth Index		
Poor	14490	17.5
Poorer	14515	17.5
Middle	17425	21
Richer	18640	22.5
Richest	14910	18
Missing	2815	3.4

Six hazard models were explored to establish the effect of observed and unobserved heterogeneity on the timing of sexual debut in Namibia. The fitted models were defined as follows:

Model 1: $\eta_1 = f(baseline)$

Model 2: $\eta_2 = f(baseline) + trend$

Model 3: $\eta_3 = f(baseline) + trend + fixed\ (cat) + fixed(Region)$

Model 4a: $\eta_4 = f(baseline) + trend + fixed + nonlinear + random\ (Region)$

Model 4b: $\eta_4 = f(baseline) + trend + fixed + nonlinear + spatial(Region)$

Model 5: $\eta_5 = f(baseline) + trend + fixed + nonlinear + random(Reg) + spatial(Region)$

The nesting structure of the models is summarized in Table 9. The symbol (x) indicates that the component was included in the model.

Table 9: Nesting structure of models 1 to 5.

Model specification	Baseline $g_0(t)$	Time t	Fixed effect V_j	Non-linear effect	Random effect	Spatial effect
1	X					
2	X	X				
3	X	X	X			
4a	X	X	X	X	X	
4b	X	X	X	X		X
5	X	X	X	X	X	X

Table 10 shows the model diagnostic statistics for all the fitted models. Model 5 had the smallest AIC and BIC was therefore chosen as the best model and was considered for further discussion.

Table 10: model diagnostic statistics

Model specification	-2 Log-Likelihood	df	AIC	BIC
1	68530.1	9.41	68548.9	68635.8
2	68527.1	10.4	68547.9	68643.9
3	65068.6	31.71	65132	65423.7
4a	64672.8	30.86	64734.6	65018.4
4b	64668.7	32.28	64733.2	65030.2
5*	64671.1	30.52	64732.1	65012.9

*Best model

6.3.2Trend and Fixed Effects

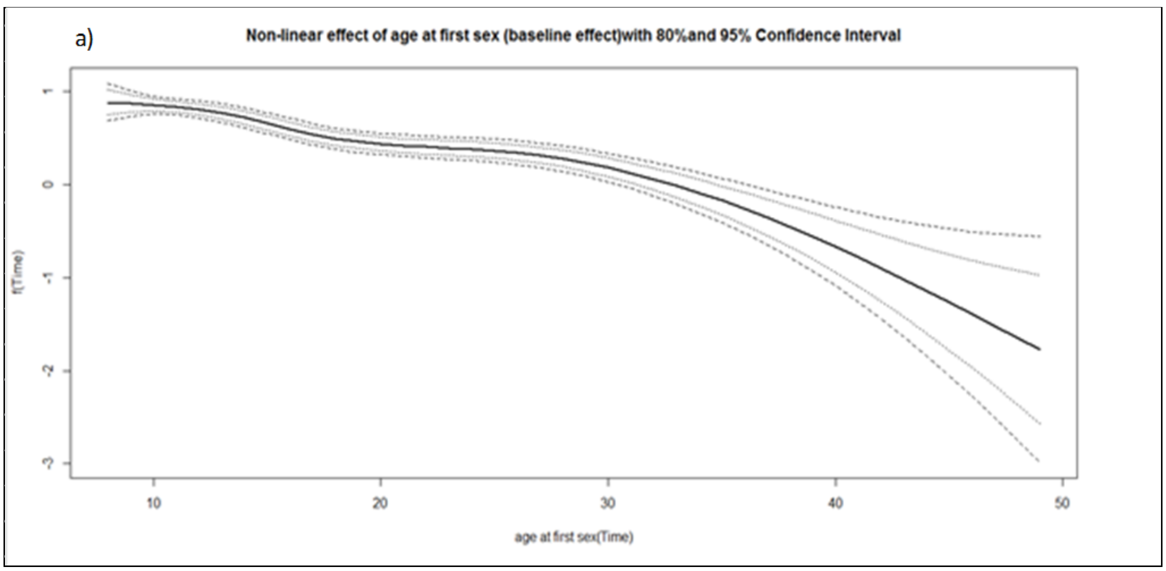
Table 11 displays the estimates of posterior modes of the fixed effect parameters for the baseline and the best model (Model 5). Presented are the posterior modes, standard deviations and 95% confidence intervals. Results indicate that compared to 2000, there has been an increase in the relative risk in sexual debut. Compared to women in rural areas, urban women are at higher risk of early sexual debut even though the differentials were not significant. With regard to the highest educational level of the woman, an insignificant higher risk of early sexual debut was observed for those women with secondary or higher education compared to those with primary or no formal education. Compared to the poor women, women in the middle, and those in the rich wealth index categories also had an insignificantly higher risk of early sexual debut. Religion did not seem to impact on sexual debut. Even though Catholic women were at a higher risk of early sexual debut compared to their protestant counterparts, the differentials were not significant.

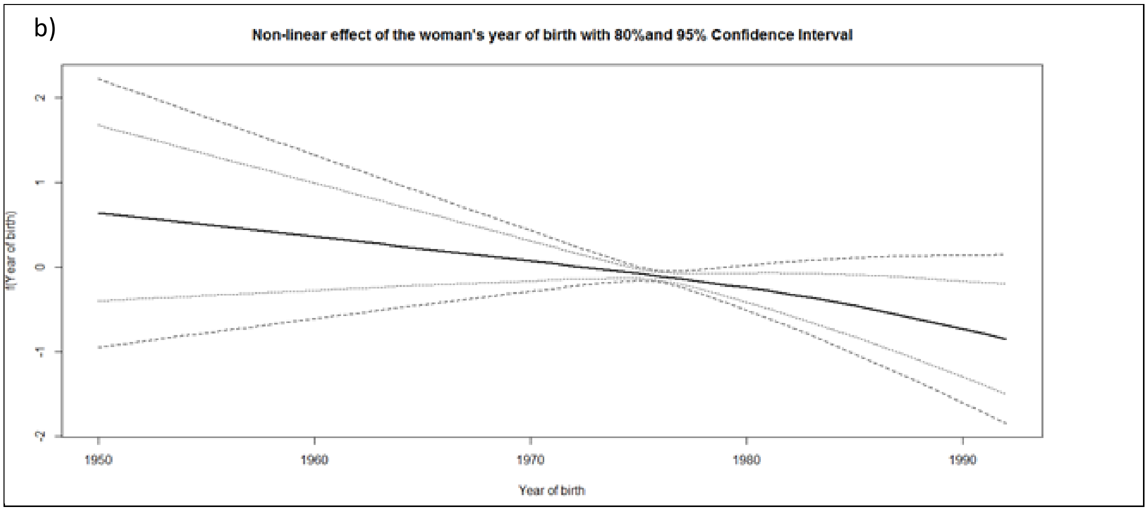
Table 11: Estimates of posterior modes of the fixed effect parameters for the baseline and the best model

Variable	Results for Model 1				Results for model 5 (best			
	Posterior Mode	SD	95% Confidence interval		Mean	SD	95% Credible interval	
Constant	-2.037*	0.1	-2.226*	-1.85	-2.197*	0.14	-2.463	-1.931
Period								
2000 (ref)					0			
2006/7					0.195	0.2	-0.187	0.577
Place of Residence								
Rural (ref)					0			
Urban					0.00029	0.03	-0.049	0.054
Level of education								
Primary or No Formal (ref)					0			
Secondary or Higher					0.0006	0.02	-0.053	0.041
Wealth Index								
Poor(ref)					0			
Middle					0.0242	0.03	-0.034	0.062
Rich					0.012	0.03	-0.052	0.076
Religion								
Protestant (ref)					0			
Catholic					0.0145	0.02	-0.033	0.062

6.3.3Baseline and non-linear effects

Figure 9 (a-c) displays the estimated posterior modes together with their corresponding 95% confidence bands for the non-linear effects of time to first sex (baseline effect); respondent’s year of birth (cohort effect); and respondent’s age (age effect). The baseline effect exhibited the same pattern for all the explored models. From as early as the age of 8, the risk of sexual debut is high until the age of around 30 years, where it begins to drop, first slowly until age 40, after which it deeps down sharply. Beyond age forty, as expected, a lower risk is observed since most women will have experienced the event by this period. From the plots, it is evident that the effects of the respondent's cohort effect and the respondent's age were non –linear, thus an assumption of linear effect would have given misleading results and interpretations. The results also indicate a cohort shift such that the hazard of early sexual debut is reduced as the as the woman's year of birth increases, suggesting a generational effect. The hazard of sexual debut initially increases steeply from age 15 and peaks at about age 21. Thereafter, the risk of sexual debut steadily declines with the respondent's age.





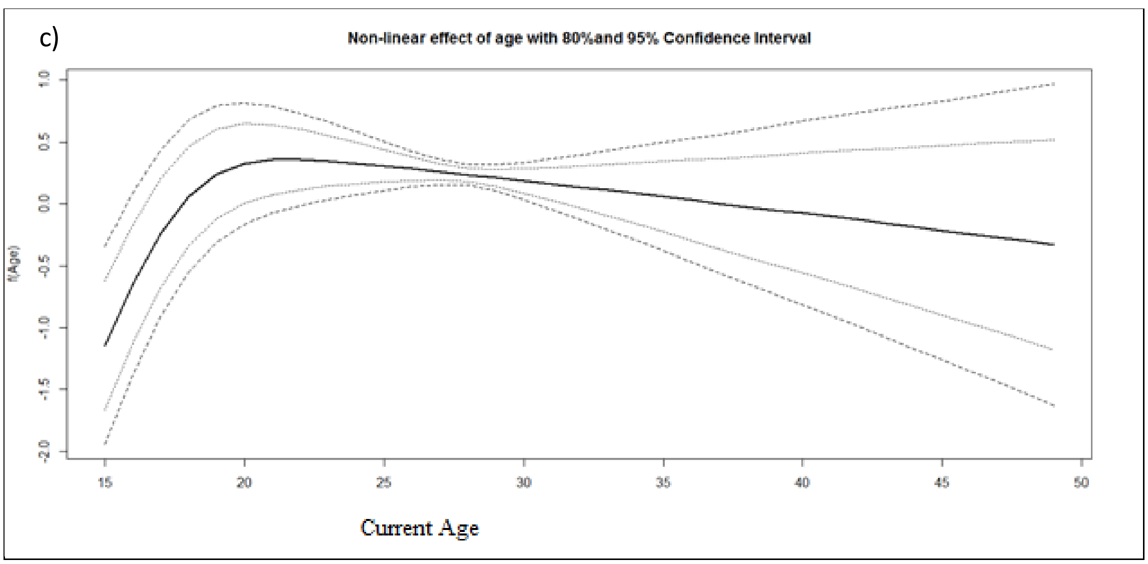


Figure 9: Estimated posterior modes and corresponding 95% confidence bands for the non-linear effects of time to first sex (baseline effect); respondent's year of birth (cohort effect); and respondent's age (age effect)

6.3.4Spatial effects

The spatial effects of model 5 (the best model) are shown in **Figure 10**. The first two maps show the location of the 80% and 95% confidence intervals while the third map displays the posterior modes. The confidence intervals are used to assess the significance of the spatial effect. In this analysis, regions with white colour are significantly associated with higher risk of first sex (i.e. the 80%/95% confidence interval lies on the positive side.); regions with black colour are significantly associated with lower risk (the 80%/ 95% confidence interval lies on the negative side), while the risk is not significant in regions with grey colour (the 80%/95% confidence interval includes zero).

The 80% confidence interval suggest that the North Eastern part of Namibia (Kavango and Zambezi regions)are associated with a high risk of early sexual debut, while those in Omusati and Oshana regions are associated with low risk. The risk of early first sex is not significant in the rest of the regions.

The 95% confidence intervals suggest that only the Zambezi region associated with a high risk of early sexual debut, while the risk of early first sex is insignificant in all other regions.

Figure 10, showing the posterior modes also indicates that the North Eastern regions, followed by the central regions of Namibia are associated with a higher risk of early sexual debut. It is interesting to observe that the Southern regions and the North Western regions are associated with a relatively lower risk of early sexual debut.

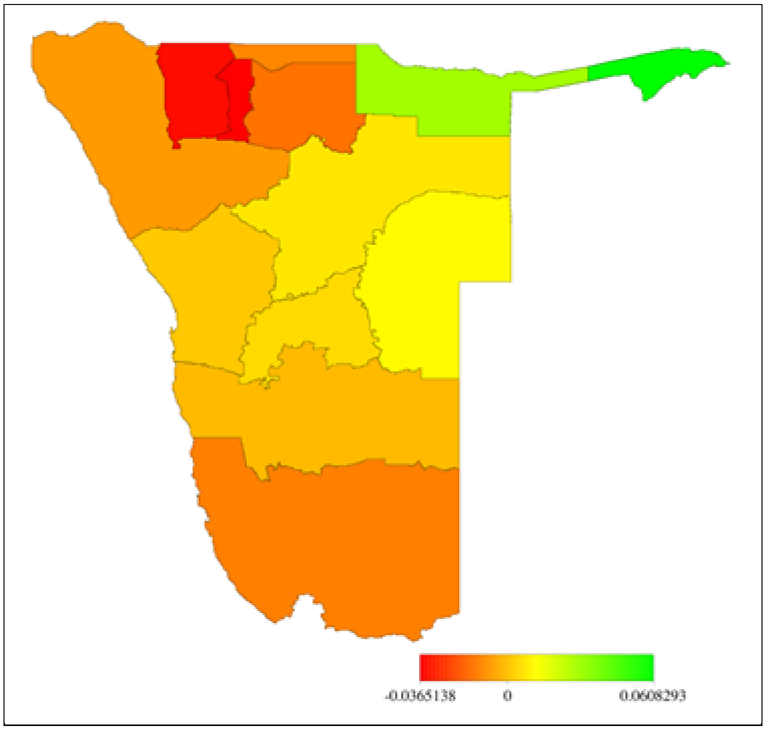


Figure 10: Non-linear spatial effects for age at first sex. Shown are log hazard plotted at regional level.

Figure 11: Significance maps of spatial effects for estimates in Figure 9: (a) 80% credible interval; and (b) 95%of confidence interval

6.2 Results of the analysis of the timing of first marriage

The background characteristics of the sample after restructuring the data are presented in Table 12.

Table 12: Sample Characteristics of women (N=82795)

Variable	N	Percentage
Age-group		
15-19	18175	22
20-24	15970	19.3
25-29	13350	16.1
30-34	12150	14.7
35-39	9325	11.3
40-44	8025	9.7
45-49	5800	7
Period		
2000	33775	40.8
2006/7	49020	59.2
Cohort		
1950-1964	15100	18.3
1965-1974	21770	26.3
1975-1984	29575	35.7
1985-1992	16350	19.7
Region		
Zambezi	4860	5.9
Erongo	5985	7.2
Hardap	5220	6.3
!Karas	4890	5.9
Kavango(East and West)	7525	9.1
Khomas	7730	9.3
Kunene	8105	9.8
Ohangwena	4660	5.6
Omaheke	5420	6.5
Omusati	6905	8.3
Oshana	7920	9.6
Oshikoto	7010	8.5
Otjozondjupa	6565	7.9
Place of Residence		
Rural	45260	54.7
Urban	37537	45.3
Level of education		
Primary or No Formal	31795	38.4
Secondary or Higher	51000	61.6
Religion		
Protestant	61985	74.9
Catholic	18835	22.8
No religion	1150	1.4
Other	475	0.6
Missing	350	0.4
Wealth Index		
Poor	14490	17.5
Poorer	14515	17.5
Middle	17425	21
Richer	18640	22.5
Richest	14910	18
Missing	2815	3.4

Age group composition was a s follows: 15-19 (22.5%), 20-24 (19.1%), 25-29 (15.9%), 30-34 (14.5%), 35-39 (11.0%), 40-44 (9.7%), and 45-49 (7.3%). More than half of the women resided in rural areas (55.1%). The distribution of the women's highest educational level was 7.9% no formal education, 26.7% primary education, 59.7% secondary education, and 5.7% higher education. The wealth index income quintiles comprised of the poorest (16.3%), poorer (17.9%), middle (22.7%), richer (25.0%) and richest (18.2%). The main languages spoken at home by the women were Afrikaans (9.2%), Damara/Nama (15.1%), Herero (8.1%), Caprivi and Kavango (11.4%), Oshiwambo (45.7%), English and other languages (10.5%).

Figure 12 is a histogram showing the distribution of age at first marriage. The mean age at first marriage was 22.6 years with a standard deviation of 6.1 years.

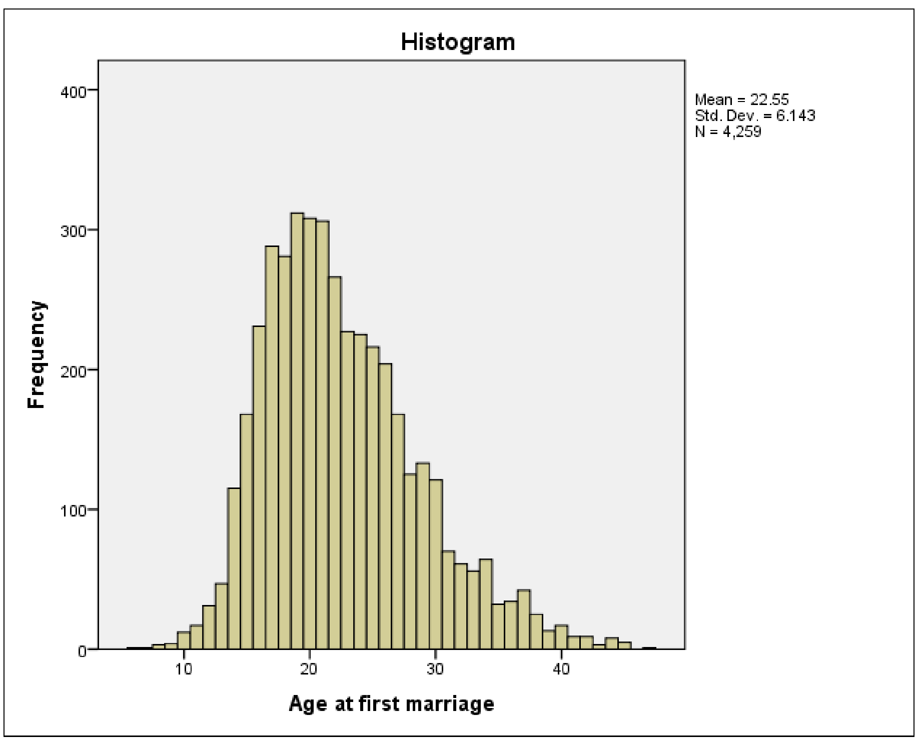


Figure 12: Histogram of age at first marriage

Figure 13 shows the survival function by age group. The function suggests that the probability of first marriage differs by age group

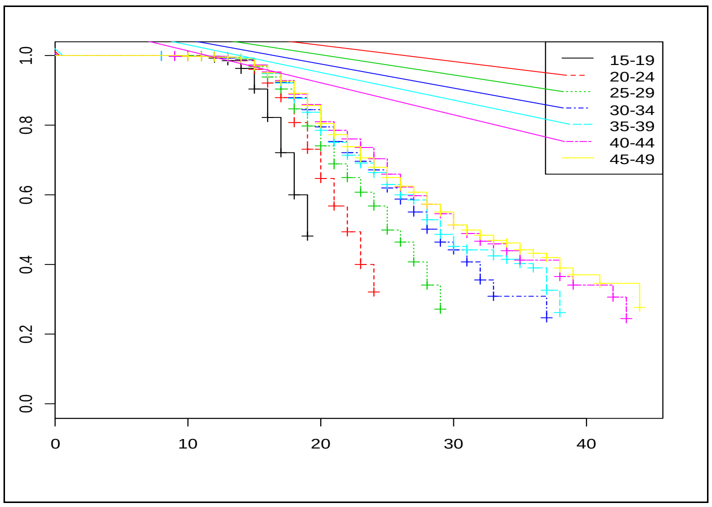


Figure 13: Survival function by age group

Figure 14 shows the survival function by highest educational level. Again the function also suggests that the probability of first marriage seems to differ by the educational level of the woman.

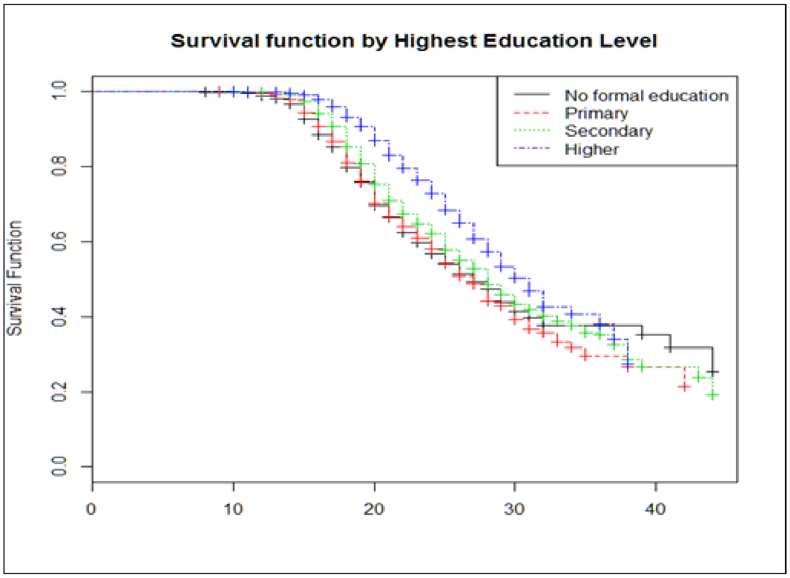


Figure 14: Survival function by Highest Educational level

Six hazard models were explored to investigate the effect of observed and unobserved heterogeneity on the timing of first marriage in Namibia. The fitted models were defined as follows:

Model 1: $\eta_1 = f(baseline)$

Model 2: $\eta_2 = f(baseline) + trend$

Model 3: $\eta_3 = f(baseline) + trend + fixed\ (cat) + fixed(Region)$

Model 4a: $\eta_4 = f(baseline) + trend + fixed + nonlinear + random\ (Region)$

Model 4b: $\eta_4 = f(baseline) + trend + fixed + nonlinear + spatial(Region)$

Model 5: $\eta_5 = f(baseline) + trend + fixed + nonlinear + random(Reg) + spatial(Region)$

The nesting structure of the models is summarized in Table 13.

Table 13: Nesting structure of models 1 to 5.

Model specification	**Baseline** $g_0(t)$	**Time** t	**Fixed effect** V_j	**Non-linear effect**	**Random effect**	**Spatial effect**
1	X					
2	X	X				
3	X	X	X			
4a	X	X	X	X	X	
4b	X	X	X	X		X
5	X	X	X	X	X	X

Table 14 shows the model comparison statistics for all the fitted models. Model 3 had the smallest AIC and BIC was therefore chosen as the best model and was considered for discussion.

Table 14: Model comparison statistics

Model specification	**-2 Log-Likelihood**	**df**	**AIC**	**BIC**
1	38095.6	11.26	38118.2	38214.4
2	38095.6	13.26	38122.2	38235.5
3*	**36564.6**	**43.18**	**36650.8**	**37018**
4a	36564.4	48.01	36660.4	37068.8
4b	36564.4	47.37	36659.1	37062
5	36564.4	48.22	36660.8	37071

*Best model

6.4.1Results of Cox Regression based on the best model

Table 15 displays the Cox regression results.

Table 15: Cox Regression estimates under the best model

Variable	Hazard Ratio	95% Confidence interval	
Age			
15-19	7.205***	5.633	9.218
20-24	3.528***	2.921	4.26
25-29	2.093***	1.788	2.45
30-34	1.520***	1.326	1.742
35-39	1.235***	1.107	1.377
40-44	1.151**	1.051	1.259
45-49 (Ref)	1.000		
Period			
2000	1.143***	1.073	1.218
2006	1.074*	1.002	1.152
2007(ref)	1.000		
Cohort			
1950-1964	0.578***	0.457	0.73
1965-1974	0.612***	0.504	0.743
1975-1984	0.707***	0.605	0.828
1985-1992 (ref)	1.000		
Place of residence			
Rural	0.869***	0.817	0.923
Urban(ref)			
Educational level			
No Formal (ref)	1.354***	1.195	1.534
Primary	1.252**	1.121	1.398
Secondary	1.086	0.979	1.205
Higher	1.000		
Wealth Index			
Poorest	0.888*	0.795	0.992
Poorer	0.845**	0.765	0.934
Middle	0.877**	0.807	0.954
Richer	0.921*	0.855	0.993
Richest (ref)	1.000		
Religion			
Catholic	1.049	0.992	1.109
Protestant (ref)	1.000		
Region			
Zambezi	1.133*	1.003	1.28
Erongo	0.944	0.847	1.052
Hardap	0.9	0.8	1.013
Karas	0.856*	0.76	0.964
Kavango	1.022	0.92	1.136
Khomas	0.912	0.821	1.014
Kunene	0.975	0.859	1.107
Ohangwena	1.117	0.992	1.258
Omaheke	0.938	0.831	1.059
Omusati	0.728***	0.632	0.838
Oshana	0.800***	0.711	0.9
Oshikoto	0.765***	0.678	0.864
Otjozondjupa (ref)	1.000		

*****p<0.001, **p<0.01, * p<0.05**

Compared to women in the 45-49 age group, there was a significantly higher risk of first marriage among those women in the younger age groups namely 15-19 (HR=7.205), 20-24 (HR=3.528), 25-29 (HR=2.093), 30-34 (HR=1.520), 35-39(HR=1.235), 40=44(HR=1.151). The risk of first marriage decreased as the age of the woman decreased. With regard to period, the risk of first marriage was higher in 2000 (HR=1.143), and reduced in 2006 (HR=1.074) compared to 2007. There were significant differences in the timing of first marriage between birth cohorts. Women born in the cohorts 1950 -1964 (HR=0.578), 1965-1974 (HR=0.612), and the 1975-1984 (HR=0.707) had lower risk of first marriage compared to their counterparts in the 1985-1992 cohort.

With regard to the highest educational level of the woman, risk of early first marriage was significantly higher among those women with no formal education (HR=1.354) and those with primary education (HR=1.252) compared to those with higher education. However, there were no significant differentials in the timing of first marriage between women with secondary education and those with higher education (p=0.120). Compared to the richest women, richer women (HR=0.921), women in the middle socio-economic quintile (HR=0.877) , the poorer (HR=0.845) and the poorest women (HR=0.888) had relatively lower risk of first marriage. There were no significant differentials in the timing of first marriage with respect to religion (p=0.091).

With regard to region, women in the Oshikoto region (HR=0.765), Oshana region (HR=0.800) and Omusati region (HR=0.728) had relatively lower risk of early first marriage compared to those in the Otjozondjupa region. However, women from the Zambezi region (HR=1.133) had significantly higher risk of early first marriage compared to their counterparts in the Otjozondjupa region. Compared to women in urban areas, rural women (HR=0.869) were at a significantly lower risk of early first marriage.

6.5 Discussion

6.5.1The timing of sexual debut

This paper employed a structural additive regression model for discrete time-to-event outcome, a procedure which allows simultaneous modelling of fixed, non-linear, unobserved heterogeneity and spatial effect within a single framework, to examine age, period and cohort effects on the timing of first sex among women in Namibia.

From as early as the age of 8, the risk of sexual debut peaked at 21 years of age and was still high until the age of around 30 years, and then dropped until age 40, after which it dipped down sharply. In South Africa, Bakilana (2005) established that the peak of the rate of entry into sexual relations occurred at age 18 and that virtually all the women had had their sexual debut by age 23. In contrast, younger age was strongly related to earlier age at first sex in Spain (de Sanjose et al., 2008). Even though the age at first sex increase between 2000 and 2006/7, the period effect was not significant. Zaba et al. (2004) also established a slow rise in the age at first sex in six African countries. For Namibia, a clear pattern may emerge as more survey data becomes available.

Results also indicated a cohort shift with the hazard of early sexual debut being reduced as the woman's year of birth increased. Similar results were obtained in Tanzania (Zaba et al., 2009) and Uganda (Slaymaker et al., 2009) , where women who were born after 1970, on average, had their sexual debut at a later age than those born earlier. On the other hand, younger cohorts of women in South Africa were entering into sexual relations at earlier ages than older women (Bakilana, 2005). However, the age at sexual debut did not differ by birth cohort in Northern Malawi (Glynn et al, 2010). The reduction in the risk of first sex as the year of birth increased in Namibia could be explained by generational differentials brought about by urbanization, dynamism of culture, values and norms and weakening traditional frameworks (Harding and Jencks ,2003; Gayaman and Adebayo, 2013).

The non-linear association exhibited by the age at first sex and the continuous covariates clearly indicates that an assumption of linear association of these continuous variables would have led to misleading results, and these could have adverse effects on policy recommendations. The structured additive regression model enabled the specification of the predictor structure in a more flexible manner so that all relationships could be appropriately estimated.

Results of spatial analysis revealed that age at first sex varied though not significantly, according to region, with women from the Zambezi and Kavango regions exhibiting higher risk of early sexual debut compared to all other regions. Elendou-Enyegue and Magazi (2011) found teenage pregnancy to be relatively high (34%) among the 15 to 19 year olds in Kavango region, which suggests high prevalence of unprotected, early sexual debut. The authors established that very little of the fertility was wanted, and most of the teens in the area wished to delay first birth and even desired fewer children. It may be necessary in further research to assess whether these adolescent sexual activities leading to such high pregnancy rates are not coerced as established by Muharaj and Munthree (2007) in KwaZulu Natal, South Africa, and Uganda (Koenig, et al.,2004) so that appropriate intervention policy can be developed for policy.

6.5.2The timing of first marriage

Regression results indicated that there was a significantly higher risk of first marriage among those women in the younger age groups compared to those in the 45-49 age group. This is expected since most first marriages occur in the twenties to early thirties and by age forty most of those wishing to marry will have already done so. With regard to period, the risk of first marriage was higher in 2000 and decreased in 2006 compared to 2007. This reduction in the risk of first marriage could be attributed to the general decline in marriage rates over the years due to increasing cohabitation and singlehood (Copen et al., 2012). There were significant differences in the timing of first marriage between birth cohorts. Women born in the 1950 -1974 cohorts had lower risk of first marriage compared to their counterparts in the 1985-1992 cohort. This is somehow surprising as results from other studies suggest that women born in the older cohorts had higher risk of early first marriage (Aryal,2007).

With regard to the highest educational level of the woman, risk of early first marriage was significantly higher among those women with no formal education (HR=1.354) and those with primary education (HR=1.252) compared to those with higher education. However, there were no significant differentials in the timing of first marriage between women with secondary education and those with higher education (p=0.120). These findings are in line with results from other parts of the world (Agaba, Atuhaire, and Rutaremwa, 2011;Kamchulesi, Palamuleni, and Kalule-Sabiti, 2011;Hymowitz et al., 2013; Haloi and Limbu, 2013; Hoq,2013)

Compared rich women, poor women had relatively lower risk of first marriage. These findings seem to suggest that in Namibia, women's riches may attract male marriage partners. Studies elsewhere suggest the opposite, with poor women having a relatively higher risk of first marriage (Haloi and Limbu, 2013; Saviram, Richard, and Rao, 1995; Hoq,2013). There were no significant differentials in the timing of first marriage with respect to religion (p=0.091). This could be because Namibia has become a secular society causing vast dilution of the once so strong religions like the Roman Catholic and protestant religions. However, in some societies, religion still plays a significant role in the timing of first marriage (Okeibunor, 1999; Hoq, 2013; Kamchulesi, Palamuleni, and Kalule Sabiti, 2011; Agaba, Atuhaire, and Rutaremwa, 2011; Rahman, Islam, and Hossain, 2008).

With regard to region, women in the Oshikoto region (HR=0.765), Oshana region (HR=0.800) and Omusati region (HR=0.728) had relatively lower risk of early first marriage compared to those in the Otjozondjupa region. However, women from the Zambezi region (HR=1.133) had a significantly higher risk of early first marriage compared to their counterparts in the Otjozondjupa region. Regional differentials in other countries (Adewole, et al, 2012, Rokonuzzaman and Chowdry, 2013; Pande, 2004).The regional differences in the timing of first marriage in Namibia could be due to different levels of economic development, clustering of regional ethnic groupings and varying levels of access to information which influences marital decision making. Compared to women in urban areas, rural women (HR=0.869) were at a significantly lower risk of early first marriage. These findings are unexpected as similar studies elsewhere suggest otherwise (Hoq, 2013; Sivaram et al., 1995; Agaba, Atuhaire, and Rutaremwa, 2011, Adir, 2007).

6.6 Summary

Age, period and cohort effects in the timing of first sex were evident among women in Namibia. Efforts to discourage early sexual debut should be stepped up especially in North-Eastern Namibia. Intervention strategies should not only target schools and the wider community in isolation, but should involve the individual family units as they have a bigger role to play in this regard (Huschek et al., 2010).

The effects of age, period and cohort in the timing of first marriage were not significant among women in Namibia. Marriage timing among women was influenced by rural urban place of residence, highest educational level, socio-economic status and region.

Efforts to discourage early marriage should be stepped up especially in the Zambezi region.

CHAPTER 7

A QUALITATIVE EVALUATION OF NAMIBIAN WOMEN'S PERCEPTIONS REGARDING FAMILY FORMATION PROCESSES

7.1 Introduction

A qualitative study was conducted to construct supplementary in-depth understanding of women's feelings and attitudes towards family formation processes in Namibia. This information was reconciled with quantitative findings from statistical models for the determinants of the timing of sexual debut and first marriage (Bayesian structured additive discrete time-to-event history models), correlates of marital patterns and trends (trend analysis and multinomial logistic regression models), and factors influencing non-marital fertility (Hurdle Negative Binomial Regression Models) in Namibia.

7.2 Methods

In the qualitative design, an interview guide was developed for focus group discussions to gain in-depth understanding on perceptions of Namibian women with regard to matters of marriage, divorce, cohabiting, polygamy, sex before and outside marriage. The target population was women of marriageable age who were in the fertility age-group in Namibia at the time of the survey. With regard to in-depth interviews and focus group discussions, the key informants targeted included among others, social sector heads/ workers, marriage counselors and officers, other community leaders and health workers. Focus group discussions were conducted to construct additional or supplementary information for a better understanding of women's feelings and attitudes towards marriage, divorce, and non-marital fertility until saturation is reached. The data from these focus group discussions was supplementary to the survey data to further support or clarify statistical results. The group discussions were held in both urban and rural settings. Each focus group discussion was small, consisting of about 6 to 9 participants to allow full participation of all discussants and was selected using purposive sampling so that in-depth information that supports or substantiates findings would be gathered from individuals believed to be knowledgeable about the subject (Pathfinder International, 2006).

In this qualitative approach, a semi-structured group interview format was adopted for focus group discussions to ensure that the same subject or scope was maintained in each group. The questionnaires were translated into six local languages namely Afrikaans, Damara/Nama, Oshiwambo, Otjiherero, Kavango and Silozi. Focus group discussions were conducted in Oshana, Otjizondjupa, Zambezi, Kavango West, Omaheke, !Karas, Kunene, and Khomas regions of Namibia. The research instruments were piloted in Khomas region. The questionnaires were pretested in both urban and rural areas and the results of the pilot survey were used to modify the research instruments as necessary. The focus group discussions were professionally administered to allow space for exploration of any emerging issues not already catered for. The proceedings of the discussions were captured by audio tape, which was later transcribed and translated into English where necessary. These tapes were sufficiently reviewed to capture all sentiments and to come up with verbatim transcriptions in which other psycho-social indicators (e.g. anger, discomfort, enthusiasm, silence, and anxiety) could also be captured. These findings were then organized and summarized according to themes, to illustrate different beliefs, myths, attitudes and emotions related to the quantitative data (Indongo & Naidoo, 2008; Green, Mukuria, & Rubin, 2009).

Analysis of the qualitative data was based on framework analysis and consisted of 5 key stages namely identifying a thematic framework, indexing, charting, mapping and interpretation. This was achieved through examining, categorizing, categorizing or combining the evidence and getting rid of redundant extra and irrelevant information, by carefully filtering through the maze of the large and complicated path of information (Rabiee, 2004).

A letter of introduction was developed for potential participants in focus group discussions, introducing them to the researcher, objectives and significance of the study. Respondents were free to accept or decline to participate in this study, and for those who would have initially accepted, it was made known to them that they were free to drop out at any point during the process if they no longer wished to continue. Informed consent was sought from respondents and anonymity and confidentiality was guaranteed. Access to recorded information from the discussions was monitored and the records were kept confidential. Findings and recommendations from the study were communicated to the community through various appropriate publications and feedback workshops.

7.3 Results

7.3.1 Views regarding marriage

Generally most women agreed that married was a good idea so that people could build families. They felt that that family formation was especially good under marriage umbrella. Some women reported that people usually form families with people they love and sometimes according to situations they find themselves in. Other women felt that it could be a problem when one did not know how best to form the family. The general feeling across all regions was that family formation was a very important, yet difficult step in life, to decide when, and who to marry, or even how many children to have. These were some of their statements:

"I believe that before a family is formed, marriage should come first" – Oshana region, Young Woman, Rural.

"Marriage is good because it keeps the family intact" Omaheke Region, Urban, Older woman

"It is normal, ok and great. Everybody needs and deserves someone to spend their entire life with."- Omaheke Region , Urban, Young woman

"It is a good thing, you are fully responsible for your husband, children and family and all your children are from the same father."- Omaheke Region, Rural, Older woman

These statements seem to suggest that the women felt the need for family intactness, companionship, and a binding fabric of moral values.

There were varying responses when it came to the ideal age for a woman to get married. The suggested ages ranged from 25 to 35 years of age. They felt that after 25 years of age, the woman is likely to be done with schooling, she is mature, she is above the legal age of marriage, her mind is clear, she can make rational decisions, and others felt that a woman needs to enjoy herself before she gets married. The responses were presented according to the following emerging themes summarized in Table 16.

Table 16: Women's perception about the ideal age at first marriage

Maturity	*"if you marry when you are too young, you encounter problems because of lack of experience and you suffer financially" – Zambezi Region, rural, older women*
	"After the age of 25, a woman is mature enough to decide whom to marry" –Kunene Region, rural, older women.
Health	*"Between 25 and 35 so that she will be mature enough to handle the challenges and young enough to still be able to reproduce without health complications"- Oshana Region, Old woman, Urban*
Experience	*that "young wives fight with their husbands a lot because they are not mature enough to resolve certain disputes and at times they will not enjoy settling in marriage because they still want to enjoy the life of teenagers" –Zambezi Region, rural, girl.*

It also emerged that if the husband abuses drugs and alcohol the young wife can be beaten for not cooking, cheating and other accusations. Some women felt that it is only after 30 that a woman will understand many things about life, having the experience of dating, love, and how to take care of kids.

Young and older women in !Karas region reported that was no culture of early marriages in their region. However, the culture of early marriage still happened usually in rural as some parents are still traditional especially in some parts of the Kavango, Zambezi, Otjozondjupa and Kunene regions. In the Kunene region, the prevalence of early marriages was much lower than before. Traces of early marriages were reported in Zambezi region as suggested by the following statement,

"when a child is being born, in a certain family, another family would put a sign or mark on that child, which would symbolize that the child was going to get married in that family when she was grown up. Sometimes the pre-chosen husband did not appeal to the girl as he was usually way much older which led to problems of unhappiness and even suicide"- *Older woman, rural, Zambezi region*.

At times the girls would be taken to their husbands at very tender ages leading to early motherhood, school drop outs and forfeited future life opportunities. The women expressed concern about early marriages as some women put it:

"The government must come up with legislation to further protect girls from early marriages which sometimes occur even at the age of 4 years or younger. Government must impose regulations to allow girls to complete their secondary education before getting married because early marriages can ruin the future of our children" – *Older woman, rural, Kunene Region*

"Government should protect girls from early marriage because it destroys their future" – *Oshana Region, Old woman, Urban.* However other women reported that government had already started to intervene and early marriage practices were almost a thing of the past.

7.3.2 Forms of marital union in Namibia

All forms of marital unions were reported namely, the married (through church, magistrate's court, customary), cohabiting, never married, divorced, and widowed. The most common forms of marital union in the !Karas region was cohabiting while some women were married at church, at the magistrates court, traditional marriages but there were no polygamous unions. In the Kunene region polygamy was the most common marital union. In Khomas, Otjozondjupa, and Kavango there were various forms even though the majority were mostly cohabiting unions.

Polygamous unions

Women in the !Karas and Khomas region reported that their regions did not have polygamous unions. However, traces of polygamy were reported in the Oshana, Kavango West, Otjozondjupa and Zambezi regions. Factors contributing to polygamous unions were summarized according to the emerging themes summarized Table 17.

Table 17: Factors promoting polygamous unions

Factor	Suggestive Statements
Poverty	*"Our community has very few polygamous unions, only by rich businessmen or very traditional men. Women turn to polygamous unions for security" – Oshana Region, Older woman, rural.*
	"Especially if there is a rich man in the community, a lot of women want to be married to him for good living and men still have that pride of saying he can marry any woman he likes". Zambezi Region, rural, Older woman
Gender Issues	*Division of labour e.g. milking cows, washing clothes, and sometimes if a man has a lot of cattle, they have to marry many wives so that they can manage many cattle posts, Older woman Kunene Region*
Culture/ Tradition	*"Men can marry more than one wife and there are no restrictions, they can marry as many women as they want to." Kunene Region –rural, Older woman.*
Infidelity	*"The men here have one wife in the house, and other women and children outside", !Karas Region, Young women*
Labour Source	*"if for example, one woman attends a funeral, the other women can satisfy him sexually and perhaps help him with the work at home" – Old women, Omaheke Region*
Infertility	*"Yes, many men marry more than one wife because the first wife is unable to give birth (infertility), that particular husband is forced to find another wife". Young woman, Zambezi region*

In the Kunene and Omaheke regions the polygamous unions were most common form of marital union. Interestingly, polygamy was also perceived as a symbol of status and as a tool to reduce HIV infection as one woman put it,

"But polygamous unions in a sense build a network of support for children and women and somehow reduce the risk of sexually transmitted diseases as cheating is limited especially if the wives of the one husband are a faithful team", Oshana Region, young woman, rural.

On the other hand, other risks of polygamous unions cited by the other women included the spread of sexually transmitted diseases (STI) and HIV/AIDS, jealous among the wives of one husband, which in some cases could lead to fighting, food poisoning, and witchcraft. The women reported that the benefits of polygamy were mainly for the man as there were no benefits at all cited for the women except for financial security in some cases. A big problem of polygamy raised by one of the women was stated as follows, *"since each wife will have a set of children born to her, once those children grow up, they will also become jealous of each other and they usually fight over the inheritance of their father's property", Zambezi Region, rural, Older woman.*

Cohabiting unions

Cohabiting unions were reported in all the regions investigated. Factors leading to cohabiting unions were summarized according to the themes summarized in Table 18.

Table 18: Factors promoting cohabiting unions

Factor	Suggestive Statement
Marriage costs	*Some men are unable to pay lobola, maybe because the parents/relatives of the girl are known to charge very heavily (expensive),*
Modernization /cultural erosion	*with changes in times and modernization among people especially the youth engages in cohabiting relationships*
Media	*Due to western habits in youth*
	modern time culture, media and the internet
Poverty	*"cohabitation exists because they are unable to afford expenses for example, if they are renting together they reduce their costs by dividing the expenses between themselves" – Zambezi Region Young woman*
	"Some women cohabit to share/reduce living expenses"- Older woman, Zambezi Region
"Trial "marriage	*"Preparing for marriage " - Older woman , Kunene Region*
	"Some men want to stay together first to assess whether the woman can do what he expects of a wife so that he can decide whether to go ahead and marry her - Young woman, Zambezi Region
Commitment/ Flexibility	*Men nowadays do not want to grow up and settle down - Older woman, Zambezi Region*
	Some women do not want long life commitment

The risks of cohabiting cited where that when there is no more love in the relationship and the other partner wants to leave the relationship, that's when domestic, gender-based violence and passion killings happen.

Widowhood

In all regions there were a considerable number of widows. Causes of death leading to widowhood for most women were mostly due to sickness and accidents. Widows in most of the regions were facing various challenges. Some of the challenges faced by Namibian widows are summarized in Table 19.

Table 19: Challenges faced by widows in Namibia

Challenges	Suggestive Statement
Property inheritance	*"Widows in our community face so many challenges. They don't inherit any property of their late husband. In our tradition, we have a culture of wife inheritance and sometimes an older woman can be inherited by a young man. This idea is not good because a man can accept to inherit a woman as per culture but may not like the woman". – Kunene Region , Old woman rural*
	Relatives of the deceased may be interested in the property left behind and they at times wrestle with the widow. Some widows are literally stripped off everything after the husband's death.
	"Widows are facing challenges especially when they were married in community of property, the husband's family always take all the property"- Oshana region, Old woman, Urban
Wife inheritance	*"Jealous can also arise between family members especially brothers. One brother might bewitch the other brother in order to inherit the widow together with all the riches left by the late brother. The widow usually has very little say in this. If the late husband left a will , and the family members realize that the deceased left the business in the wife's name, they will contest that the widow cannot and has no authority of running the business causing a lot of fighting and unrest." – Zambezi Region, Urban, Young woman*
	"In our tradition, we have a culture of wife inheritance and sometimes an older woman can be inherited by a young man. This idea is not good because a man can accept to inherit the woman as per culture but may not like the woman"-Older woman, Kunene Region
Poverty	*Younger widows have more financial challenges compared to their older counterparts because in most cases, they have no other sources of financial support if they were not working and their children are still very young and dependent.*
	"Yes widows are facing challenges especially those who were housewives are usually left in poverty as they cannot provide for themselves, and families of the deceased can come and take all the possessions" – Oshana Region, Young woman, Urban
	In terms of recognition in the community, some people still respected widows especially if they are rich, and they want some benefits from her.- Young Woman, Zambezi Region
Suspicion	*"being a widow is an unfortunate thing. People can laugh at you, talk a lot about you, and say things such as "she is the one who killed her husband to inherit the riches of the husband".*
	"In some cases some widows will be hated by married women who suspect that their husbands might consider having an affair with her." –Older woman, Zambezi Region
Remarriage options	*Younger widows who might still desire to remarry will find themselves in a very difficult position because they are still in-charge of their deceased husband's property of which the husband's family will not support that she gets married elsewhere again.*
	Women generally agreed that there was no problem with widows to remarry. One woman even suggested that someone should set up a widow dating site. However, if younger widows decided to remarry, it was very difficult to blend the children from the previous marriage with new remarriage setup. In some cases the new husband can mistreat or abuse the step children.
Stigma	*Some of the widows would also be having sickness challenges e.g. HIV and AIDS making it difficult for them to maintain high standard of living*

Never married women

In all regions investigated, there were women who had never married. Some of the reasons why they had decided not to marry are summarized in Table 20:

Table 20: Women's reasons for deciding not to marry

Reasons	Suggestive Statement
Promiscuity/ Infidelity	*They are either too unlucky in relationships or have been promiscuous that at the end nobody wants to marry them*
	"They have seen married men wanting to take other women and at the same time ill-treating their wives. The unmarried women are watching!"- !Karas region, Rural Young Woman
No Right match available	*They might not have found their perfect match or are too critical and self-conscious to try*
	Maybe they are still waiting for the right man who never comes
	"yes, there are women who never married, some were never proposed, while others choose a life of celibacy and others may not have found a suitable partner", Oshana Region, Young woman, Urban.
Independence	*Not interested in marriage*
	Some women want to be independent and to take full control of their lives
	They don't want to be tied down and to be told what to do in terms of submitting to a man
	Disappointments past experiences and they need their independence
Infertility	*Because maybe "they cannot bear children, cannot be a wife material, and men of this generation don't marry uneducated women, so women who are uneducated tend to lose hope of getting married" – Zambezi Region, Rural, Young Woman*
Abusive relationships	*They are scared of being hurt and divorced*
	They were broken hearted
	They cannot tolerate abusive relationships
	"They do not want marriage that will not last long , if they are able to look after themselves i.e. have enough money" – Karas region, Rural, Old woman
	They see fighting in married relationships
Absence of role models	*From observing the experience of married friends and relatives, they feel marriage makes a woman suffer and they would rather remain single*

Reasons for deciding never to marry included risks of spouse infidelity, absence of perfect match on the marriage market, no interest in marriage and independence, infertility fears, fear of abusive relationships, risks of being broken hearted, and lack of role models already in marriage to emulate. It was noted that even though a considerable number of women decided not to marry, most of them do not abstain from sexual activities which make them vulnerable to STI and HIV/AIDS.

Factors influencing choice of marital union form

With regard to factors which the women considered for marital union choices, their considerations focused on the issues tabulated in Table 21.

Table 21: Factors influencing the type of marital union

Factors	Suggestive Statement
Childhood Sexual abuse	*Childhood sexual abuse, parental involvement, economic status, level of education, tribe or ethnic group*
Parents	*mostly influence by parents.*
	At times parents also force issues. When they feel that you should now get married, they will start pressurizing you and calling you names so that you can be lead to any type of marital union without careful considerations.
Poverty	*Because some people want to benefit from the money of the man or the woman, especially those coming from poor backgrounds. On the other hand rich parents don't want their daughter to be married by a poor man.*
	"Peer pressure and jealousy, for example when you see your friends are living in luxury, you envy them so you also try to get married to rich men who are usually older to live a luxurious life" – Zambezi Region, Rural, Young woman
	Culture also influences marital choices for example in the Zambezi region, women reported that even though the practice was fading some parents betrothed baby girl to a rich men in the community in exchange for food especially in times of famine
Culture	*"In our culture mostly marriages are allowed between cousins. The idea is to keep the inheritance in the family" – Kunene Region, Rural Old woman*
	Societal pressure, in some communities, if you don't marry then the society will not regard you as a complete woman and so you will be forced to get married just to avoid shame and to be recognized.
Age	*Age is also a factor. When you reach a certain age, you can no longer look after yourself or do chores especially men, that's when tend to seriously look for wives to marry so that they can be taken care of.*
Religion	*Religion also influences women to marry as one woman quote from the bible saying "The bible says it is not good for a man to be alone" – Zambezi region, Rural, Old woman.*
	"People don't want to be alone, others do it as a religious practice, and for others it might be an opportunity to a better life in terms of poverty and riches" Oshana Region, young woman, Urban

Marital stability

The general feeling among women from all regions was that most marriages were not stable at all. According to the women, the factors that influence marital stability are summarized in Table 22.

Table 22: Factors influencing marital stability

Factors	Statement
Infidelity	*Temptations and lies influence marital stability greatly. There are divorces and hardly any marriages*
	Cheating your partner, unfaithfulness as someone put it " Marriage can last if the husband is not cheating "
	"Husbands have other girlfriends who are usually younger and more beautiful than the wife in the house and this leads to divorce"
	There is a lot of adultery and people don't seem to be scared of HIV/AIDS.
communication	*Misunderstandings,*
Patience and tolerance	*How good women cooperated with their husbands*
	Stability is achieved by patience and tolerance
Children	*Children born outside that marriage is one of the reason contributing to marital instability*
	"People later realize that they got married for the wrong reasons. Children might keep some marriages stable" –Oshana region older woman, rural
In laws	*Sometimes relatives of the husband do not want the wife*
Money and Budgets	*Money is a problem because every time they are arguing about expenses in the house*
	There are also problems in marriage if the wife earns more than the husband
Alcohol abuse	*Drinking alcohol as there is always quarreling and fighting after drinking*
Age/education	*Marriages are stable for elderly couples compared to the younger couples because "the young ladies are educated and they do not want to be undermined and tossed since most men depend on women for everything that has to do with house chores.*
Religion/culture	*"In today's life, cases of divorce have increased, marriage is not valued anymore, but the few that are married are either together for the sake of God and family"- Oshana region, Young Woman, rural*
	The married people who go to church look more stable because either they are fine or they hide what is happening in their home to avoid discouraging other church members.

Factors influencing marital stability that were reported by the women included infidelity, communication, patience and tolerance, children, in-laws, money and budgets, alcohol abuse, age, education, religion and culture. However some women felt that it was difficult to tell how stable a marriage was as one woman said, " The marriage looks happy from outside but we don’t know inside”- *Khomas region, Urban , Older woman.*

Divorced women

Divorces were reported to be taking place in all regions and the reasons for divorcing included domestic violence, alcohol and drug abuse, inadequate income, poor sex performance, having feelings for someone else and cheating, witchcraft, and in some cases if the wife was not able to cook properly.

Suggestions for promoting marital viability

The women’s suggestions to promote workable marriage relationships are summarized in Table 23.

Table 23: Suggestions to make marriages work in the community

Suggestions	Statements
Marriage counselling	*Community marriage counseling every 3 months*
	Creating marriage awareness or discussions and projects which can help families.
	Promoting the benefits of marriage.
	Educate girls and boys about marriage before they get into it
	Pastors should be close to those who are married to keep them on the right track by continuously advising them.
	Couples should be counselled by older men and women, not young men and women
Religious and moral education	*They should go to church and read the bible more*
	"In the bible there is a verse which says women should be under their husbands for a healthy marriage, but husbands usually misunderstand the concept and take advantage of that and for the better they must be equal" – Zambezi region, Young woman
	"As a Christian, I strongly believe that only God is the solution to issues as such but other means like counselling and educating the community on the values of marriage can help" Oshana region, young woman, Urban
Fidelity	*Honesty from both parties*
	Tolerance and honesty can fix your marriage
Alcohol abuse	*They take less alcohol and must not drink to get drunk or they should drink at home*
Gender roles	*Men should be taught how to take care of women and to understand their roles in marriage*
Government Intervention	*Maybe government should intervene by constructing legislation to strengthen the marriage fabric*
Age / Peer pressure	*Women should marry the right person, not just rush into marriage because others are married*
Acceptance /Tolerance	*Wives and husbands to be _ loyal and faithful and respectful to each other*
	Spouses should accept each other
Communication	*"Sometimes discussing with your partner about sex and giving condoms to your partner when he is going out due to the fact that he/she will cheat on you. It's a fact"- Kunene Region, Rural, Older woman*
	Need for better communication skills for couples

7.3.4 Sexual Debut and premarital sex

The women generally did not support premarital sex and were of the opinion that sexual debut should coincide with the onset of marriage and should occur at least after 18 years of age. Their sentiments are presented in Table 24. Women in all regions expressed concern that young girls were having premarital sex from as early as 10 years old in some cases. The risks of premarital sex mentioned were sexually transmitted infections, HIV/AIDS, unwanted pregnancy and school dropout.

Table 24: Women's views on sexual debut and premarital sex

Views	Suggestive Statement
Unwanted pregnancy	*Premarital sex is not good and it leads to unwanted pregnancies*
	"There is high risk of getting pregnant and times the man will leave you because he is still getting support from his parents, which is a tough responsibility"- Zambezi Region, Young woman
STI/ HIV AIDS	*It exposes girls to STI and HIV /Aids*
Culture/ Religion	*"Sexual debut should be after 18 years of age and should happen after marriage " - Khomas Region, urban, Older woman*
	Very wrong practice
	Very bad
	"Only after marriage but nowadays they don't wait" !Karas Region, Rural, Old woman
	"It is not good it is a sin" - Otjozondjupa Region, Urban, Old woman
	"It is not good, they are influenced by others, It's hard to control kids" – Otjozondjupa Region, Urban, Old woman
	"It's not allowed but people still do it. It's wrong", -Kavango Region, Rural, young woman
	"Premarital sex is immoral/wrong but it is happening. I am totally against it" - Oshana region, young woman, rural
	"Yes, even though these relationships are usually kept a secret as it is a shameful thing. Usually done by older men and young women and not vice versa"
School dropout	*Premarital sex can also affect girls studies because they will have concentration problems in school*
	"Most girls drop out of school due to such practices "--Kunene region , Young woman, Rural
Community relations	*It is not good. It creates tensions between families*
	A man having sex with a girl before they are married is not good because that man is not guaranteed to marry the woman

It was reported that the girls were having premarital sex mostly with rich older men and in some cases relatives. However some girls were having premarital sex with not necessarily rich men, but even those who could offer services like transport (taxi drivers, truck drivers, teachers/lecturers), and at times young boys of their age. Below are some of the reasons why girls where having premarital sex.

"Some have sex with older men because the young boys have no advance knowledge about sex"

"They always go for older men than them although you still find a few of them engage with younger boys" – Kavango region, Rural Young woman

"Some use this as a tool to get money from men, others for pleasure and peer pressure"

"Older men with money who can support them. Nothing for mahala" - !Karas Region, Rural, Old woman

"Some have sex with boys of their age imitating what they see in movies and TV and also what they see their bigger brothers doing openly with their girlfriends while watching television in the house" - Zambezi region, young woman

Sometimes unplanned pregnancies led to marriage but in very few cases as indicated by the following statements.

"In very few cases when a girl gets pregnant she gets married. There are many single mothers"

"No because on man can impregnate 3 girls at the same time and cannot marry all three of them"

"No the girls don't get married. Men just give them empty promises and the men tend to refuse ownership of the pregnancy."

"Only a handful actually get married to their baby's father. Men do not want to commit themselves or take responsibility." Kavango Region, Rural, Young woman

"Yes they do get married, especially girls raised without both parents, so when they grow up they wish to get married because they don't want the same thing of growing without both parents to also happen to their children" – Zambezi Region, Older women

"Yes , pregnancy can lead to marriage for the girl to avoid shame of the society for example when they engage in pre-marital sex, and the girl gets pregnant, parents of the girl may force the man to marry their daughter so that their family name will not be put to shame and sometimes the impregnated girl is too poor to take care of the baby so she has no option but to ensure that she gets married so that the man can help here with the expenses of raising the baby" – Zambezi Region, Rural, Young woman.

Factors influencing premarital sex

According to the women, the factors influencing premarital sex in their communities were poverty, media, cultural erosion, alcohol and drug abuse, unemployment, peer pressure, education level, lack of self-esteem, lack of parental guidance, lack of self control and good role models. These factors were evidenced by the statements in Table 25:

Table 25: Factors influencing premarital sex

Factor	Suggestive Statement
Poverty	*Poverty*
	Modern life and poverty
	To get benefits such as cell phone credit, buying fashionable clothes, and they usually do this with older men
	Money is the factor that drives sex
	Poverty in the case of (maids, orphans and vulnerable children)
	Show off- young girls want to live above their means. They want to live the life of a working person so they end up in pre-marital sex
	"Young girls in our community normally have sex with older man to get money in return, and sometimes to pay for their studies and not necessarily being prostitution"
Media	*Media, peer pressure, international aid, copying things like pornography, X-rated movies, teens want to experiment with such things*
	TV and other media exposure to pornography
	Watching television on certain immoral channels and surfing pornographic sites on the internet since the internet has everything from the best to the worst and this can stir girls into premarital sex.
Religious and Moral education	*Lack of compulsory religious and moral education in the school curriculum*
Childhood sexual abuse	*Abuse by relatives e.g. step father, and other relatives*
Alcohol and drug abuse	*Alcohol and drug abuse*
Peer pressure	*Peer pressure*
Curiosity	*Curiosity*
Education/ Self esteem	*They think they are in love and their boyfriends ask them to "prove" the love*
	Poor academic performance
	To try and check if the woman is fertile or not before committing to marry her on the part of the man
Parental guidance and Role models	*Rebellion against parents and guardians*
	They fail to control their feelings in certain environments
	If parents are not good role models, children may be influenced to engage in premarital sex
Unemployment	*Sex for employment*
Lack of self-control	*"I can't wait until I get married because I have feeling " - !Karas Region Young woman*
	"Lack of respect for elders, they think they are big enough, the feelings are too much for sex. They think they are in love, the hormones are high and they can't control them " – Otjozonjupa region, urban, Older woman

Suggestions for delaying sexual debut and reducing premarital sex

Suggestions on what could be done to delay sexual debut and to avoid or reduce premarital sex are presented in Table 26.

Table 26: Suggestions for girls to delay sexual debut and avoid premarital sex

Suggestion	Statement
Media	*DSTV, NBC must filter and control access to media programmers from some channels so that they can only be viewed by older people through passwords*
	Government should come up with laws against programs with pornography on television, radio and any other sources of information
	Government should restrict the selling of immoral magazines and other sources
Religious and Moral education	*educate young children from young age about the dangers of premarital sex*
	need for community workshop for kids
	there is need for continuous education, help them with money, introduce Christianity, refer to social workers, train more social workers to help them, parents should discuss with their kids about sex and create awareness clubs
	continue educating young girls why it is important not to engage in non-marital activities
	Girls should stop going to clubs
	comprehensive sexuality education coupled with moral and spiritual support –Khomas region, Urban, Older woman
	"It's a big challenge in our community, a child does not walk in her mother's pockets, hence maybe we can just pray to our God/ancestors" Kunene Region, Rural, Old woman
	Government must introduce subjects based on such topics, may be this problem may be overcome
	"well nothing that I can think of now, but for me salvation through Christ has kept me away from such practices" Oshana region, young woman, urban
Parental guidance and Role models	*parents can sit down with their daughters*
	there is need for communication in the family, need to talk to the girls
	Sex education should be emphasized in the community. Parents should not hide things from their kids
	Premarital sex can be reduced if we have good role models such as aunties, parents, friends, leaders, pastors
	Parents should make time for their children and be more involved with them
	Education and good examples from adults in the community
	Parents and education

7.3 5 Non-marital fertility

Women's perceptions regarding non-marital fertility were mixed and mainly centered on cultural issues, the woman's need for children whether married or not, parental guidance, religion, poverty and independence. Their views are summarized in Table 27.

Table 27: Women's Perceptions regarding non-marital child bearing

Factor	Statements
Fewer men	*Yes because the men are fewer*
Modernization	*"Since it has become common to have children out of marriage, many don't see anything wrong with bearing a child out of wedlock. Personally I think it is wrong", Oshana Region, Young woman, urban*
Disappointments	*Some women choose to be single parents after several disappointments*
Need to have children	*" They are our children. There is nothing we can do. We must just accept them. For how long can one wait until marriage and bear children. There is a possibility of not getting married and you have to bear children", Kunene Region, Rural , Older woman*
	Such children will assist parents once they get old if the child happens to stay with the mother or father
	Such children can help to take care of the family in terms of making money to assist with other expenses.
Baby Dumping	*"It's not good, some women end up dumping babies", Omaheke region, Urban, Old woman*
Independence	*"There is no problem unless the man is not supporting the child" !Karas region, Rural, Young woman*
Poverty	*It is usually difficult for one parent to raise the children especially if not working*
	"It's bad, they can suffer if they are poor", Otjozondjupa region, Urban, Young woman
Parental Guidance	*"It's wrong to do that in our community as it will be seen as though you were not taught well" Kavango West Region, Rural, Young woman*
Culture	*It's a problem bearing children when you are not married.*

Unmarried women with children were reported to be present in all the investigated regions. Some women reported that unmarried women did not face any problems. However other women cited lack of a father-figure in the home, financial problems, stigma, and challenges with disciplining children. The women's sentiments are presented in Table 28:

Table 28: Challenges faced by unmarried women with children

Challenge	Statement
Father-Figure	*I don't think most of them face any problems, but the children do need a male figure in their lives.*
	the father needs to come and visit the child every now and then
	"the kids do not have the father's love" Otjozondjupa region, Urban, Old woman
	"Yes, I myself have a daughter but I am not married. The only challenge I face is when I have to attend school meetings alone. I just wish the dead was around"- Oshana region, Older woman, urban
Finance	*there are financial problems*
	Some don't face a lot of challenges because they are working
	"Unmarried women with children face challenges of poverty and children sometimes will ask them humiliating questions" Oshana Region, Old woman, Urban
Discipline	*women try hard to manage the family*
	Raising the children as independent mothers are the biggest challenges they face in the community especially disciplining the children
Stigma	*It is difficult for them to try to go back to school and continue studying because of discrimination*

Factors contributing to non-marital fertility

The reported factors contributing to non-marital fertility were mainly lack of a father-figure in the home where the children grow, and poverty. The can be deduced from the statements presented in Table 29.

Table 29: Factors contributing to non-marital fertility

Factor	Statement
Lack of father-figure	*Many, growing up without both parents can have a very negative impact socially to a child. Mothers are there to nature and show gentleness and love. Fathers are there to teach and instill a sense of obedience. Also some needs are not met by one parent" Oshana region, young woman, urban*
Poverty	*They also need money to make a living, so they will have a child with richer men.*
	"you will be forced to sleep around in order to get money to feed your children" Zambezi region, Rural, Young woman
	Some women even resort to stealing to cover all expenses
	Some of the factors are because they want money, lack of knowledge and boyfriend pressures

Suggestions for avoiding or reducing pre-marital and non-marital fertility

Regarding policy, there were mixed feelings as to what should be done to reduce pre-marital and non-marital fertility

As to whether school children, student nurses etc. should be expelled from schools or colleges if they impregnate each other, the women's suggestions are presented in Table 30. There were mixed feelings with some women in favour of expulsion so that school rules could be adhered to, while others felt that the girls needed second and equal opportunity to proceed with their education. One woman even suggested setting up a special school to accommodate pregnant girls.

Table 30: Women's feelings regarding expulsion of students who fell pregnant during school/college

Feelings	Statements
Second/ Equal Opportunity	*"yes, they should be expelled but at the same time everyone deserves a second chance so expelling both mother and father of the child until birth can be done and then they return to school after giving birth" Oshana region, young woman, urban*
	"Discipline will solve the problem. They must be expelled just to be away from others but should be given a chance to go back to school after giving birth. Boys should be expelled too until the child is born" – Oshana region, old woman, urban
	"No policy formulation will not help 100% but they must be there may be a small percentage of people will adhere to such policy. The policy can be as follows: the man who impregnates the girl must be allowed to marry in case where the girl wants to be married. If the man is already in marriage, he must be given full responsibility over the child"- *Kunene Region, Rural, Old woman.*
	Boys can still go back to school
	Girls can give birth and then go back to school
	No they should not be expelled as they need to study in order to support their babies
Expulsion	*No they both should be expelled to teach others a lesson. This will help reduce premarital sex if they enforce and educate young people on how and when it is the right time*
	How will the girls proceed with their studies while pregnant as most of them become ill, experiencing nausea and vomiting in class?" Khomas Region, Urban, Old woman
	If they are not expelled, the problem is that then more young girls will get pregnant knowing that they can still come back to school
Special School	*Maybe a separate school for pregnant girls and new young mothers should be set up so that once the pregnant girls give birth, they will be counselled and they can later rejoin the conventional school system*
Rules to be adhered to	*Schools should be given rules to adhere to and nurses to give education on the relevant topics which will ensure economic development of the country.*

7.4 Discussion

Generally most of the women felt that marriage should be part and parcel of family formation and were all against the practice of early marriage. These findings are in agreement with Pathfinder international (2006) who reported the negative consequences of marriage ranging from instability of marriage, poor health, fistula and related problems, too many children, school dropouts, less education, negative impact on the wellbeing of children, to reduced future opportunities. With regard to the most appropriate age at first marriage most women concurred that the ideal age was at least 25 years. In Namibia, the mean age at marriage has been rising and this trend has been associated with increasing educational levels in women as they tend to spend more years in school before settling down to marriage (NDHS Report, 1992, NDHS Report, 2000), NDHS Report, 2006/7)). Government has since put in place interventions to protect young girls from early marriages (Namibia Constitution, 1998, Article 15, Paragraph 2, Combating of Immoral Practices Amendment Act, 2000) which stipulate that the legal age of consent is 16 for girls. What is not clear is whether penalties for offenders are punitive enough to curb the challenge of early marriages. On the other hand, Bongaarts (2006) found a significant positive correlation between HIV prevalence and median age at first marriage, and the interval between first sexual intercourse and first marriage, supporting the hypothesis of a link between a high average age at first marriage and a long period of premarital intercourse during which partner changes were relatively common, thereby facilitating the spread of HIV.

Women in all regions reported that young girls were having mostly premarital sexual debut from as early as 10 years of age in some areas. The women generally felt that this was wrong. These findings are also supported by Mufune (2003) who established that the taboos that increased a sense of responsibility and the social sanctions against prohibited sexual behaviours in Northern Namibia have changed markedly thereby loosening community control over sexuality and sexual behaviours that could also pre-dispose HIV/AIDS related risk. A history of having practiced unprotected sex, having sex with total strangers, having sex with multiple partners, having sex with high risk sexual partners, low self-risk perception and history of sexually transmitted infections (STI) was associated with alcohol abusers. Chinsembu (2008) showed that the prevalence of sexual intercourse among adolescents was associated with cigarette smoking, alcohol drinking, and drug use. The author suggested that efforts to control unhealthy lifestyles may impact on adolescent sexual activity. Thomas (2007) explained that the tendency of many young women to seek out relationships with older men and the increasing cost of bride wealth payments play a key role in reinforcing patriarchal attitude and fueling disrespect for women's rights both before and after marriage. The author added that failure to adhere to customary norms which uphold men's dominant role, continued to threaten the support networks and assets available to women.

Premarital fertility was found to be high in Namibia by Garenne and Zwang (2006) with the proportion of premarital births being as high as 43% of all births and 60% for the first birth with major variations among ethno-linguistic groups. The Herero and Damara/Nama had the highest level of premarital fertility, followed by the Ovambo and Lozi. The Kavango and San appeared to have kept a more traditional behaviour of early marriage low levels of premarital fertility.

Sexual communication among many mothers and daughters is still relatively limited. The study revealed that mothers generally left the discussion of sex and sex related issues until quite late in their daughters' lives. The daughters wished that their mothers would communicate about sex and sex related matters more directly, openly, supportively and emphatically without being judgmental (Akpokiniovo, 2011; Nambambi and Mufune, 2011).

All forms of common marital unions were reported among the women ranging from the never married, married, cohabiting, divorced, to the widowed. Cohabiting seemed to be the most common and increasing marital form in Namibia Similar results were obtained by Bocquier and Khasakhal (2009) in Kenya were cohabitation without formal marriage was the most prominent form of union especially among the younger generation and appeared also to be on the increase. Unlike for women, for men, the timing of family formation was more dependent on human capital acquisition than on cultural factors. Studies in Southern Africa revealed delays in the onset of marriage , a clear-cut trend of proportions of never married, decreasing prevalence of ever- married, increasing cohabitation and variation in marriage patterns across population groups (Mokomane, 2006;Shapiro and Grebreselassie, 2014;Palamuleni and Palamuleni, 2011). Research in the United States indicates that marriage, although for reasons not entirely understood, does seem to bring with it a range of benefits for individuals, couples and, especially children (Cohen, 2004). The Centre for Law and Social Policy (CLASP) reported that children who grow up in a low-conflict household with married biological parents, when compared to those who grow up in other types of households, are usually more healthier, more likely to achieve higher education levels, and less likely to become parents themselves while still teenagers (Park, 2003).

Discussions within the Roman Catholic Church recommended that in future, it would be good to see unity between the ecclesiastical and civil aspects of marriage. The article concluded by focusing on the need to update their understanding of customary unions given that the South African Government enacted the Recognition of Customary

Marriages Act 120 in 1998 as part of the law of the land applicable to all South Africans (Henriques, 2013).

A few women were aware of the health dangers of early marriage cited by (Chen et al, 2006; Jolly et al, 2000; Lawlor and Shaw, 2002 and Cunnington, 2001) who associate early marriage with teenage pregnancy, cardio-vascular disease, cancer, mental challenges, pre-term births, low birth weight and neonatal deaths. Walker (2012) also associates early marriage with poverty. A new bride often coerced by her family into marrying an older man, may be at higher risk of contracting HIV than if she had remained single. Grinding poverty, tradition, the low status of women, and lack of education all contribute to the practice of early marriage (Cohen, 2004; Clark et al, 2006). According to Palamuleni (2010) men and women in South Africa are staying single more and more because of social and economic conditions such as increasing education, employment of women, urbanization and modernization. The culture of early marriage was reported to be fading in Namibia though still happening in some parts of the country. Women in the North –West Kunene region tend to experience child birth in their teens than others according to Orieji (1997).

Results from studies in 10 Sub-Saharan African Countries indicate little association between female orphan hood and early marriage or teenage pregnancy, but evidence from 7 of the countries associated orphan hood with early sexual debut (Palemo and Peterman, 2009).

Anyolo (2008) acknowledged that polygyny as a form of marriage has long directed the way African people have conducted their marriage lives, but expressed the need for

African women to address some of the misleading legal interpretations of polygyny. Generally polygyny was found to be more prevalent in rural compared to urban settings (Timaeus and Reynar, 2010). Cook (2007) argued that polygyny has a positive effect on population growth and fertility but at the same time may be harmful to health to the health and wellbeing of women and children. On the other hand, Togarasei(2012) argues that in many ways , Paul's teachings on marriage and sex challenges dangerous masculinities and that if Paul's teaching are taken seriously, Christian communities may witness a decline in HIV prevalence.

Schutz et al (2009) showed that even though single women were seen as more lonely, less warm and caring than married couples, some groups related single persons as more sophisticated and sociable than married people. Wand and Abbort (2013) acknowledged than in China, traditional and societal values in general still place pressure on single females to marry and have a child. Their studies revealed three major themes in the lived experiences of being single namely; awareness of the advantages and disadvantages of singlehood, ambiguous attitudes towards marriage and adjustments in life needed to making living as singles worthwhile.

Widows in regions of Namibia that were investigated were reported to be experiencing various challenges because of this marital status in terms of property rights, recognition, and general wellbeing. Peterman (2012) revealed that across 15 DHS countries in Sub-Saharan Africa, less than of the reported inheriting any assets, leading to poverty for themselves and their children. Siskonen (2009) revealed that re-marriage was a real solution for many widows and divorced women in the 1930s and 1940s if they were at the best childbearing age even though remarriage rates decreased from 1950s onwards. Adetunji (2001) assumed that young widows who remain unmarried are sexually active and may widely spread HIV infection if they are seropositive and do not use condoms, and showed that the proportions of young widows was higher in countries with high HIV prevalence rates than in countries with low prevalence rates. While widowers commonly remarry, the traditional "option" open to women through widow inheritance had been outlawed (Thomas, 2008). The author further explained that even though even though forcing widows of the land was now prohibited, social cultural pressures, the status of the women's children, and a lack of basic support from the late husband's relatives was a more subtle form of property disinheritance. Many widows were also limited in in undertaking livelihood activities as they were constrained in their capacity to engage in profitable, income–earning opportunities and heavily depended on the support of others.

The study was based on the cross-sectional design. Examination of marital patterns and trends, analysis of the hazard of first marriage, and non-marital fertility used secondary quantitative data collected as part of the Namibia Demographic and Health survey (NDHS), while the examination of perceptions of women regarding principles of family formation used primary qualitative data collected to fulfill this objective. The limitation of cross-sectional data is that it offers a fixed time perspective of the existing relationship, which has a short coming of not capturing the dynamics of family formation processes. Moreover, since the data was collected in 1992, 2000 and 2006/7 changes may have happened between now and then, thus the relationship obtained is valid for that period when the data was collected. Furthermore, the use of secondary data implies inheritance of some errors which may have been made in the data collection process. As of the qualitative component of the research, results depend on the willingness of women to participate in focus group discussions, availability of resources for travel to various parts of the country.

7.5 Summary

Women in Namibia felt that marriage is important for family formation and they suggested the ideal age range for entry into first marriage to be between 25 and 35 citing issues of maturity and sexual and reproductive health. The practice of early marriage was reported to be still happening especially in rural areas of the Kavango, Zambezi, Otjozondjupa, and Kunene regions but was on the decline.

Various forms of marital unions were reported. Marital union choice was dictated by parental guidance, childhood sexual abuse, poverty, culture, age, and religion. Some women were married either customarily, at the magistrate court (in or out of community of property) or at church. The general feeling among women was that most of the marriages were not stable and that divorces were on the increase. Factors causing marital instability and divorces cited ranged from infidelity, ineffective communication, impatience and intolerance, step children, financial matters, alcohol and drug abuse, young age at marriage, poor sexual relations, witchcraft allegations, negative in-law relationships and even poor cooking. For more stable marriages, the women proposed continuous pre and post marriage counselling by older and more experienced and exemplary pastors, religious and moral education, programs to promote faithfulness in married couples.

Cohabiting unions were present in all the sampled regions. Factors promoting cohabiting unions cited included exorbitant lobola, marriage and general marriage costs, modernization, media influences, poverty, "trial marriage", and flexibility. The risks associated with cohabiting unions reported by the women were mainly gender based violence and passion killings in the event of dissolution of the relationship and lack of legal representation framework especially with respect to property in the event of partner death.

A sizeable number of widows was reported in all the communities sampled. The causes of spousal death were mainly sickness and accidents. Challenges faced by the widows ranged from property inheritance, widow inheritance, poverty, suspicion and accusations, remarriage challenges and stigmatization.

A lot of women in the sampled regions had never married. Reasons for not marrying included no acceptable mate yet available on the marriage market; need for independence, infertility, fear of abusive relationships, bad past experiences of heart aches, and absence of good married role models to inspire them to also marry.

Women generally did not accept pre-marital sex and early sexual debut for girls. Their fears were more on the risks of unwanted pregnancy, STI and HIV/AIDS, cultural erosion, school dropout, and bad community relations. Sadly the women reported with concern, how children as young as 10 years of age were already indulging in unprotected premarital sex with boys of their own age, not-so-rich, and rich older men due to poverty, curiosity, bad media influence, lack of religious and moral education, alcohol and drug abuse, low self-esteem, peer pressure, lack of parental guidance and good role models, and unemployment. Proposals by the women for girls to delay sexual debut and avoid premarital sex included the call to parents and government policy to filter out immoral media content from reaching children, to introduce compulsory religious and moral education in schools, and to encourage parents and guardians to be good role models on issues pertaining to sexuality.

Women expressed mixed feelings with regard to non-marital fertility with some expressing that there was nothing wrong with it since it had become common to have children outside marriage in Namibia, while other women felt that it was bad culturally and since it at times resulted in problems such as baby dumping. Challenges faced by unmarried women with children mostly had to do with absence of a father-figure in the home, financial challenges, disciplining children and stigmatization. Factors influencing non-marital fertility cited were lack of a father-figure during childhood, poverty, the woman’s desire to have children regardless of her marital status, past disappointments, men shortage, modernization, and independence.

Regarding school girl pregnancies, some women felt that such girls needed and equal and second chance to education and thereafter lead a relatively better life and be in a position to support the child. Others strongly felt that both the girl and the boy responsible for the pregnancy be expelled from school to teach others a lesson arguing that otherwise more girls would follow suit.

CHAPTER 8

CONCLUSIONS AND RECOMMENDATIONS

8.1 Conclusions

Marital patterns and trends

In conclusion, the study demonstrated the fact that demographic and socio-economic characteristics have important and similar effects for all marriage patterns. The role played by these factors is important to inform policy. It should be noted that these explanatory factors are limited to explain the complex and dynamic processes that define marriage decisions and practices. However, literature persistently reports on these key factors, and this study has been defined within such general theoretical framework. Moreover, as pointed out by Vignoli and Ferro (2009), some of these variables may raise selection bias and endogeneity, and appropriate techniques are required to model the relationship that may exist between the response variable and the explanatory variables. For instance, a mixed regression model that incorporates random effects may be appropriate. Random effects may capture some of the unobserved and unmeasured population effects that influence marriage practices. Be as it may, there is an apparent social change in the Namibian society as reflected in the emerging marital patterns.

Non marital fertility

Results indicate that, non-marital fertility in Namibia is associated with the age of the woman, her level of education, economic status, place of residence. Non- marital fertility was higher among cohabiting women compared to never married women. Fertility probability was higher in rural areas compared to urban areas even though there were no significant differences in fertility intensity between non-married women from rural and urban areas. Both Non marital fertility probability and intensity decreased with increased educational level. Intervention efforts should focus on promoting education among girls and women especially in rural areas to reduce teenage pregnancy and non-marital fertility.

Age at first sex and age at first marriage

Age, period and cohort effects in the timing of first sex were evident among women in Namibia. Efforts to discourage early sexual debut should be stepped up especially in North-Eastern Namibia. Intervention strategies should not only target schools and the wider community in isolation, but should involve the individual family units as they have a bigger role to play in this regard (Huschek et al., 2010).

The effects of age, period and cohort in the timing of first marriage were not significant among women in Namibia. Marriage timing among women was influenced by rural urban place of residence, highest educational level, socio-economic status and region. Efforts to discourage early marriage should be stepped up especially in the Zambezi region.

Perceptions of women regarding family formation processes

Women in Namibia felt that marriage is important for family formation and they suggested the ideal age range for entry into first marriage to be between 25 and 35 citing issues of maturity and sexual and reproductive health. The practice of early marriage was reported to be still happening especially in rural areas of the Kavango, Zambezi, Otjozondjupa, and Kunene regions but was on the decline.

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8.2 Recommendations

The following recommendations stemming from this study can shape guide policy and further research in family demography.

1. Efforts to discourage early sexual debut and early marriage should be stepped up especially in North-Eastern Namibia. Intervention strategies should not only target schools and the wider community in isolation, but should involve the individual family units as they have a bigger role to play in this regard.

2. Intervention efforts should focus on promoting education among girls and women especially in rural areas to improve their socio-economic status, reduce teenage pregnancy and non-marital fertility.

3. For more stable marital relationships, Government should promote continuous pre and post marriage counselling by older and more experienced and exemplary pastors, religious and moral education, programs to promote faithfulness in married couples.

4. For girls to delay sexual debut and avoid premarital sex, parents and government should formulate policy to filter out immoral media content from reaching children, introduce compulsory religious and moral education in schools, and encourage parents and guardians to be good role models on issues pertaining to sexuality.

5. Government should step up poverty alleviation programs and income disparities to improve the standard of living and raise the self-esteem of girls both in rural and urban areas.

6. Further research could also look at factors influencing marital fertility on one hand and non-marital fertility on the other hand. The research would be more enriching both males and females are also considered. . GIS mapping for age at marriage was recommended for further research.

7. The regional disparities observed in marital patterns may require a multilevel or random effects model that includes regional variables to capture contextual effects. Such models would be an interesting extension to the regression model that was fitted in this study and would be worth exploring. Random effects may capture some of the unobserved and unmeasured population effects that influence marriage practices.

8. Further research on family formation processes in Southern Africa and in particular, Namibia, could be in form of a multi-disciplinary study involving statisticians, demographers, sociologists, anthropologists, economists and GIS specialists to give a holistic picture.

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LIST OF APPENDICES

APPENDIX I: Focus Group Discussion Guide
Date ……Community …

Title…………………………………………………

Introduction

I am Lillian Pazvakawambwa, a UNAM doctoral student in Applied Statistics. I would like to invite you to participate in this interview. The title of this study is: "**An evaluation of women's perceptions on family formation processes in Namibia"**

The purpose of such as marriage, divorce, cohabitation, polygamy, premarital sex and extra marital sex. This information will construct additional or supplementary explanations to the quantitative findings and will be used to develop policy recommendations on fostering stable family units for sustainable socio-economic development.

Your participation in this study means that you are willing to share your experiences with me. The risks to you as a participant in this research study are minimal. There are no risks involved and confidentiality and anonymity is guaranteed. You can choose not to answer a question. You can also withdraw from the discussion at any time. I expect our discussion to last between thirty minutes to an hour.

Findings from this study may be published in a scientific research journal or presented at professional conferences. All recorded information from the discussions will be kept confidential and destroyed upon completion of the study. Your participation is voluntary and no remuneration will be given.

If you have any questions about this study, you may contact the researcher by phone on +264 61 2064713; +264813791830 or by email at lpazvakawambwa@unam.na . You may also contact my supervisors: Dr. Nelago Indongo on +264 61 206 3004 or at nkanime@unam.na, and Professor Lawrence Kazembe on +264 61 206 4515 or lkazembe@unam.na. We would be glad to answer any questions you may have.

A: Marriage

What are your views about family formation and marriage?

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What do you think is the ideal age for a woman to get married and why?

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What about the culture of early marriages? Do you think the government should come up with legislation to protect young girls from early marriages?

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What are the most common forms of marital unions in your community?

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Does your community have polygamous unions? What factors lead to such marital forms? What are risks or benefits of polygamous unions?

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Do cohabiting unions exist in your community? If so, what could be the factors leading cohabiting unions? What do you think are the risks/benefits of such unions?

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Are there widows in your community? What could be the contributory factors? What challenges do widows face in your community in terms of inheritance, recognition, re-marriage etc.?

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Are there women who have never married in their whole life? What do you think could be the reasons why they decided not to marry?

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What do you think are the factors influencing marital choices?

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How stable are the marriages is your community? What are the factors influencing marital stability? Are there any divorces?

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What do you think can be done to make marriages work in your community today?

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B: Sexual Debut and premarital sex

What are your views on sexual debut?

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What are your views on premarital sex?

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Do girls in your community engage in premarital sex? If so, at what age, and Why? What do you think are the risks/benefits of engaging in premarital sex?

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With whom do they normally have debut with? Young boys their age or older men?

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Do you know about intergenerational sex or transactional sex? Are these common in your area?

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Do unplanned pregnancies commonly lead to marriages? Explain

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In your opinion, what do you think are the factors influencing premarital sex in your community?

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What can be done to delay / reduce premarital sex?

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C: Non marital fertility

What are your views regarding non-marital child-bearing?

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Are there unmarried women with children in your community? What challenges, if any do they face? What could be the factors contributing to non-marital fertility?

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<u>D. Policy issues</u>

Do you think policy formulation can help reduce pre-marital sex? What regulations should they come up with? Should school children, student nurses etc. be expelled from schools or colleges if the impregnate each other?

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APPENDIX II: **Letter of Approval by www.measure.dhs to download and use the Namibia Demographic and Health Survey Data**

Lilian Pazvakawambwa
Lecturer
Statistics
University of Namibia
Tel: 061-2064713 - E-mail: lpazvakawambwa@unam.na - Web: http://www.unam.na - Fax:
Private Bag 13301, 340 Mandume Ndemufayo Ave, Pionierspark,Windhoek, NAMIBIA

-----Original Message-----
From: archive@measuredhs.com [mailto:archive@measuredhs.com]
Sent: Thursday, March 29, 2012 2:19 PM
To: Pazvakawambwa,Lilian
Subject: DHS Download Account Application

You have been authorized to download data from the Demographic and Health surveys (DHS) on-line archive. This authorization is for unrestricted countries requested on your application.

All DHS data should be treated as confidential, and no effort should be made to identify any household or individual respondent interviewed in the survey.

The data sets must not be passed on to other researchers without the written consent of DHS. Users are requested to submit a copy of any reports/publications resulting from using the DHS data files. These reports should be sent to the attention of the DHS Data Archive:archive@measuredhs.com.

To begin downloading datasets, please login at http://legacy.measuredhs.com/login.cfm. Once you are logged in, you may also edit your contact information, change your email/password, request additional countries or Edit/Modify an existing Description of Project.

Some resources to help you analyze DHS data efficiently are available at:
http://measuredhs.com/data/Using-Datasets-for-Analysis.cfm

The files you will download are in zipped format and must be unzipped before analysis. Following are some guidelines:

After unzipping, print the file with the .DOC extension (found in the Individual/Male Recode Zips). This file contains useful information on country specific variables and differences in the Standard Recode definition.

Please download the DHS Recode
Manual: http://measuredhs.com/publications/publication-dhsg4-dhs-questionnaires-and-manuals.cfm

The DHS Recode Manual contains the documentation and map for use with the data. The Documentation file contains a general description of the recode file, including the rationale for recoding; coding standards; description of variables etc. The Map file contains a listing of the standard dictionary with basic information relating to each variable.

It is essential that you consult the questionnaire for a country, when using the data files. Questionnaires are in the appendices of each survey's final report: http://measuredhs.com/publications/publications-by-type.cfm.

We also recommend that you make use of the Data Tools and Manuals: http://www.measuredhs.com/accesssurveys/technical_assistance.cfm.

DHS statistics can also be obtained using the STATcompiler tool: http://www.statcompiler.com. This tool allows users to select countries and indicators to create customized tables. It accesses nearly all of the indicators that are published in the final reports. Authorization is not needed to use the STATcompiler.

If you have any questions or need assistance, please send an email to: archive@measuredhs.com.

MEASURE DHS Data Archive
ICF International
11785 Beltsville Drive
Calverton, MD 20705
LOGIN INFORMATION:
Login Email: lpazvakawambwa@unam.na
Password: tinotenda

APPENDIX III: Programming codes for statistical analysis

SPSS Code for Binary and Multinomial Logistic Regression for marital patterns

```
DATASET ACTIVATE DataSet1.
NOMREG V501 (BASE=FIRST ORDER=ASCENDING) BY V024 V025 V106 V130 V153 V155 V157 V158 V159 V190 V201
   V302 V312 V319 V503 V504 V505 V513 V535 V538 V701 V704 V714 V716 V719 V721 V739 V741 V743A V743B
   V743C V743D V743F V744A V744B V744C V744D V744E V746 V750 V751 V767A WITH V012 V212 V506 V511 V525
   V537
 /CRITERIA CIN(95) DELTA(0) MXITER(100) MXSTEP(5) CHKSEP(20) LCONVERGE(0) PCONVERGE(0.000001)
   SINGULAR(0.00000001)
 /MODEL
 /STEPWISE=PIN(.05) POUT(0.1) MINEFFECT(0) RULE(SINGLE) ENTRYMETHOD(LR) REMOVALMETHOD(LR)
 /INTERCEPT=INCLUDE
 /PRINT=CELLPROB CLASSTABLE FIT PARAMETER SUMMARY LRT CPS STEP MFI.
```

R code for non-marital fertility

```
> vuong(model.poi,model.nb)

> vuong(model.poi,zip)

> vuong(model.poi,zinb)

> vuong(model.poi,hurdle.mod)

> vuong(model.poi,hurdle.negbin)

> vuong(hurdle.mod,hurdle.negbin)

> summary(model.poi)

>glm(formula = V201 ~ V302 + V501 + V714 + AgeCur2 + AgeCur3 +
   AgeCur4 + Rural + EduPri + EduSec + EduHigher + WInd2 + WInd3 +
   WInd3 + WInd4 + WInd5, family = poisson, data = nonmarital)
```

```
> confint(model.poi)
> summary(model.quasipoi)
>glm(formula = V201 ~ V302 + V501 + V714 + AgeCur2 + AgeCur3 +
    AgeCur4 + Rural + EduPri + EduSec + EduHigher + WInd2 + WInd3 +
    WInd3 + WInd4 + WInd5, family = quasipoisson, data = nonmarital)
> confint(model.quasipoi)
> summary(model.nb)
glm.nb(formula = V201 ~ V302 + V501 + V714 + AgeCur2 + AgeCur3 +
    AgeCur4 + Rural + EduPri + EduSec + EduHigher + WInd2 + WInd3 +
    WInd3 + WInd4 + WInd5, data = nonmarital, init.theta = 4097.063566,
    link = log)
> confint(model.nb)
> summary(zip)
zeroinfl(formula = V201 ~ V302 + V501 + V714 + AgeCur2 + AgeCur3 +
    AgeCur4 + Rural + EduPri + EduSec + EduHigher + WInd2 +
    WInd3 + WInd3 + WInd4 + WInd5 | 1, data = nonmarital, dist = "poisson",
    link = "logit")
> confint(zip)
> summary(zinb)
zeroinfl(formula = V201 ~ V302 + V501 + V714 + AgeCur2 + AgeCur3 +
    AgeCur4 + Rural + EduPri + EduSec + EduHigher + WInd2 +
    WInd3 + WInd3 + WInd4 + WInd5 | 1, data = nonmarital, dist = "negbin",
```

```
    link = "logit")
> confint(zinb)
> summary(hurdle.mod)
hurdle(formula = V201 ~ V302 + V501 + V714 + AgeCur2 + AgeCur3 +
    AgeCur4 + Rural + EduPri + EduSec + EduHigher + WInd2 +
    WInd3 + WInd3 + WInd4 + WInd5, data = nonmarital, zero.dist = "poisson",
    link = "logit", control = hurdle.control(method = "BFGS",
        maxit = 1000, trace = TRUE, separate = TRUE))
> confint(hurdle.mod)
> summary(hurdle.negbin)
hurdle(formula = V201 ~ V302 + V501 + V714 + AgeCur2 + AgeCur3 +
    AgeCur4 + Rural + EduPri + EduSec + EduHigher + WInd2 +
    WInd3 + WInd3 + WInd4 + WInd5, data = nonmarital, zero.dist = "negbin",
    link = "logit", control = hurdle.control(method = "BFGS",
        maxit = 1000, trace = TRUE, separate = TRUE))
> confint(hurdle.negbin)
> par(mfrow=c(1,1))
> boxplot(res1,res2,res3,res4,res5,res6,res7,
names=c("Poi","QuasiPoi","NegBin","ZIP","ZINB","HLPo","HLNB"))
```

Bayes X code and R code, SPSS code for Event History models for age at first sex and first marriage

Recoding the age at first sex variable (SPSS)

```
DATASET ACTIVATE DataSet1.
RECODE V013 (1=1) (ELSE=0) INTO age15to19.
VARIABLE LABELS  age15to19 'age15to19'.
EXECUTE.
DATASET ACTIVATE DataSet1.
RECODE V013 (2=1) (ELSE=0) INTO age20to24.
VARIABLE LABELS  age20to24 'age20to24'.
EXECUTE.
DATASET ACTIVATE DataSet1.
RECODE V013 (3=1) (ELSE=0) INTO age25to29.
VARIABLE LABELS  age25to29 'age25to29'.
EXECUTE.
DATASET ACTIVATE DataSet1.
RECODE V013 (4=1) (ELSE=0) INTO age30to34.
VARIABLE LABELS  age30to34 'age30to34'.
EXECUTE.
DATASET ACTIVATE DataSet1.
RECODE V013 (5=1) (ELSE=0) INTO age35to39.
VARIABLE LABELS  age35to39 'age35to39'.
EXECUTE.
DATASET ACTIVATE DataSet1.
RECODE V013 (6=1) (ELSE=0) INTO age40to44.
VARIABLE LABELS  age40to44 'age45to49'.
EXECUTE.
DATASET ACTIVATE DataSet1.
RECODE V013 (7=1) (ELSE=0) INTO age45to49.
VARIABLE LABELS  age45to49 'age45to49'.
EXECUTE.

RECODE V024 (1=1) (SYSMIS=SYSMIS) (ELSE=0) INTO RCaprivi.
VARIABLE LABELS  RCaprivi 'RCaprivi'.
EXECUTE.
RECODE V024 (2=1) (SYSMIS=SYSMIS) (ELSE=0) INTO RErongo.
VARIABLE LABELS  RErongo 'RErongo'.
EXECUTE.
RECODE V024 (3=1) (SYSMIS=SYSMIS) (ELSE=0) INTO RHardap.
VARIABLE LABELS  RHardap 'RHardap'.
EXECUTE.
RECODE V024 (4=1) (SYSMIS=SYSMIS) (ELSE=0) INTO RKaras.
```

```
VARIABLE LABELS  RKaras 'RKaras'.
EXECUTE.
RECODE V024 (5=1) (SYSMIS=SYSMIS) (ELSE=0) INTO RKavango.
VARIABLE LABELS  RKavango 'RKavango'.
EXECUTE.
RECODE V024 (6=1) (SYSMIS=SYSMIS) (ELSE=0) INTO RKhomas.
VARIABLE LABELS  RKhomas 'RKhomas'.
EXECUTE.
RECODE V024 (7=1) (SYSMIS=SYSMIS) (ELSE=0) INTO RKunene.
VARIABLE LABELS  RKunene 'RKunene'.
EXECUTE.
RECODE V024 (8=1) (SYSMIS=SYSMIS) (ELSE=0) INTO ROhangwena.
VARIABLE LABELS  ROhangwena 'ROhangwena'.
EXECUTE.
RECODE V024 (9=1) (SYSMIS=SYSMIS) (ELSE=0) INTO ROmaheke.
VARIABLE LABELS  ROmaheke 'ROmaheke'.
EXECUTE.
RECODE V024 (10=1) (SYSMIS=SYSMIS) (ELSE=0) INTO ROmusati.
VARIABLE LABELS  ROmusati 'ROmusati'.
EXECUTE.
RECODE V024 (11=1) (SYSMIS=SYSMIS) (ELSE=0) INTO ROshana.
VARIABLE LABELS  ROshana 'ROshana'.
EXECUTE.
RECODE V024 (12=1) (SYSMIS=SYSMIS) (ELSE=0) INTO ROshikoto.
VARIABLE LABELS  ROshikoto 'ROshikoto'.
EXECUTE.
RECODE V024 (13=1) (SYSMIS=SYSMIS) (ELSE=0) INTO ROtjozonjupa.
VARIABLE LABELS  ROtjozonjupa 'ROtjozonjupa'.
EXECUTE.


RECODE V106 (SYSMIS=SYSMIS) (0=1) (1=1) (ELSE=0) INTO Primarynoformal.
VARIABLE LABELS  Primarynoformal 'Primarynoformal'.
EXECUTE.
RECODE V106 (SYSMIS=SYSMIS) (2=1) (3=1) (ELSE=0) INTO SecHigher.
VARIABLE LABELS  SecHigher 'SecHigher'.
EXECUTE.

RECODE V025 (SYSMIS=SYSMIS) (1=1) (ELSE=0) INTO Urban.
VARIABLE LABELS  Urban 'Urban'.
EXECUTE.
```

```
RECODE V130 (SYSMIS=SYSMIS) (1=1) (ELSE=0) INTO Catholic.
VARIABLE LABELS  Catholic 'Catholic'.
EXECUTE.

RECODE V190 (SYSMIS=SYSMIS) (1=1) (2=1) (ELSE=0) INTO Wpoor.
VARIABLE LABELS  Wpoor 'Wpoor'.
EXECUTE.
RECODE V190 (SYSMIS=SYSMIS) (3=1) (ELSE=0) INTO Wmiddle.
VARIABLE LABELS  Wmiddle 'Wmiddle'.
EXECUTE.
RECODE V190 (SYSMIS=SYSMIS) (4=1) (5=1) (ELSE=0) INTO Wrich.
VARIABLE LABELS  Wrich 'Wrich'.
EXECUTE.


RECODE V820 (SYSMIS=SYSMIS) (1=1) (ELSE=0) INTO Condomfirstsex.
VARIABLE LABELS  Condomfirstsex 'Condomfirstsex'.
EXECUTE.

RECODE S119 (SYSMIS=SYSMIS) (1=1) (ELSE=0) INTO LAfrikaans.
VARIABLE LABELS  LAfrikaans 'LAfrikaans'.
EXECUTE.
RECODE S119 (SYSMIS=SYSMIS) (2=1) (ELSE=0) INTO LDamaraNama.
VARIABLE LABELS  LDamaraNama 'LDamaraNama'.
EXECUTE.
RECODE S119 (SYSMIS=SYSMIS) (3=1) (96=1) (ELSE=0) INTO LEnglishOthers.
VARIABLE LABELS  LEnglishOthers 'LEnglishOthers'.
EXECUTE.
RECODE S119 (SYSMIS=SYSMIS) (4=1) (ELSE=0) INTO LHerero.
VARIABLE LABELS  LHerero 'LHerero'.
EXECUTE.
RECODE S119 (SYSMIS=SYSMIS) (5=1) (6=1) (8=1) (9=1) (ELSE=0) INTO
LCaprivKavango.
VARIABLE LABELS  LCaprivKavango 'LCaprivKavango'.
EXECUTE.
RECODE S119 (SYSMIS=SYSMIS) (7=1) (ELSE=0) INTO LOshiwambo.
VARIABLE LABELS  LOshiwambo 'LOshiwambo'.
EXECUTE.
```

Creating the event variable

```
DATASET ACTIVATE DataSet1.
RECODE v511 (SYSMIS=SYSMIS) (6 thru 15=1) (ELSE=0) INTO agefm6to15.
```

```
EXECUTE.
DATASET ACTIVATE DataSet1.
RECODE v511 (SYSMIS=SYSMIS) (16 thru 20=1) (ELSE=0) INTO agefm16to20.
EXECUTE.
DATASET ACTIVATE DataSet1.
RECODE v511 (SYSMIS=SYSMIS) (21 thru 25=1) (ELSE=0) INTO agefm21to25.
EXECUTE.
DATASET ACTIVATE DataSet1.
RECODE v511 (SYSMIS=SYSMIS) (26 thru 30=1) (ELSE=0) INTO agefm26to30.
EXECUTE.
DATASET ACTIVATE DataSet1.
RECODE v511 (SYSMIS=SYSMIS) (31 thru 48=1) (ELSE=0) INTO agefm31to48.
EXECUTE.

DATASET ACTIVATE DataSet1.
COXREG V511
  /STATUS=trans1(1)
 /CONTRAST (ycohort)=Indicator
 /CONTRAST (V190)=Indicator
  /CONTRAST (V024)=Indicator
  /CONTRAST (V106)=Indicator
  /CONTRAST (V013)=Indicator
  /CONTRAST (V025)=Indicator
  /CONTRAST (V130recoded)=Indicator
  /CONTRAST (V007)=Indicator
  /METHOD=ENTER   V013 V024 V025 V106 V130recoded V007 ycohort v190
  /PLOT SURVIVAL HAZARDS
  /PRINT=CI(95) BASELINE
  /CRITERIA=PIN(.05) POUT(.10) ITERATE(20).
```

Bayesian structured additive regression syntax

```
dataset afs
afs.infile using c:\aspatialR\AFS\afs27oct.txt
%afs.tabulate v001 v013
%afs.descriptive v531

map m
m.infile using c:\aspatialR\AFS\nam_regions.csv
m.reorder

remlreg b
b.outfile=c:\aspatialR\AFS\b
```

```
b.regress trans1=v531(psplinerw2), family=binomial using afs

remlreg b1
b1.outfile=c:\aspatialR\AFS\b1
b1.regress trans1=v531(psplinerw2)+p20067, family=binomial using afs

remlreg b2
b2.outfile=c:\aspatialR\AFS\b2
b2.regress
trans1=v531(psplinerw2)+age2024+age2529+age3034+age3539+age4044+age4549+er
ongo+hardap+karas+kavango+khomas+kunene+ohangwena+omaheke+omusati+oshana
+oshikoto+otjozonjupa
+sechigher+urban+catholic+middle+rich+p20067+cohort6574+cohort7584+cohort8592
, family=binomial using afs


remlreg b3
b3.outfile=c:\aspatialR\AFS\b3
b3.regress
trans1=sechigher+urban+catholic+middle+rich+p20067+v010(psplinerw2)+v012(psplin
erw2)+v531(psplinerw2)+v014(random), family=binomial using afs

remlreg b4
b4.outfile=c:\aspatialR\AFS\b4
b4.regress
trans1=sechigher+urban+catholic+middle+rich+p20067+v014(spatial,map=m)+v010(ps
plinerw2)+v012(psplinerw2)+v531(psplinerw2), family=binomial using afs


remlreg b5
b5.outfile=c:\aspatialR\AFS\b5
b5.regress
trans1=sechigher+urban+catholic+middle+rich+p20067+v014(random)+v014(spatial,m
ap=m)+v010(psplinerw2)+v012(psplinerw2)+v531(psplinerw2), family=binomial using
afs

%bayesreg b4
%b4.outfile=e:\book\b4
%b4.regress
trans1=sechigher+urban+catholic+middle+rich+p20067+v001(random)+v024(spatial,
map=m)+v010(psplinerw2)+v012(psplinerw2)+ v531(psplinerw2), family=binomial
%iterations=12000 burnin=2000 step =10 predict using afs
```

R event history analysis code

```
> library(foreign)
> da<-read.spss(file.choose(),to.data.frame=T,use.value.labels=F)
  E:\aspatialR\NaM2006_AgeFirstSex_AgeFirstMarriage.sav:
> names(da)
 [1] "V010"          "V012"          "V013"          "V024"
 [5] "V025"          "V106"          "V130"          "V190"
 [9] "V511"          "V525"          "V632"          "V820"
[13] "V830"          "V851A"         "V851G"         "V851H"
[17] "S119"          "S941A"         "age15to19"     "age20to24"
[21] "age25to29"     "age30to34"     "age35to39"     "age40to44"
[25] "age45to49"     "Urban"         "Primarynoformal" "SecHigher"
[29] "Catholic"      "Wpoor"         "Wmiddle"       "Wrich"
[33] "Condomfirstsex"  "LAfrikaans"    "LDamaraNama"   "LEnglishOthers"
[37] "LHerero"       "LCaprivKavango"  "LOshiwambo"    "ageFirstSex"
[41] "AgeFirstSex_Cat" "EventFirstSex"
> library(survival)
> da.surv<-coxph(Surv(ageFirstSex, EventFirstSex) ~ 1, data=da)
> plot(da.surv)
> summary(da.surv)
> da.surv<-coxph(Surv(ageFirstSex, EventFirstSex) ~ as.factor(Urban), data=da)
> summary(da.surv)

> da.surv.fit<-survfit(Surv(ageFirstSex, EventFirstSex) ~ 1, data=da)
> plot(da.surv.fit)
> da.surv.fit<-survfit(Surv(ageFirstSex, EventFirstSex) ~ as.factor(Urban), data=da)
> plot(da.surv.fit)
> da.surv.fit<-survfit(Surv(ageFirstSex, EventFirstSex) ~ as.factor(V013), data=da)
> plot(da.surv.fit)
> da.surv.fit<-survfit(Surv(ageFirstSex, EventFirstSex) ~ as.factor(V190), data=da)
> plot(da.surv.fit)
> da.surv.fit<-survfit(Surv(ageFirstSex, EventFirstSex) ~ as.factor(V106), data=da)
> plot(da.surv.fit)
> summary(da$V106)
> table(da$V106)

> plot(da.surv.fit,lty=2:5,col=2:5)
> legend("topright", c("none","pri","sec","higher"),lty=2:5)
> plot(da.surv.fit,lty=2:5)
> legend("topright", c("none","pri","sec","higher"),lty=2:5)
> plot(da.surv.fit,lty=2:5,col=2:5)
> legend("topright", c("none","pri","sec","higher"),lty=2:5,col=2:5)
```

```
> da.surv.fit<-survfit(Surv(ageFirstSex, EventFirstSex) ~ as.factor(V024),data=da)
> plot(da.surv.fit,lty=1:13)
> plot(da.surv.fit,lty=1:13,col=1:13)
> da.surv<-coxph(Surv(ageFirstSex, EventFirstSex) ~ as.factor(V024), data=da)
> summary(da.surv)

> da.surv<-coxph(Surv(ageFirstSex, EventFirstSex) ~ as.factor(V190), data=da)
> summary(da.surv)

> da.surv<-coxph(Surv(ageFirstSex, EventFirstSex) ~ as.factor(V025), data=da)
> summary(da.surv)
> da.surv<-coxph(Surv(ageFirstSex, EventFirstSex) ~ as.factor(V106), data=da)
> summary(da.surv)

> da.surv<-coxph(Surv(ageFirstSex, EventFirstSex) ~ as.factor(V013), data=da)
> summary(da.surv)

> da.surv<-coxph(Surv(ageFirstSex, EventFirstSex) ~ as.factor(S119), data=da)
> summary(da.surv)

> da.surv<-coxph(Surv(ageFirstSex, EventFirstSex) ~
as.factor(V013)+as.factor(V025)+as.factor(V106)+as.factor(V190)+as.factor(V024),
data=da)
> summary(da.surv)
```

APPENDIX IV: Data Analysis from various models

Non marital fertility output

> vuong(model.poi,model.nb)

Vuong Non-Nested Hypothesis Test-Statistic: 0.7433991

(test-statistic is asymptotically distributed N(0,1) under the

null that the models are indistinguishible)

in this case:

model1 > model2, with p-value 0.22862

> vuong(model.poi,zip)

Vuong Non-Nested Hypothesis Test-Statistic: 0.7138195

(test-statistic is asymptotically distributed N(0,1) under the

null that the models are indistinguishible)

in this case:

model1 > model2, with p-value 0.2376694

> vuong(model.poi,zinb)

Vuong Non-Nested Hypothesis Test-Statistic: 0.7436469

(test-statistic is asymptotically distributed N(0,1) under the

null that the models are indistinguishible)

in this case:

model1 > model2, with p-value 0.2285451

> vuong(model.poi,hurdle.mod)

```
Vuong Non-Nested Hypothesis Test-Statistic: -11.02194
(test-statistic is asymptotically distributed N(0,1) under the
 null that the models are indistinguishible)
in this case:
model2 > model1, with p-value 1.497665e-28
> vuong(model.poi,hurdle.negbin)
Vuong Non-Nested Hypothesis Test-Statistic: -12.80816
(test-statistic is asymptotically distributed N(0,1) under the
 null that the models are indistinguishible)
in this case:
model2 > model1, with p-value 7.380035e-38
> vuong(hurdle.mod,hurdle.negbin)
Vuong Non-Nested Hypothesis Test-Statistic: -4.933439
(test-statistic is asymptotically distributed N(0,1) under the
 null that the models are indistinguishible)
in this case:
model2 > model1, with p-value 4.039706e-07
> summary(model.poi)

Call:
glm(formula = V201 ~ V302 + V501 + V714 + AgeCur2 + AgeCur3 +
    AgeCur4 + Rural + EduPri + EduSec + EduHigher + WInd2 + WInd3 +
    WInd3 + WInd4 + WInd5, family = poisson, data = nonmarital)
```

```
Deviance Residuals:
    Min       1Q   Median       3Q      Max
-3.1070  -0.6823  -0.4718   0.4010   3.9936

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -1.28034    0.06193 -20.673  < 2e-16 ***
V302         0.38500    0.02782  13.840  < 2e-16 ***
V501         0.17509    0.01090  16.069  < 2e-16 ***
V714        -0.01226    0.02132  -0.575   0.5653
AgeCur2      1.62449    0.04845  33.532  < 2e-16 ***
AgeCur3      2.29787    0.04890  46.990  < 2e-16 ***
AgeCur4      2.61516    0.05108  51.197  < 2e-16 ***
Rural        0.03468    0.02567   1.351   0.1767
EduPri      -0.07891    0.03135  -2.517   0.0118 *
EduSec      -0.46697    0.03445 -13.556  < 2e-16 ***
EduHigher   -0.90989    0.07863 -11.571  < 2e-16 ***
WInd2       -0.13325    0.03192  -4.174 2.99e-05 ***
WInd3       -0.14478    0.03144  -4.605 4.13e-06 ***
WInd4       -0.24980    0.03609  -6.922 4.46e-12 ***
WInd5       -0.44842    0.04835  -9.275  < 2e-16 ***
---
```

```
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for poisson family taken to be 1)

    Null deviance: 15457.3  on 7073  degrees of freedom
Residual deviance:  6437.4  on 7059  degrees of freedom
  (43 observations deleted due to missingness)
AIC: 17085

Number of Fisher Scoring iterations: 5

> confint(model.poi)
Waiting for profiling to be done...
                  2.5 %      97.5 %
(Intercept) -1.40251364 -1.15970944
V302         0.33072144  0.43977386
V501         0.15372618  0.19643913
V714        -0.05406388  0.02950403
AgeCur2      1.53048823  1.72044605
AgeCur3      2.20296102  2.39470512
AgeCur4      2.51585901  2.71614516
Rural       -0.01560691  0.08502198
EduPri      -0.14008774 -0.01718694
```

```
EduSec      -0.53425695 -0.39921803
EduHigher   -1.06642893 -0.75804234
WInd2       -0.19585483 -0.07070085
WInd3       -0.20637597 -0.08312608
WInd4       -0.32057448 -0.17909897
WInd5       -0.54347623 -0.35394755
>
>
>
> summary(model.quasipoi)

Call:
glm(formula = V201 ~ V302 + V501 + V714 + AgeCur2 + AgeCur3 +
    AgeCur4 + Rural + EduPri + EduSec + EduHigher + WInd2 + WInd3 +
    WInd3 + WInd4 + WInd5, family = quasipoisson, data = nonmarital)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-3.1070  -0.6823  -0.4718   0.4010   3.9936

Coefficients:
            Estimate Std. Error t value Pr(>|t|)
(Intercept) -1.28034    0.05948 -21.527  < 2e-16 ***
```

V302 0.38500 0.02671 14.412 < 2e-16 ***

V501 0.17509 0.01046 16.733 < 2e-16 ***

V714 -0.01226 0.02047 -0.599 0.54936

AgeCur2 1.62449 0.04652 34.918 < 2e-16 ***

AgeCur3 2.29787 0.04696 48.931 < 2e-16 ***

AgeCur4 2.61516 0.04905 53.312 < 2e-16 ***

Rural 0.03468 0.02465 1.407 0.15949

EduPri -0.07891 0.03011 -2.621 0.00879 **

EduSec -0.46697 0.03308 -14.116 < 2e-16 ***

EduHigher -0.90989 0.07551 -12.049 < 2e-16 ***

WInd2 -0.13325 0.03066 -4.346 1.40e-05 ***

WInd3 -0.14478 0.03019 -4.795 1.66e-06 ***

WInd4 -0.24980 0.03466 -7.208 6.28e-13 ***

WInd5 -0.44842 0.04643 -9.658 < 2e-16 ***

Signif. codes: 0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for quasipoisson family taken to be 0.9222169)

Null deviance: 15457.3 on 7073 degrees of freedom

Residual deviance: 6437.4 on 7059 degrees of freedom

(43 observations deleted due to missingness)

AIC: NA

Number of Fisher Scoring iterations: 5

```
> confint(model.quasipoi)
Waiting for profiling to be done...
                  2.5 %      97.5 %
(Intercept) -1.39763614 -1.16446761
V302         0.33286572  0.43759065
V501         0.15457434  0.19559242
V714        -0.05240413  0.02784776
AgeCur2      1.53418227  1.71660005
AgeCur3      2.20669177  2.39082498
AgeCur4      2.51976856  2.71210474
Rural       -0.01361227  0.08302364
EduPri      -0.13766996 -0.01964641
EduSec      -0.53159596 -0.40191575
EduHigher   -1.06012280 -0.76398348
WInd2       -0.19336962 -0.07318231
WInd3       -0.20393259 -0.08557364
WInd4       -0.31776498 -0.18190343
WInd5       -0.53969309 -0.35768560
> summary(model.nb)
```

```
Call:
glm.nb(formula = V201 ~ V302 + V501 + V714 + AgeCur2 + AgeCur3 +
    AgeCur4 + Rural + EduPri + EduSec + EduHigher + WInd2 + WInd3 +
    WInd3 + WInd4 + WInd5, data = nonmarital, init.theta = 4097.063566,
    link = log)

Deviance Residuals:
    Min       1Q   Median       3Q      Max
-3.1061  -0.6822  -0.4717   0.4009   3.9917

Coefficients:
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -1.28038    0.06195 -20.668  < 2e-16 ***
V302         0.38513    0.02783  13.839  < 2e-16 ***
V501         0.17512    0.01090  16.066  < 2e-16 ***
V714        -0.01226    0.02133  -0.575   0.5654
AgeCur2      1.62444    0.04845  33.526  < 2e-16 ***
AgeCur3      2.29783    0.04891  46.980  < 2e-16 ***
AgeCur4      2.61516    0.05109  51.185  < 2e-16 ***
Rural        0.03469    0.02568   1.351   0.1767
EduPri      -0.07895    0.03137  -2.517   0.0118 *
EduSec      -0.46703    0.03446 -13.552  < 2e-16 ***
EduHigher   -0.90996    0.07865 -11.570  < 2e-16 ***
```

```
WInd2       -0.13325    0.03194  -4.172 3.02e-05 ***
WInd3       -0.14478    0.03145  -4.603 4.16e-06 ***
WInd4       -0.24982    0.03610  -6.920 4.52e-12 ***
WInd5       -0.44844    0.04836  -9.273  < 2e-16 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

(Dispersion parameter for Negative Binomial(4097.063) family taken to be 1)

    Null deviance: 15452  on 7073  degrees of freedom
Residual deviance:  6435  on 7059  degrees of freedom
  (43 observations deleted due to missingness)
AIC: 17087

Number of Fisher Scoring iterations: 1


              Theta:  4097
          Std. Err.:  10570
Warning while fitting theta: alternation limit reached

 2 x log-likelihood:  -17055.32
> confint(model.nb)
```

```
Waiting for profiling to be done...
                  2.5 %      97.5 %
(Intercept) -1.40257593 -1.15972028
V302         0.33083558  0.43992446
V501         0.15374407  0.19647150
V714        -0.05407884  0.02951850
AgeCur2      1.53043229  1.72040169
AgeCur3      2.20290922  2.39466914
AgeCur4      2.51584804  2.71616192
Rural       -0.01561329  0.08505040
EduPri      -0.14016508 -0.01720068
EduSec      -0.53434401 -0.39925006
EduHigher   -1.06652230 -0.75807658
WInd2       -0.19588102 -0.07067643
WInd3       -0.20640013 -0.08309877
WInd4       -0.32062070 -0.17909313
WInd5       -0.54352249 -0.35393903
> summary(zip)

Call:
zeroinfl(formula = V201 ~ V302 + V501 + V714 + AgeCur2 + AgeCur3 +
    AgeCur4 + Rural + EduPri + EduSec + EduHigher + WInd2 +
    WInd3 + WInd3 + WInd4 + WInd5 | 1, data = nonmarital, dist = "poisson",
```

```
   link = "logit")

Pearson residuals:
    Min      1Q  Median      3Q     Max 
-2.2877 -0.5149 -0.3684  0.4173  6.1473 

Count model coefficients (poisson with log link):
            Estimate Std. Error z value Pr(>|z|)    
(Intercept) -1.28031    0.06194 -20.670  < 2e-16 ***
V302         0.38499    0.02782  13.836  < 2e-16 ***
V501         0.17509    0.01090  16.069  < 2e-16 ***
V714        -0.01226    0.02132  -0.575   0.5652    
AgeCur2      1.62449    0.04845  33.529  < 2e-16 ***
AgeCur3      2.29787    0.04891  46.985  < 2e-16 ***
AgeCur4      2.61515    0.05109  51.191  < 2e-16 ***
Rural        0.03468    0.02567   1.351   0.1768    
EduPri      -0.07891    0.03135  -2.517   0.0118 *  
EduSec      -0.46699    0.03445 -13.556  < 2e-16 ***
EduHigher   -0.90989    0.07864 -11.571  < 2e-16 ***
WInd2       -0.13327    0.03193  -4.174 2.99e-05 ***
WInd3       -0.14479    0.03144  -4.605 4.12e-06 ***
WInd4       -0.24981    0.03609  -6.922 4.47e-12 ***
WInd5       -0.44844    0.04835  -9.275  < 2e-16 ***
```

Zero-inflation model coefficients (binomial with logit link):

```
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   -11.09      16.98  -0.653    0.514
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Number of iterations in BFGS optimization: 34
Log-likelihood: -8528 on 16 Df
> confint(zip)
                        2.5 %      97.5 %
count_(Intercept)  -1.40170954 -1.15890845
count_V302          0.33045561  0.43952567
count_V501          0.15373667  0.19644959
count_V714         -0.05404663  0.02952142
count_AgeCur2       1.52953182  1.71945460
count_AgeCur3       2.20201798  2.39372786
count_AgeCur4       2.51502825  2.71528098
count_Rural        -0.01563827  0.08499368
count_EduPri       -0.14036455 -0.01746335
count_EduSec       -0.53450694 -0.39946757
count_EduHigher    -1.06401221 -0.75576577
count_WInd2        -0.19585219 -0.07069192
```

```
count_WInd3       -0.20641180 -0.08316578
count_WInd4       -0.32054626 -0.17907058
count_WInd5       -0.54320145 -0.35368006
zero_(Intercept)  -44.37790028 22.19657697
> summary(zinb)

Call:
zeroinfl(formula = V201 ~ V302 + V501 + V714 + AgeCur2 + AgeCur3 +
    AgeCur4 + Rural + EduPri + EduSec + EduHigher + WInd2 +
    WInd3 + WInd3 + WInd4 + WInd5 | 1, data = nonmarital, dist = "negbin",
    link = "logit")

Pearson residuals:
    Min      1Q  Median      3Q     Max
-2.2876 -0.5149 -0.3684  0.4173  6.1475

Count model coefficients (negbin with log link):
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -1.28045    0.06194 -20.672  < 2e-16 ***
V302         0.38501    0.02782  13.837  < 2e-16 ***
V501         0.17509    0.01090  16.068  < 2e-16 ***
V714        -0.01226    0.02132  -0.575   0.5652
AgeCur2      1.62456    0.04845  33.529  < 2e-16 ***
```

```
AgeCur3      2.29795    0.04891  46.985  < 2e-16 ***
AgeCur4      2.61526    0.05109  51.192  < 2e-16 ***
Rural        0.03472    0.02567   1.352   0.1763
EduPri      -0.07891    0.03135  -2.517   0.0118 *
EduSec      -0.46701    0.03445 -13.556  < 2e-16 ***
EduHigher   -0.91003    0.07864 -11.572  < 2e-16 ***
WInd2       -0.13322    0.03193  -4.172 3.01e-05 ***
WInd3       -0.14475    0.03144  -4.604 4.15e-06 ***
WInd4       -0.24978    0.03609  -6.920 4.50e-12 ***
WInd5       -0.44838    0.04835  -9.274  < 2e-16 ***
Log(theta)  10.12049   16.67800   0.607   0.5440

Zero-inflation model coefficients (binomial with logit link):
            Estimate Std. Error z value Pr(>|z|)
(Intercept)   -12.01      26.98  -0.445    0.656
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Theta = 24846.8205
Number of iterations in BFGS optimization: 47
Log-likelihood: -8528 on 17 Df
> confint(zinb)
                      2.5 %      97.5 %
```

```
count_(Intercept)  -1.40184835 -1.15904411
count_V302          0.33047927  0.43955068
count_V501          0.15373061  0.19644614
count_V714         -0.05404807  0.02952338
count_AgeCur2       1.52959836  1.71952843
count_AgeCur3       2.20208905  2.39380642
count_AgeCur4       2.51512868  2.71538806
count_Rural        -0.01560202  0.08503281
count_EduPri       -0.14036773 -0.01746162
count_EduSec       -0.53453023 -0.39948516
count_EduHigher    -1.06415788 -0.75589231
count_WInd2        -0.19579694 -0.07063831
count_WInd3        -0.20637911 -0.08312648
count_WInd4        -0.32051909 -0.17903758
count_WInd5        -0.54314052 -0.35361278
zero_(Intercept)  -64.90056478 40.87720251
> summary(hurdle.mod)

Call:
hurdle(formula = V201 ~ V302 + V501 + V714 + AgeCur2 + AgeCur3 +
    AgeCur4 + Rural + EduPri + EduSec + EduHigher + WInd2 +
    WInd3 + WInd3 + WInd4 + WInd5, data = nonmarital, zero.dist = "poisson",
    link = "logit", control = hurdle.control(method = "BFGS",
```

```
          maxit = 1000, trace = TRUE, separate = TRUE))

Pearson residuals:
    Min      1Q  Median      3Q     Max 
-2.3105 -0.5306 -0.2756  0.4241  6.1072 

Count model coefficients (truncated poisson with log link):
             Estimate Std. Error z value Pr(>|z|)    
(Intercept) -0.773777   0.118138  -6.550 5.76e-11 ***
V302         0.026652   0.031881   0.836  0.40317    
V501         0.136038   0.012474  10.905  < 2e-16 ***
V714        -0.022173   0.025187  -0.880  0.37869    
AgeCur2      1.364853   0.109383  12.478  < 2e-16 ***
AgeCur3      2.112351   0.108499  19.469  < 2e-16 ***
AgeCur4      2.387178   0.109640  21.773  < 2e-16 ***
Rural        0.005827   0.030452   0.191  0.84825    
EduPri      -0.067070   0.033777  -1.986  0.04707 *  
EduSec      -0.451003   0.039175 -11.512  < 2e-16 ***
EduHigher   -0.661520   0.104200  -6.349 2.17e-10 ***
WInd2       -0.059297   0.036508  -1.624  0.10433    
WInd3       -0.115949   0.036440  -3.182  0.00146 ** 
WInd4       -0.202621   0.042796  -4.735 2.20e-06 ***
WInd5       -0.358748   0.060860  -5.895 3.76e-09 ***
```

Zero hurdle model coefficients (censored poisson with log link):

```
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -1.804925   0.118224 -15.267  < 2e-16 ***
V302         1.193429   0.056177  21.244  < 2e-16 ***
V501         0.343592   0.024786  13.862  < 2e-16 ***
V714         0.006573   0.043215   0.152 0.879099
AgeCur2      1.506985   0.058067  25.953  < 2e-16 ***
AgeCur3      2.161937   0.068524  31.550  < 2e-16 ***
AgeCur4      2.555310   0.101116  25.271  < 2e-16 ***
Rural        0.164005   0.050669   3.237 0.001209 **
EduPri      -0.048911   0.092413  -0.529 0.596621
EduSec      -0.548612   0.088548  -6.196 5.81e-10 ***
EduHigher   -1.245884   0.134087  -9.292  < 2e-16 ***
WInd2       -0.269764   0.071038  -3.797 0.000146 ***
WInd3       -0.152439   0.069844  -2.183 0.029067 *
WInd4       -0.302469   0.074963  -4.035 5.46e-05 ***
WInd5       -0.512903   0.089610  -5.724 1.04e-08 ***
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Number of iterations in BFGS optimization: 41
Log-likelihood: -8280 on 30 Df
> confint(hurdle.mod)
```

	2.5 %	97.5 %
count_(Intercept)	-1.00532318	-0.5422311458
count_V302	-0.03583400	0.0891372138
count_V501	0.11158835	0.1604872983
count_V714	-0.07153890	0.0271935284
count_AgeCur2	1.15046713	1.5792396775
count_AgeCur3	1.89969673	2.3250043177
count_AgeCur4	2.17228765	2.6020690793
count_Rural	-0.05385692	0.0655110431
count_EduPri	-0.13327126	-0.0008684071
count_EduSec	-0.52778571	-0.3742210380
count_EduHigher	-0.86574774	-0.4572929468
count_WInd2	-0.13085163	0.0122569316
count_WInd3	-0.18737138	-0.0445273033
count_WInd4	-0.28650037	-0.1187415655
count_WInd5	-0.47803182	-0.2394632414
zero_(Intercept)	-2.03663879	-1.5732107622
zero_V302	1.08332474	1.3035325825
zero_V501	0.29501202	0.3921721869
zero_V714	-0.07812611	0.0912730175
zero_AgeCur2	1.39317611	1.6207933291
zero_AgeCur3	2.02763358	2.2962408645
zero_AgeCur4	2.35712605	2.7534934793

```
zero_Rural        0.06469511  0.2633142508
zero_EduPri      -0.23003815  0.1322156574
zero_EduSec      -0.72216410 -0.3750607978
zero_EduHigher   -1.50868868 -0.9830783507
zero_WInd2       -0.40899647 -0.1305309252
zero_WInd3       -0.28933034 -0.0155479808
zero_WInd4       -0.44939334 -0.1555453280
zero_WInd5       -0.68853536 -0.3372704758
> summary(hurdle.negbin)

Call:
hurdle(formula = V201 ~ V302 + V501 + V714 + AgeCur2 + AgeCur3 +
    AgeCur4 + Rural + EduPri + EduSec + EduHigher + WInd2 +
    WInd3 + WInd3 + WInd4 + WInd5, data = nonmarital, zero.dist = "negbin",
    link = "logit", control = hurdle.control(method = "BFGS",
        maxit = 1000, trace = TRUE, separate = TRUE))

Pearson residuals:
    Min      1Q  Median      3Q     Max
-2.3000 -0.5534 -0.1894  0.4026  7.3355

Count model coefficients (truncated poisson with log link):
            Estimate Std. Error z value Pr(>|z|)
```

```
(Intercept) -0.773777   0.118138  -6.550 5.76e-11 ***
V302         0.026652   0.031881   0.836  0.40317
V501         0.136038   0.012474  10.905  < 2e-16 ***
V714        -0.022173   0.025187  -0.880  0.37869
AgeCur2      1.364853   0.109383  12.478  < 2e-16 ***
AgeCur3      2.112351   0.108499  19.469  < 2e-16 ***
AgeCur4      2.387178   0.109640  21.773  < 2e-16 ***
Rural        0.005827   0.030452   0.191  0.84825
EduPri      -0.067070   0.033777  -1.986  0.04707 *
EduSec      -0.451003   0.039175 -11.512  < 2e-16 ***
EduHigher   -0.661520   0.104200  -6.349 2.17e-10 ***
WInd2       -0.059297   0.036508  -1.624  0.10433
WInd3       -0.115949   0.036440  -3.182  0.00146 **
WInd4       -0.202621   0.042796  -4.735 2.20e-06 ***
WInd5       -0.358748   0.060860  -5.895 3.76e-09 ***
Zero hurdle model coefficients (censored negbin with log link):
            Estimate Std. Error z value Pr(>|z|)
(Intercept) -1.79769    0.26257  -6.847 7.57e-12 ***
V302         2.14929    0.16009  13.426  < 2e-16 ***
V501         0.95583    0.11413   8.375  < 2e-16 ***
V714         0.04806    0.09105   0.528  0.59757
AgeCur2      2.49147    0.17774  14.017  < 2e-16 ***
AgeCur3      4.08000    0.33122  12.318  < 2e-16 ***
```

```
AgeCur4      5.09053    0.50461  10.088  < 2e-16 ***
Rural        0.34821    0.11099   3.137  0.00171 **
EduPri      -0.28740    0.23447  -1.226  0.22030
EduSec      -1.36631    0.24495  -5.578 2.43e-08 ***
EduHigher   -2.79190    0.35717  -7.817 5.42e-15 ***
WInd2       -0.43893    0.14617  -3.003  0.00268 **
WInd3       -0.10182    0.14414  -0.706  0.47995
WInd4       -0.45557    0.15729  -2.896  0.00377 **
WInd5       -0.87517    0.18968  -4.614 3.95e-06 ***
Log(theta)  -0.39355    0.14934  -2.635  0.00841 **
---
Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Theta: zero = 0.6747
Number of iterations in BFGS optimization: 50
Log-likelihood: -8220 on 31 Df
> confint(hurdle.negbin)
                        2.5 %       97.5 %
count_(Intercept) -1.00532318 -0.5422311458
count_V302        -0.03583400  0.0891372138
count_V501         0.11158835  0.1604872983
count_V714        -0.07153890  0.0271935284
count_AgeCur2      1.15046713  1.5792396775
```

count_AgeCur3	1.89969673	2.3250043177
count_AgeCur4	2.17228765	2.6020690793
count_Rural	-0.05385692	0.0655110431
count_EduPri	-0.13327126	-0.0008684071
count_EduSec	-0.52778571	-0.3742210380
count_EduHigher	-0.86574774	-0.4572929468
count_WInd2	-0.13085163	0.0122569316
count_WInd3	-0.18737138	-0.0445273033
count_WInd4	-0.28650037	-0.1187415655
count_WInd5	-0.47803182	-0.2394632414
zero_(Intercept)	-2.31231287	-1.2830608991
zero_V302	1.83551591	2.4630559152
zero_V501	0.73214542	1.1795184767
zero_V714	-0.13039036	0.2265195294
zero_AgeCur2	2.14310187	2.8398319233
zero_AgeCur3	3.43081553	4.7291846553
zero_AgeCur4	4.10150663	6.0795565783
zero_Rural	0.13066522	0.5657463340
zero_EduPri	-0.74695200	0.1721594213
zero_EduSec	-1.84640158	-0.8862283352
zero_EduHigher	-3.49194225	-2.0918494403
zero_WInd2	-0.72542327	-0.1524297814
zero_WInd3	-0.38433757	0.1806950847

```
zero_WInd4        -0.76384726 -0.1472904123

zero_WInd5        -1.24692142 -0.5034090268

> par(mfrow=c(1,1))

> boxplot(res1,res2,res3,res4,res5,res6,res7)

> ?boxplot

> boxplot(res1,res2,res3,res4,res5,res6,res7,
names=c("Poi","QuasiPoi","NegBin","ZIP","ZINB","HLPo","HLNB"))

>
```

remlreg object b: reml procedure

Response:

Number of observations:	75625
Number of observations with positive weight:	75625
Response Variable:	trans1
Family:	binomial
Response function:	logistic distribution function (logit link)

Predictor:

$$\eta = \gamma_{const} const + f_{v531}(v531)$$

Priors:

Fixed effects:
diffuse priors

$f_{v531}(v531)$:
P-spline with second order random walk penalty
Number of knots: 20
Knot choice: equidistant
Degree of Splines: 3

General Options:

Levels for credible intervals:	
Level 1:	95
Level 2:	80
Maxmimum number of iterations:	400
Termination criterion:	1e-05
Stopping criterion for small variances:	0.001

Model Fit:

-2*log-likelihood:	68530.1
Degrees of freedom:	9.40957
(conditional) AIC:	68548.9
(conditional) BIC:	68635.8
GCV (based on deviance residuals):	0.906409

Fixed Effects:

Variable	Post. Mode	Std. Dev.	p-value	95% confidence interval	
const	-2.03715	0.0964107	4.09836e-15	-2.22615	-1.84814

Plots:

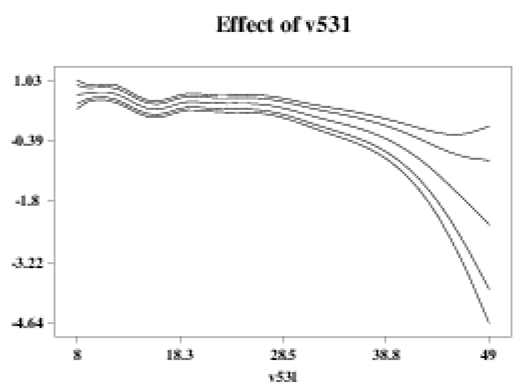

Figure 1: Non–linear Effect of 'v531'. Shown are the posterior modes together with 95% and 80% pointwise credible intervals.

remlreg object b1: reml procedure

Response:

Number of observations:	75625
Number of observations with positive weight:	75625
Response Variable:	trans1
Family:	binomial
Response function:	logistic distribution function (logit link)

Predictor:

$$\eta = \gamma_{const} const + \gamma_{p20067} p20067 + f_{v531}(v531)$$

Priors:

Fixed effects:
diffuse priors

$f_{v531}(v531)$:
P-spline with second order random walk penalty
Number of knots: 20
Knot choice: equidistant
Degree of Splines: 3

General Options:

Levels for credible intervals:	
Level 1:	95
Level 2:	80
Maxmimum number of iterations:	400
Termination criterion:	1e-05
Stopping criterion for small variances:	0.001

Model Fit:

-2*log-likelihood:	68527.1
Degrees of freedom:	10.3974
(conditional) AIC:	68547.9
(conditional) BIC:	68643.9
GCV (based on deviance residuals):	0.906393

Fixed Effects:

Variable	Post. Mode	Std. Dev.	p-value	95% confidence interval	
const	-2.0157	0.0968581	5.21779e-15	-2.20558	-1.82582
p20067	-0.034642	0.0197959	0.0796736	-0.0734497	0.00416567

Plots:

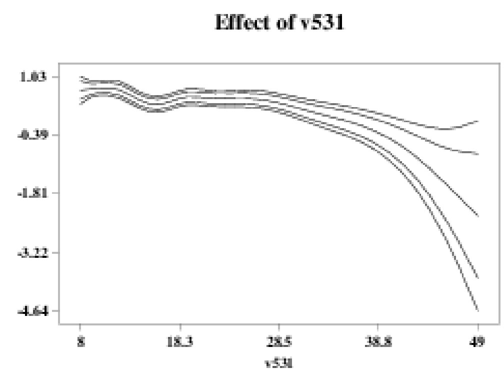

Figure 1: Non–linear Effect of 'v531'. Shown are the posterior modes together with 95% and 80% pointwise credible intervals.

remlreg object b2: reml procedure

Response:

Number of observations:	73120
Number of observations with positive weight:	73120
Response Variable:	trans1
Family:	binomial
Response function:	logistic distribution function (logit link)

Predictor:

$$\eta = \gamma_{const}const + \gamma_{age2024}age2024 + \gamma_{age2529}age2529 + \gamma_{age3034}age3034 + \gamma_{age3539}age3539 + \gamma_{age4044}age4044 + \gamma_{age4549}age4549 + \gamma_{erongo}erongo + \gamma_{hardap}hardap + \gamma_{karas}karas + \gamma_{kavango}kavango + \gamma_{khomas}khomas + \gamma_{kunene}kunene + \gamma_{ohangwena}ohangwena + \gamma_{omaheke}omaheke + \gamma_{omusati}omusati + \gamma_{oshana}oshana + \gamma_{oshikoto}oshikoto + \gamma_{otjozonjupa}otjozonjupa + \gamma_{sechigher}sechigher + \gamma_{urban}urban + \gamma_{catholic}catholic + \gamma_{middle}middle + \gamma_{rich}rich + \gamma_{p20067}p20067 + \gamma_{cohort6574}cohort6574 + \gamma_{cohort7584}cohort7584 + \gamma_{cohort8592}cohort8592 + f_{v531}(v531)$$

Priors:

Fixed effects:
diffuse priors

$f_{v531}(v531)$:
P-spline with second order random walk penalty
Number of knots: 20
Knot choice: equidistant
Degree of Splines: 3

General Options:

Levels for credible intervals:	
Level 1:	95
Level 2:	80

Maxmimum number of iterations:	400
Termination criterion:	1e-05
Stopping criterion for small variances:	0.001

Model Fit:

-2*log-likelihood:	65068.6
Degrees of freedom:	31.7107
(conditional) AIC:	65132
(conditional) BIC:	65423.7
GCV (based on deviance residuals):	0.89066

Fixed Effects:

Variable	Post. Mode	Std. Dev.	p-value	95% confidence interval	
const	-2.51165	0.0982628	1.98748e-16	-2.70428	-2.31901
age2024	0.681424	0.0388272	7.77156e-14	0.605308	0.757541
age2529	0.713015	0.0488085	1.4031e-12	0.617331	0.808699
age3034	0.735613	0.0595309	1.93268e-11	0.618909	0.852317
age3539	0.730576	0.0729786	5.04732e-10	0.587509	0.873643
age4044	0.735146	0.0842382	4.09806e-09	0.570006	0.900286
age4549	0.729384	0.0952199	2.89713e-08	0.542715	0.916052
erongo	-0.0766796	0.0557313	0.168942	-0.185935	0.0325757
hardap	-0.0967149	0.0582354	0.0963756	-0.210879	0.0174494
karas	-0.111599	0.058801	0.0572605	-0.226872	0.00367412
kavango	6.35252e-05	0.0508896	0.999017	-0.0997003	0.0998273
khomas	-0.0688222	0.0515924	0.182381	-0.169964	0.0323193
kunene	-0.0737298	0.0580764	0.20453	-0.187582	0.0401228
ohangwena	-0.100821	0.0521378	0.0527184	-0.203031	0.00139001
omaheke	-0.0598347	0.0576966	0.30017	-0.172943	0.0532734
omusati	-0.167292	0.054421	0.00255622	-0.273978	-0.0606049
oshana	-0.175976	0.0521764	0.00108164	-0.278262	-0.0736894
oshikoto	-0.141354	0.0533493	0.00844172	-0.24594	-0.0367682
otjozonjupa	-0.0534774	0.0541113	0.323446	-0.159557	0.0526022
sechigher	0.0121857	0.0241357	0.613176	-0.0351297	0.0595012
urban	-0.0133698	0.0268461	0.618006	-0.0659988	0.0392591
catholic	0.0162161	0.0242492	0.503451	-0.0313218	0.063754
middle	0.0239404	0.030575	0.433691	-0.0359988	0.0838795
rich	0.000875841	0.0337987	0.979551	-0.065383	0.0671347
p20067	0.045664	0.0267493	0.0873752	-0.00677518	0.0981032
cohort6574	-0.0229899	0.0501133	0.64595	-0.121232	0.075252
cohort7584	-0.0573266	0.0713566	0.42187	-0.197214	0.0825606
cohort8592	-0.314045	0.0908445	0.000847986	-0.492136	-0.135953

Plots:

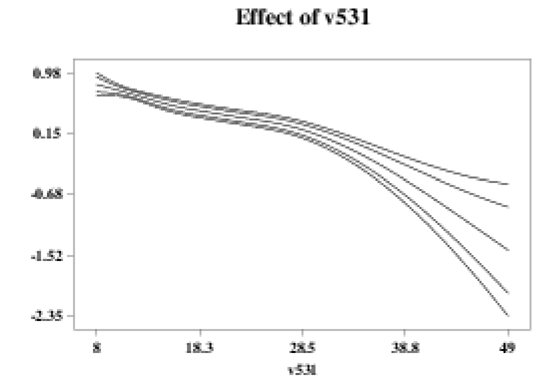

Figure 1: Non–linear Effect of 'v531'. Shown are the posterior modes together with 95% and 80% pointwise credible intervals.

remlreg object b3: reml procedure

Response:

Number of observations:	73120
Number of observations with positive weight:	73120
Response Variable:	trans1
Family:	binomial
Response function:	logistic distribution function (logit link)

Predictor:

$$\eta = \gamma_{const} const + \gamma_{sechigher} sechigher + \gamma_{urban} urban + \gamma_{catholic} catholic + \gamma_{middle} middle + \gamma_{rich} rich + \gamma_{p20067} p20067 + f_{v010}(v010) + f_{v012}(v012) + f_{v531}(v531) + f_{v014}(v014)$$

Priors:

Fixed effects:
diffuse priors

$f_{v010}(v010)$:
P-spline with second order random walk penalty
Number of knots: 20
Knot choice: equidistant
Degree of Splines: 3

$f_{v012}(v012)$:
P-spline with second order random walk penalty
Number of knots: 20
Knot choice: equidistant
Degree of Splines: 3

$f_{v531}(v531)$:
P-spline with second order random walk penalty
Number of knots: 20
Knot choice: equidistant
Degree of Splines: 3

$f_{v014}(v014)$
i.i.d. Gaussian random effects

General Options:

Levels for credible intervals:	
Level 1:	95
Level 2:	80
Maxmimum number of iterations:	400
Termination criterion:	1e-05
Stopping criterion for small variances:	0.001

Model Fit:

-2*log-likelihood:	64672.8
Degrees of freedom:	30.8583
(conditional) AIC:	64734.6
(conditional) BIC:	65018.4
GCV (based on deviance residuals):	0.885222

Fixed Effects:

Variable	Post. Mode	Std. Dev.	p-value	95% confidence interval	
const	-2.20136	0.135725	2.69978e-13	-2.46744	-1.93529
sechigher	-0.00501816	0.0240997	0.835282	-0.0522631	0.0422268
urban	0.00557006	0.0262433	0.832128	-0.0458772	0.0570173
catholic	0.0133436	0.0240096	0.577949	-0.0337247	0.0604118
middle	0.0242235	0.029338	0.40916	-0.0332906	0.0817376
rich	0.0111393	0.0315425	0.723692	-0.0506964	0.0729751
p20067	0.195231	0.1947	0.316436	-0.186458	0.576921

Plots:

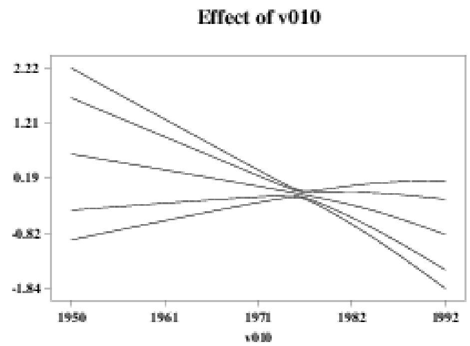

Figure 1: Non–linear Effect of 'v010'. Shown are the posterior modes together with 95% and 80% pointwise credible intervals.

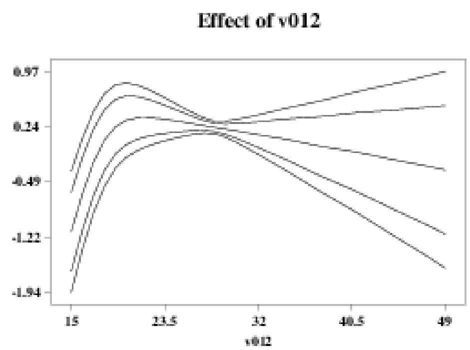

Figure 2: Non–linear Effect of 'v012'. Shown are the posterior modes together with 95% and 80% pointwise credible intervals.

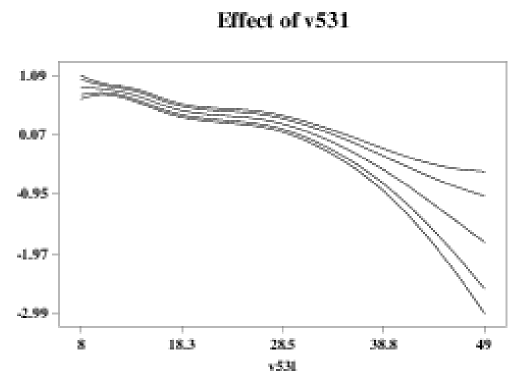

Figure 3: Non–linear Effect of 'v531'. Shown are the posterior modes together with 95% and 80% pointwise credible intervals.

remlreg object b4: reml procedure

Response:

Number of observations:	73120
Number of observations with positive weight:	73120
Response Variable:	trans1
Family:	binomial
Response function:	logistic distribution function (logit link)

Predictor:

$$\eta = \gamma_{const} const + \gamma_{sechigher} sechigher + \gamma_{urban} urban + \gamma_{catholic} catholic + \gamma_{middle} middle + \gamma_{rich} rich + \gamma_{p20067} p20067 + f_{v010}(v010) + f_{v012}(v012) + f_{v531}(v531) + f_{v014}(v014)$$

Priors:

Fixed effects:
diffuse priors

$f_{v010}(v010)$:
P-spline with second order random walk penalty
Number of knots: 20
Knot choice: equidistant
Degree of Splines: 3

$f_{v012}(v012)$:
P-spline with second order random walk penalty
Number of knots: 20
Knot choice: equidistant
Degree of Splines: 3

$f_{v531}(v531)$:
P-spline with second order random walk penalty
Number of knots: 20
Knot choice: equidistant
Degree of Splines: 3

$f_{v014}(v014)$
Markov random field

General Options:

Levels for credible intervals:	
Level 1:	95
Level 2:	80
Maxmimum number of iterations:	400
Termination criterion:	1e-05
Stopping criterion for small variances:	0.001

Model Fit:

-2*log-likelihood:	64671.1
Degrees of freedom:	30.5234
(conditional) AIC:	64732.1
(conditional) BIC:	65012.9
GCV (based on deviance residuals):	0.88519

Fixed Effects:

Variable	Post. Mode	Std. Dev.	p-value	95% confidence interval	
const	-2.19729	0.135612	2.74359e-13	-2.46314	-1.93144
sechigher	-0.0060408	0.0241227	0.802332	-0.0533307	0.0412491
urban	0.00284574	0.0262277	0.914063	-0.048571	0.0542625
catholic	0.0144666	0.0239924	0.546177	-0.0325681	0.0615013
middle	0.0241932	0.0298094	0.417157	-0.0342449	0.0826314
rich	0.0120038	0.0325778	0.712207	-0.0518616	0.0758691
p20067	0.194875	0.194702	0.317323	-0.186818	0.576568

Plots:

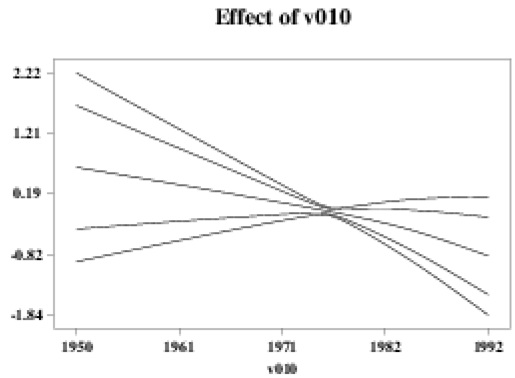

Figure 1: Non–linear Effect of 'v010'. Shown are the posterior modes together with 95% and 80% pointwise credible intervals.

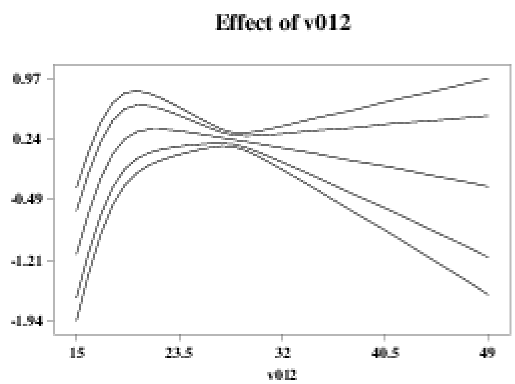

Figure 2: Non–linear Effect of 'v012'. Shown are the posterior modes together with 95% and 80% pointwise credible intervals.

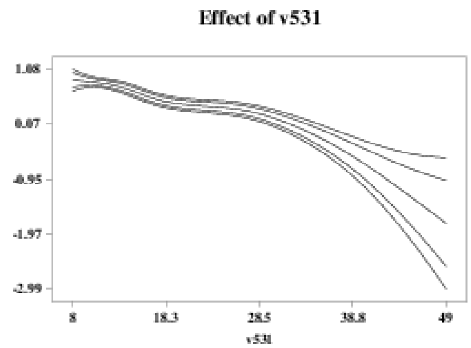

Figure 3: Non–linear Effect of 'v531'. Shown are the posterior modes together with 95% and 80% pointwise credible intervals.

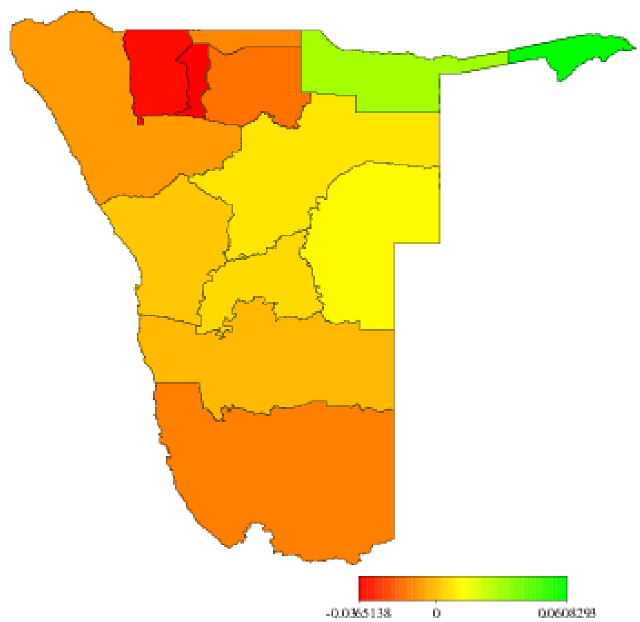

Figure 4: Non–linear Effect of 'v014'. Shown are the posterior modes.

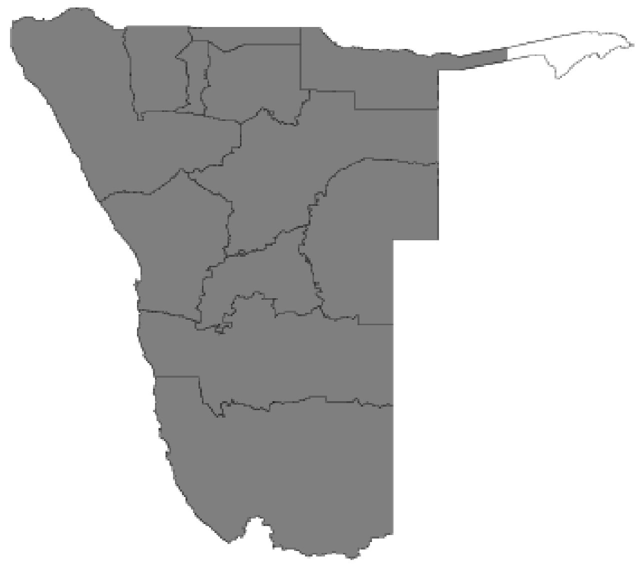

Figure 5: Non–linear Effect of 'v014'. Posterior probabilities for a nominal level of 95%. Black denotes regions with strictly negative credible intervals, white denotes regions with strictly positive credible intervals.

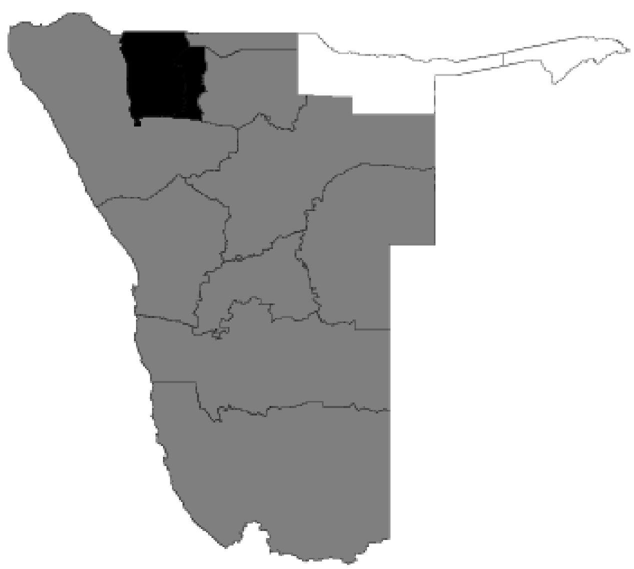

Figure 6: Non–linear Effect of 'v014'. Posterior probabilities for a nominal level of 80%. Black denotes regions with strictly negative credible intervals, white denotes regions with strictly positive credible intervals.

remlreg object b5: reml procedure

Response:

Number of observations:	73120
Number of observations with positive weight:	73120
Response Variable:	trans1
Family:	binomial
Response function:	logistic distribution function (logit link)

Predictor:

$$\eta = \gamma_{const} const + \gamma_{sechigher} sechigher + \gamma_{urban} urban + \gamma_{catholic} catholic + \gamma_{middle} middle + \gamma_{rich} rich + \gamma_{p20067} p20067 + f_{v010}(v010) + f_{v012}(v012) + f_{v531}(v531) + f_{v014}(v014) + f_{v014}(v014)$$

Priors:

Fixed effects:
diffuse priors

$f_{v010}(v010)$:
P-spline with second order random walk penalty
Number of knots: 20
Knot choice: equidistant
Degree of Splines: 3

$f_{v012}(v012)$:
P-spline with second order random walk penalty
Number of knots: 20
Knot choice: equidistant
Degree of Splines: 3

$f_{v531}(v531)$:
P-spline with second order random walk penalty
Number of knots: 20
Knot choice: equidistant
Degree of Splines: 3

$f_{v014}(v014)$
Markov random field

$f_{v014}(v014)$
i.i.d. Gaussian random effects

General Options:

Levels for credible intervals:	
Level 1:	95
Level 2:	80
Maxmimum number of iterations:	400
Termination criterion:	1e-05
Stopping criterion for small variances:	0.001

Model Fit:

-2*log-likelihood:	64668.7
Degrees of freedom:	32.2794
(conditional) AIC:	64733.2
(conditional) BIC:	65030.2
GCV (based on deviance residuals):	0.8852

Fixed Effects:

Variable	Post. Mode	Std. Dev.	p-value	95% confidence interval	
const	-2.19232	0.135626	2.84813e-13	-2.4582	-1.92643
sechigher	-0.00521511	0.0241629	0.82932	-0.0525839	0.0421537
urban	0.000720331	0.0263738	0.978445	-0.0509828	0.0524235
catholic	0.0139807	0.0240669	0.560909	-0.0332	0.0611614
middle	0.0239452	0.0300488	0.425622	-0.0349623	0.0828528
rich	0.0119392	0.0329822	0.717056	-0.052719	0.0765974
p20067	0.193723	0.194732	0.320265	-0.18803	0.575475

Plots:

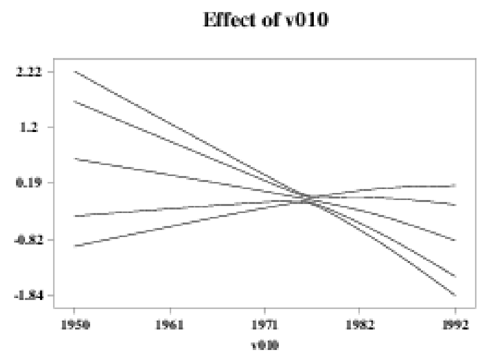

Figure 1: Non–linear Effect of 'v010'. Shown are the posterior modes together with 95% and 80% pointwise credible intervals.

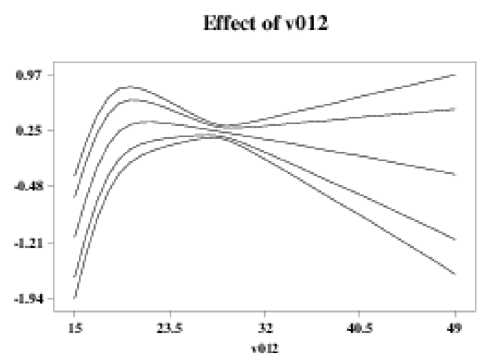

Figure 2: Non–linear Effect of 'v012'. Shown are the posterior modes together with 95% and 80% pointwise credible intervals.

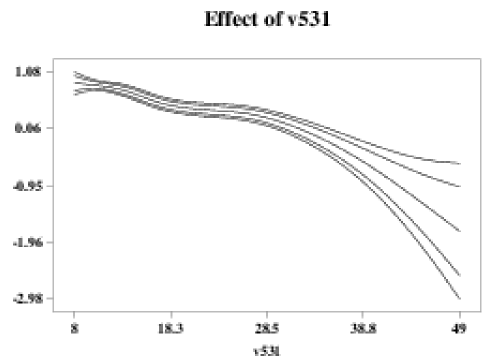

Figure 3: Non–linear Effect of 'v531'. Shown are the posterior modes together with 95% and 80% pointwise credible intervals.

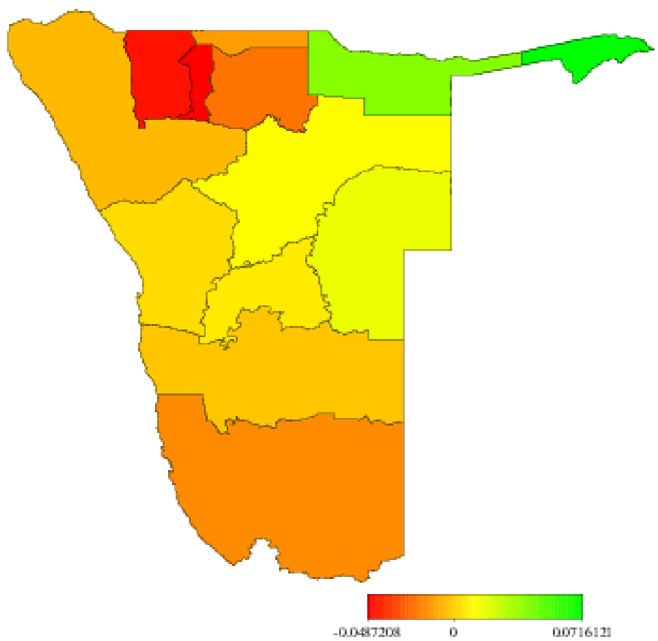

Figure 4: Non–linear Effect of 'v014'. Shown are the posterior modes.

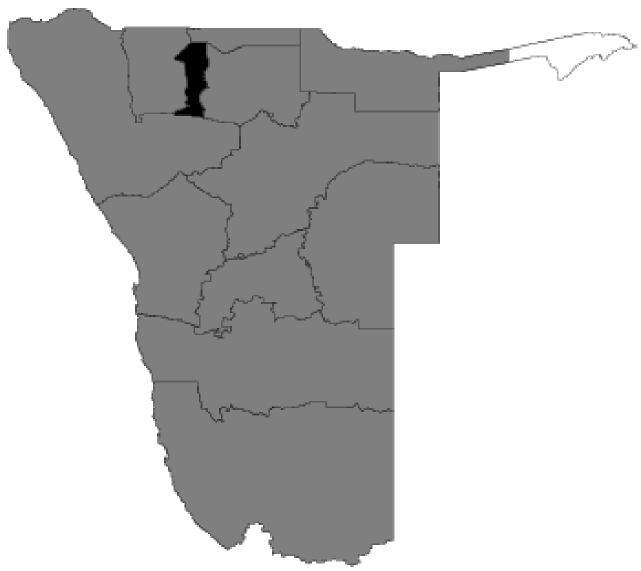

Figure 5: Non–linear Effect of 'v014'. Posterior probabilities for a nominal level of 95%. Black denotes regions with strictly negative credible intervals, white denotes regions with strictly positive credible intervals.

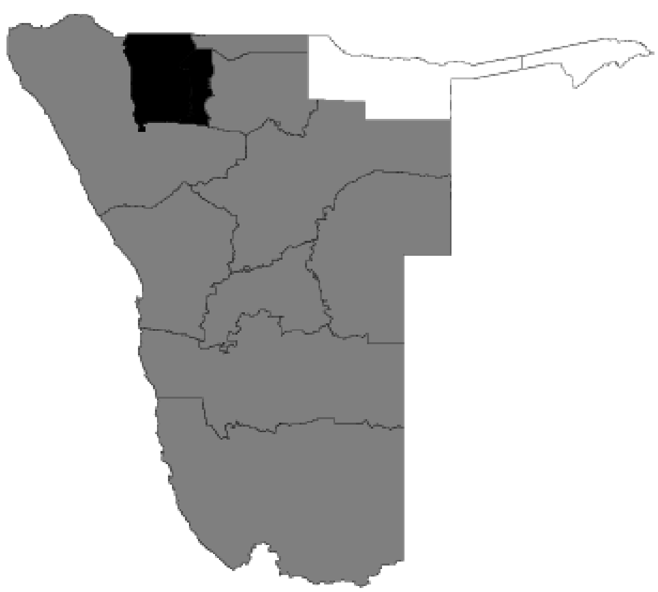

Figure 6: Non–linear Effect of 'v014'. Posterior probabilities for a nominal level of 80%. Black denotes regions with strictly negative credible intervals, white denotes regions with strictly positive credible intervals.

APPENDIX V: Published Papers

Discrete Time to Event Models for Age At First Marriage in Namibia

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The propensity to marry, the stability and duration of marriage have considerable implications for the organization of family life. The age at first marriage may also influence population growth, labour supply, consumption, wage rates, mortality, migration and to some extent fertility. This paper explores the age- period-cohort effects in Namibia by fitting discrete time-to-event models of age at first marriage. We explored a structured additive model for discrete time-to-event outcome derived from a retrospective cross-sectional data of the 2006-7 Namibian Health and Demographic Survey, to establish individual and structural effects, and simultaneously investigate non-linear effects of age, cohort and period on the timing of first marriage among women.

Various models were explored using Bayesian inference and the Cox proportional hazards model. We did not observe any significant nonlinear pattern of age at first marriage with age, cohort and period. First marriage timing among women in Namibia was influenced by the woman's age, birth cohort, period, place of residence, highest educational level, socio-economic status and region. Efforts to discourage early marriage should be stepped up especially in the Zambezi region by improving access to quality higher education.

Introduction

Marriage can be viewed as a social union or legal covenant between two people, normally of opposite sex, in which intimate sexual relationships are acknowledged. Marriage is usually formalized by a wedding or celebration ceremony. People marry for various reasons ranging from social legal, love, emotional, financial, spiritual to religious reasons. There is a general call world-wide to delay marriage and to discourage premarital sex because early marriage, especially among girls, is often associated with adolescent motherhood, school dropouts, maternal morbidity and mortality, and forfeited future life opportunities for the affected individual (Pathfinder International Report, 2006; Green, Makuria and Rubin, 2009). The propensity to marry, the stability and duration of marriage have considerable implications for the organization of family life. The age at first marriage may also influence population growth, labour supply, consumption, wage rates, mortality, migration and to some extent fertility (Mensch, Singh and Casterline, 2005). According to the Namibia Marriage Act No. 25 of 1961, Section 26, no boy under the age of 18 and no girl under the age of 15 years may contract a civil marriage without the permission of a designated government (CRC/C/ADD 12, 1993). The 1992, 2000, and 2006/7 Namibia DHS report showed that mean age at marriage was 24 in 1992, 26.2 in 2000 and 28.6 in 2006/7. In 1992, the median age at first birth was 21 years and 56% of the births were premarital. In Namibia like in most of Southern Africa, premarital child-bearing is a concern especially in terms of the financial responsibility to support the children born.

Junya (2005) established that higher educational career, namely high school to college made one's hazard ratio of marriage drop to approximately 65%, and those with no experience of living apart from their parents tended to marry early. Later marriage for highly educated women primarily reflects longer enrollment in school that university education increasingly is associated with later as less marriage (Raymo, 2003, Mensch, Singh and Casterline, 2005). These findings are in line with the argument that higher education should be negatively associated with marriage only in the countries in which gender relations make it particularly difficult for women to balance work and family. In Nepal, Aryal (2007) established that the risk of getting married early decreased gradually with increasing year of birth cohort, and was higher among females of high socio economic status compared with those of low economic status. This could be explained by the fact that high socio-economic status families were motivated, for religious and prestige, to get their daughters married at an early age, preferably before menarche. Education, occupation and age at menarche were the most powerful factors in deciding the timing of first marriage in Nepal. Other social and family background characteristics were also important determinants of age at first marriage; including how strongly traditional values and ties to the natal family were held by women (Wong, 2005). In Malawi, rising age at marriage was a combination of birth cohort and education effects, depended on the family and to some extent on the community in which a woman resided. These results confirm a downward trend in teenage marriage and that raising women's education levels in sub-Saharan Africa have the beneficial effect of increasing age at marriage, and by implication reducing total fertility rates (Manda and Meyer, 2005).

For men, the decision whether to get married was strongly negatively affected by holding unstable contracts or not working relative to when an indefinite contract was held. However, for women, holding fixed term contracts was not a deterrent factor for the decision whether to get married (De La Rica and Iza, 2005). Discrete time to event models have been widely used (Manda and Meyer, 2005; Raymo, 2003; Mensch, Singh and Casterline, 2005;Aryal, 2005; Wong,2005) to analyze the timing of first marriage, first sex and first birth due to their flexibility and robustness .

This paper explores the age- period-cohort effects on age at first marriage in Namibia by fitting discrete time-to-event models to retrospective cross-sectional data from the 2006-7 NDHS, to establish individual and structural effects that impact on the timing of first marriage among women in Namibia

Data and Methods

This study is based on the 2000 and 2006/7 Namibia Demographic and Health Survey (DHS). DHS is a national survey drawn on using a multistage cluster sampling. At first stage, a random sample of enumeration areas (EA), which are primary sampling units, was chosen from the census sampling frame. From the selected EAs, households were systematically drawn. Only women of reproductive age (15–49 years), in the selected households, were interviewed using a face-to-face questionnaire. The questionnaire included variables on individual bio-demographic factors, household characteristics, history of marital unions and births. Final samples included in the analysis were respectively, 6755 from the 2000 survey and 9800 women, from the 2006/7 round of surveys. The independent variables include age, period, cohort, place of residence, age-group, highest educational level, region, religion, and socio-economic status. We explored a structured additive model for discrete time- to-event outcome, to assess individual and structural effects, and simultaneously investigate non-linear effects of age, cohort and period on the timing of first marriage among women. The model was estimated using Bayesian inference.

The standard procedure for examining the effects of covariates (v_i) on survival times is the Cox proportional hazard model where the multiplicative structure

$$\lambda_i = \lambda(t, v_i) = \lambda_0(t)\exp(v_i',\gamma)$$

is assumed for the hazard rate, γ is a vector of regression coefficients and $\lambda_0(t)$ is the baseline hazard rate. The baseline hazard rate is re-parameterized through $g_0 = \log(\lambda_0(t))$ and the covariates are partitioned into groups of different types to extend the Cox model to a semi-parametric hazard rate model so that $\lambda_i(t) = \exp(\eta_i(t)),\ i = 1,2,\cdots,n$ is a geo-additive predictor predictor of the form

$$\eta_i(t) = v_i'\Upsilon + g_o(t) + \sum_{j=1}^{J} f_j(x_{ij}) + f_{spat}(s_i) + b_{gi}$$

where $f_j(x_{ij})$ is the non-linear effect of continuous covariates x_j, and $f_{spat}(s)$ is the spatial effect. The vector of linear effects is denoted by γ while b_g, $g \in \{1, \cdots, G\}$ are uncorrelated individual or group specific frailties. An extended geo-additive Cox model that addresses arbitrary combinations of left , right and interval censoring schemes and relaxes the proportional hazards assumption by allowing all covariates to be piecewise constant i.e. time varying was further proposed by Kneib (2006). Extensions of geo-additive models have been widely developed and adopted (Hennerfeind et al, 2006; Khatab and Fahrmeir, 2009; Claudio et al, 2012; Olubiyi and Olubusoye, 2013).

Evaluation of the posterior distribution of the model parameters was based on Empirical Bayesian inference. Model diagnostics were based on the Akaike Information Criterion (AIC) and the Bayesian Information criteria (BIC). The best model is the one with the smallest AIC and BIC. AIC and BIC regulate the trade-off between the goodness of fit of the model and the complexity by imposing a penalty that discourages over-fitting (increasing the number of free parameters in the data-generating process). All analyses were carried out in BayesX , a software for Bayesian inference in Structured Additive Regression models – version 2.0.1 (Berlitz et al., 2009).

Results

The background characteristics of the sample after restructuring the data are presented in Table 1.

Table 1: Sample Characteristics of women (N=82795)

Variable	N	Percentage
Age-group		
15-19	18175	22.0
20-24	15970	19.3
25-29	13350	16.1
30-34	12150	14.7
35-39	9325	11.3
40-44	8025	9.7
45-49	5800	7.0
Period		
2000	33775	40.8
2006/7	49020	59.2
Cohort		
1950-1964	15100	18.3
1965-1974	21770	26.3
1975-1984	29575	35.7
1985-1992	16350	19.7
Region		
Zambezi	4860	5.9
Erongo	5985	7.2

Hardap	5220	6.3
!Karas	4890	5.9
Kavango(East and West)	7525	9.1
Khomas	7730	9.3
Kunene	8105	9.8
Ohangwena	4660	5.6
Omaheke	5420	6.5
Omusati	6905	8.3
Oshana	7920	9.6
Oshikoto	7010	8.5
Otjozonjupa	6565	7.9
Place of Residence		
Rural	45260	54.7
Urban	37537	45.3
Level of education		
Primary or No Formal	31795	38.4
Secondary or Higher	51000	61.6
Religion		
Protestant	61985	74.9
Catholic	18835	22.8
No religion	1150	1.4
Other	475	0.6
Missing	350	0.4
Wealth Index		
Poor	14490	17.5
Poorer	14515	17.5
Middle	17425	21.0
Richer	18640	22.5
Richest	14910	18.0
Missing	2815	3.4

Age group composition was a s follows: 15-19 (22.5%), 20-24 (19.1%), 25-29 (15.9%), 30-34 (14.5%), 35-39 (11.0%), 40-44 (9.7%), and 45-49 (7.3%). More than half of the women resided in rural areas (55.1%). The distribution of the women's highest educational level was 7.9% no formal education, 26.7% primary education, 59.7% secondary education, and 5.7% higher education. The wealth index income quintiles comprised of the poorest (16.3%), poorer (17.9%), middle (22.7%), richer (25.0%) and richest (18.2%). The main languages spoken at home by the women were Afrikaans (9.2%), Damara/Nama (15.1%), Herero (8.1%), Caprivi and Kavango (11.4%), Oshiwambo (45.7%) , English and other languages (10.5%).

Figure 1 is a histogram showing the distribution of age at first marriage. The mean age at first marriage was 22.6 years with a standard deviation of 6.1 years.

Figure 1. Histogram of age at first marriage

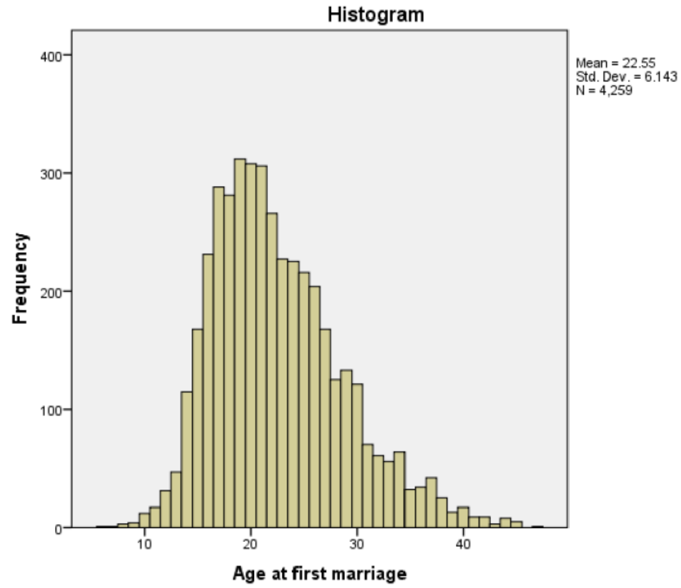


Figure 2 shows the survival function by age group. The function suggests that the probability of first marriage differs by age group

Figure 2. Survival function by age group

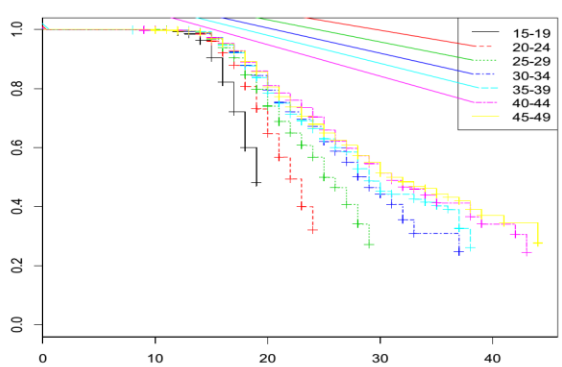
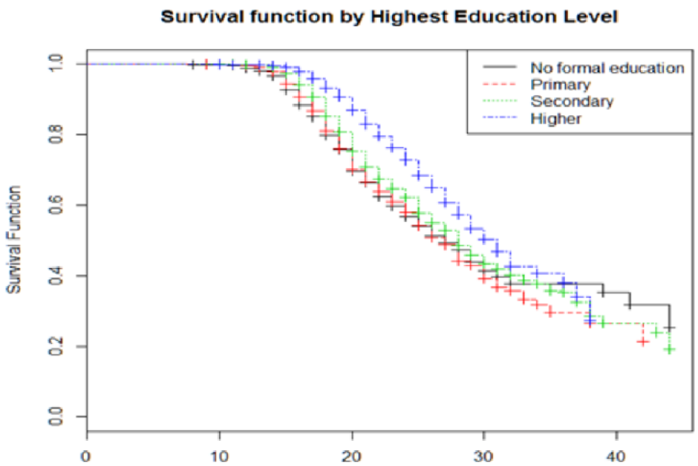


Figure 3 shows the survival function by highest educational level. Again the function also suggests that the probability of first marriage seems to differ by the educational level of the woman.

Figure 3 Survival function by Highest Educational level



Five hazard models were explored to investigate the effect of observed and unobserved heterogeneity on the timing of first marriage in Namibia. The fitted models were defined as follows:

Model 1: $\eta_1 = f(baseline)$

Model 2: $\eta_2 = f(baseline) + trend$

Model 3: $\eta_3 = f(baseline) + trend + fixed\ (cat) + fixed(Region)$

Model 4a: $\eta_4 = f(baseline) + trend + fixed + nonlinear + random\ (Region)$

Model 4b: $\eta_4 = f(baseline) + trend + fixed + nonlinear + spatial(Region)$

Model 5:
$\eta_5 = f(baseline) + trend + fixed + nonlinear + random(Reg) + spatial(Region)$

The nesting structure of the models is summarized in Table 2.

Table 2: Nesting structure of models 1 to 5.

Model specification	Baseline $g_0(t)$	Time t	Fixed effect V_j	Non-linear effect	Random effect	Spatial effect
1	X					
2	X	X				
3	X	X	X			
4a	X	X	X	X	X	
4b	X	X	X	X		X
5	X	X	X	X	X	X

Table 3 shows the model comparison statistics for all the fitted models. Model 3 had the smallest AIC and BIC was therefore chosen as the best model and was considered for discussion.

Table 3 : Model comparison statistics.

Model specification	-2 Log-Likelihood	df	AIC	BIC
1	38095.6	11.26	38118.2	38214.4
2	38095.6	13.26	38122.2	38235.5
3*	**36564.6**	**43.18**	**36650.8**	**37018.0**
4a	36564.4	48.01	36660.4	37068.8
4b	36564.4	47.37	36659.1	37062.0
5	36564.4	48.22	36660.8	37071.0

*Best model

Results of Cox Regression based on the best model

Table 4 displays the Cox regression results.

Table 4: Regression estimates under the best model

Variable	Hazard Ratio		95% Confidence interval	
Age				
15-19	7.205***		5.633	9.218
20-24	3.528***		2.921	4.260
25-29	2.093***		1.788	2.450
30-34	1.520***		1.326	1.742
35-39	1.235***		1.107	1.377
40-44	1.151**		1.051	1.259
45-49 (Ref)	1.000			

Period				
2000	1.143***		1.073	1.218
2006	1.074*		1.002	1.152
2007(ref)	1.000			
Cohort				
1950-1964	0.578***		0.457	0.730
1965-1974	0.612***		0.504	0.743
1975-1984	0.707***		0.605	0.828
1985-1992 (ref)	1.000			
Place of residence				
Rural	0.869***		0.817	0.923
Urban(ref)				
Educational level				
No Formal (ref)	1.354***		1.195	1.534
Primary	1.252**		1.121	1.398
Secondary	1.086		0.979	1.205
Higher	1.000			
Wealth Index				
Poorest	0.888*		0.795	0.992
Poorer	0.845**		0.765	0.934
Middle	0.877**		0.807	0.954
Richer	0.921*		0.855	0.993
Richest (ref)	1.000			
Religion				
Catholic	1.049		0.992	1.109
Protestant(ref)	1.000			
Region				
Zambezi	1.133*		1.003	1.280
Erongo	0.944		0.847	1.052
Hardap	0.900		0.800	1.013
Karas	0.856*		0.760	0.964
Kavango	1.022		0.920	1.136
Khomas	0.912		0.821	1.014
Kunene	0.975		0.859	1.107
Ohangwena	1.117		0.992	1.258
Omaheke	0.938		0.831	1.059
Omusati	0.728***		0.632	0.838
Oshana	0.800***		0.711	0.900
Oshikoto	0.765***		0.678	0.864
Otjozonjupa(ref)	1.000			

*****p<0.001, **p<0.01, * p<0.05**

Compared to women in the 45-49 age group, there was a significantly higher risk of first marriage among those women in the younger age groups namely 15-19 (HR=7.205), 20-24 (HR=3.528), 25-29 (HR=2.093), 30-34 (HR=1.520), 35-39(HR=1.235), 40=44(HR=1.151). The risk of first marriage decreased as the age of the woman decreased. With regard to period, the risk of first marriage was higher in 2000 (HR=1.143), and reduced in 2006 (HR=1.074) compared to 2007. There were significant differences in the timing of first marriage between birth cohorts. Women born in the cohorts 1950 -1964 (HR=0.578), 1965-1974 (HR=0.612), and the 1975-1984 (HR=0.707) had lower risk of first marriage compared to their counterparts in the 1985-1992 cohort.

With regard to the highest educational level of the woman, risk of early first marriage was significantly higher among those women with no formal education (HR=1.354) and those with primary education (HR=1.252) compared to those with higher education. However, there were no significant differentials in the timing of first marriage between women with secondary education and those with higher education (p=0.120). Compared to the richest women, richer women (HR=0.921), women in the middle socio-economic quintile (HR=0.877) , the poorer (HR=0.845) and the poorest women (HR=0.888) had relatively lower risk of first marriage. There were no significant differentials in the timing of first marriage with respect to religion (p=0.091).

With regard to region, women in the Oshikoto region(HR=0.765), Oshana region (HR=0.800) and Omusati region (HR=0.728) had relatively lower risk of early first marriage compared to those in the Otjozonjupa region. However, women from the Zambezi region(HR=1.133) had significantly higher risk of early first marriage compared to their counterparts in the Otjozonjupa region. Compared to women in urban areas, rural women (HR=0.869) were at a significantly lower risk of early first marriage.

Discussion

Regression results indicated that there was a significantly higher risk of first marriage among those women in the younger age groups compared to those in the 45-49 age group. This is expected since most first marriages occur in the twenties to early thirties and by age forty most of those wishing to marry will have already done so. With regard to period, the risk of first marriage was higher in 2000 and decreased in 2006 compared to 2007. This reduction in the risk of first marriage could be attributed to the general decline in marriage rates over the years due to increasing cohabitation and singlehood (Copen etal., 2012). There were significant differences in the timing of first marriage between birth cohorts. Women born in the 1950 -1974 cohorts had lower risk of first marriage compared to their counterparts in the 1985-1992 cohort. This is somehow surprising as results from other studies suggest that women born in the older cohorts had higher risk of early first marriage (Aryal,2007).

With regard to the highest educational level of the woman, risk of early first marriage was significantly higher among those women with no formal education (HR=1.354) and those with primary education (HR=1.252) compared to those with higher education. However, there were no significant differentials in the timing of first marriage between women with secondary education and those with higher education (p=0.120). These findings are in line with results from other parts of the world (Agaba, Atuhaire, and Rutaremwa, 2011;Kamchulesi, Palamuleni, and Kalule-Sabiti, 2011;Hymowitz et al., 2013; Haloi and Limbu, 2013; Hoq,2013)

Compared rich women, poor women had relatively lower risk of first marriage. These findings seem to suggest that in Namibia, women's riches may attract male marriage partners. Studies elsewhere suggest the opposite, with poor women having a relatively higher risk of first marriage (Haloi and Limbu, 2013; Saviram, Richard, and Rao, 1995; Hoq,2013). There were no significant differentials in the timing of first marriage with respect to religion (p=0.091). This could be because Namibia has become a secular society causing vast dilution of the once so strong religions like the Roman Catholic and protestant religions. However, in some societies, religion still plays a significant role in the timing of first marriage (Okeibunor, 1999; Hoq, 2013; Kamchulesi, Palamuleni, and Kalule Sabiti, 2011; Agaba, Atuhaire, and Rutaremwa, 2011; Rahman, Islam, and Hossain, 2008).

With regard to region, women in the Oshikoto region (HR=0.765), Oshana region (HR=0.800) and Omusati region (HR=0.728) had relatively lower risk of early first marriage compared to those in the Otjozonjupa region. However, women from the Zambezi region (HR=1.133) had a significantly higher risk of early first marriage compared to their counterparts in the Otjozonjupa region. Regional differentials in other countries (Adewole, etal, 2012, Rokonuzzaman and Chowdry, 2013; Pande, 2004).The regional differences in the timing of first marriage in Namibia could be due to different levels of economic development, clustering of regional ethnic groupings and varying levels of access to information which influences marital decision making. Compared to women in urban areas, rural women (HR=0.869) were at a significantly lower risk of early first marriage.These findings are unexpected as similar studies elsewhere suggest otherwise (Hoq, 2013; Sivaram et al., 1995; Agaba, Atuhaire, and Rutaremwa, 2011, Adir, 2007).

Conclusions

The effects of age, period and cohort in the timing of first marriage were established among women in Namibia. In addition, marriage timing among women was influenced by rural urban place of residence, highest educational level, socio-economic status and region. Efforts to discourage early marriage should be stepped up especially in the Zambezi region.

Acknowledgements

The authors acknowledge permission by Measure DHS and the Namibia Ministry of health and Social Services to use the data analyzed in this study. This research was made possible through funding from UNFPA and the University of Namibia.

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Journal of Mathematics and System Science 4 (2014) 498-508

A Hurdle Negative Binomial Regression Model for Non-Marital Fertility in Namibia

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Received: April 11, 2014 / Accepted: May 12, 2014 / Published: July 25, 2014.

Abstract: The rise of non-marital fertility, which seems to defy the Bongaarts model by decoupling marriage from fertility, has become a subject of interest in both the developed and developing world. Consequences of non-marital fertility are mostly negative particularly in developing countries. In Namibia, although premarital childbearing has been reported to be high and increasing, no studies have explicitly analyzed factors influencing non-marital fertility. This paper uses data from the 2006/7 Namibia DHS to establish the determinants of non-marital fertility among women by applying a two-part model, with one part to describe the presence of non-marital birth and the other part to explain its intensity (number of children born). Using the number of children ever born as an outcome, we explored various count data models. Based on the Voung statistics model comparison, we settled for the Hurdle logit Negative Binomial regression to model the number of non-marital births. Non-marital fertility in Namibia is associated with the age, with young women likely to have lower fertility compared to older women. Women with secondary or higher education had lower fertility compared those with no formal education. Findings also show that rural women higher fertility propensity compared to their urban counterparts even though there was no significant difference in fertility intensity. With regard to socio-economic status, fertility intensity decreased as the women got richer. Intervention efforts should focus on promoting education among girls and women especially in rural areas to improve their socio-economic status, reduce teenage pregnancy and non-marital fertility.

Keywords: non-marital fertility, hurdle logit negative binomial, two-part models, Namibia

1. Introduction

1.1 Background

The rise of non-marital fertility, which seems to defy the Bongaarts model by decoupling marriage from fertility, has become a subject of interest in both the developed and developing world (Moses and Kayizzi, 2007, Bongaarts , 1978). Non-marital fertility can arise especially among young women who never have been married, or among older women who were previously married but who were widowed or divorced at the time of the birth. Consequences of non-marital fertility include school abandonment, missed life opportunity, limited choice of future partners, higher health risks, stigmatization, exclusion, and subsequent deviant behavior (Zwang and Garenne, 2008).

Research suggests that non-marital childbearing is part of a global process of family change unlikely to disappear (Kiernan, 2004). In Southern Africa, family formation has undergone rapid transformation over the past few years with reduction in marriage rates, increasing prevalence of divorce, increase in cohabitation (Nzimande, 2007; Mturi et al, 2005, Moses and Kayizzi, 2007, Shemeikka, Notkola, Kuhanen and Siiskonen, 2008). Consequently, as marriage rates continued to decrease, non-marital child-bearing was increasingly becoming common in South Africa.

Non-marital births are mainly due to increasing diversity in marriage and family forms, changing

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social and cultural norms including increased acceptance of pre-marital sex, out of wedlock childbearing, abortions, divorce, decisions never to marry, religious reasons (Le sthaeghe, 2010; Klusener , Perelli-Harris, and Gassen , 2012); Wildssmith and Paley, 2006); Plotnick , 2004). Other studies have established that greater labour-force participation, the availability and accessibility of contraceptives have some association with non-marital child-bearing (Musick,2007; Elendou-Enyengue and Magazi, 2011, Wildssmith and Paley, 2006, Musan, Kisovi, and Tonui, 2012, Zwang and Garenne, 2008). In some cultures, non-marital child-bearing among adolescents is a means to prove fertility and might even be a pre-requisite to marriage. (Miller, Park and Thomas, 2003;Stockard, Gray, O'brien and Stone, 2009). Furthermore, instability in family living arrangements due to parents' divorce, frequent migration, sexual abuse at childhood, highly concentrated, resource-deprived neighbourhoods, and those who lack positive role models in their family and community have all been linked to differentials in non-marital fertility (Perrelli-Harris and Gerber, 2008).

Non-marital fertility is also thought to be linked to demographic factors such as younger age, early age at first intercourse, age at menarche, and delayed age at marriage, and place of residence (Amoateng, 2004; Chabeda, 2009). In Russia, Perrelli-Harris and Gerber (2008) established that women with higher education were more likely to marry once they conceived a child outside of marriage. Variation in the time to next birth among comparable unmarried and married mothers who live in different cities is partly due to variation in labour markets, housing costs, and availability and welfare policies (Curtis and Waldfogel, 2009). According to Dyer and Farlie (2004), family CAP policies did not reduce non marital births among single, less educated women with children examined the impact of family CAP policies (policies that seek to reduce fertility among welfare recipients by denying additional cash assistance to recipients that have children while on welfare) in the US.

1.2 Modelling Considerations

Non-marital fertility, measured by the number of non-marital births per woman is an example of an event count. The basic model to establish correlates of non-marital fertility is the Poisson regression model. However, this model rarely fits data because of over-dispersion. An improvement on the Poisson model is the negative binomial regression model, which addresses the problem of over-dispersion but there is often another challenge of too many zero counts in the data (Park, 2005). Count data such as non-marital fertility often show high incidence of zero counts than would be expected if the data followed a Poisson, or negative binomial distribution. In such cases, a zero inflated Poisson or Negative Binomial distribution may be more appropriate.

Zero-inflated models handle over-dispersion by changing the mean structure to explicitly model the production of zero counts, by assuming two latent groups. One is always the zero group, and the other is the not-always-zero or sometimes-zero group. That is to say, the zero counts emerge from the former group and some of the latter group with a certain probability (Ridout, Hinde & Demetrio, 2001; Park, 2005; Gonzales-Barron, Kerr, Sheridan and Butler, 2010). One may also consider the non-marital fertility births to follow a two-part process, with one part describing the incidence (whether or not a non-marital birth occurred in the first place) and the other intensity (measured by the parities) (Mwalili, Lesaffre, and Declerck, 2007; Miranda, 2010; Chipeta, Ngwira and Kazembe, 2013). In such a situation, a hurdle negative binomial regression model, that permits covariates on both parts will be ideal to explore. According to our knowledge, zero-inflated and hurdle regression models have been widely applied in economics, epidemiology and other fields but very few have been applied in fertility studies (Melkersson and Rooth 2000, Santos Silva and Covas 2000, Moffatt and

Peters 2000). Most studies on fertility have applied ordinary logistic regression (Mzimande, 2007, Gage 1998, Orieji 1997). However, use of logit model leads to loss of information, in that it only describes the process of having non-marital births versus not having, and ignores the other process of continued births after the initial birth. We argue that a two-part model is suited to describe the processes of (i) whether non-marital birth occurred; and (ii) the number of births if non-marital birth did occur. This paper, therefore used hurdle models to establish the determinants of non-marital fertility among women in the reproductive age-group (15-49) in Namibia. Our analysis also explored various count models and compared their fit to the hurdle models.

2. Methods

2.1 Data

This study was based on Namibian Demographic and Health Survey (DHS) of 2006/7. DHS is a national survey with respondents drawn using a multistage cluster sampling. At first stage, a random sample of enumeration areas (EA), which are primary sampling units, was chosen from the 2001 Namibia population and housing census sampling frame. From the selected EAs, households were systematically selected. Every woman in the selected households of the reproductive age (15-49 years) was asked to participate in the study. A total of 9804 women, in the selected households, were interviewed using a face-to-face questionnaire. The questionnaire included variables on individual bio-demographic factors, household characteristics, history of marital unions and births. Data included in this analysis comprised of 7117 non-married women who had either never married or were cohabiting at the time of the survey.

The outcome variable was the total children ever born. Covariates considered in the analysis included bio-demographic and household variables, as informed by various literature in this area (Musick,2007; Elendou-Enyengue and Magazi, 2011, Wildssmith and Paley, 2006, Musan, Kisovi, and Tonui, 2012, Zwang and Garenne, 2008). Bio-demographic characteristics related to a woman included current age, age at first birth, employment status, religion and education level and intimate relationship status. Household characteristics consisted of place of residence (rural or urban) and wealth index. The wealth index was used as a proxy for the standard of living of the household (Namibia Demographic and Health Survey Report, 2006-07). It is based on household ownership of consumer goods; dwelling characteristics; type of drinking water source; toilet facilities; and other characteristics related to household socio-economic status. To construct the index, each of the assets was assigned a weight (factor score) generated through principal component analysis and the resulting asset scores were standardized in relation to the standard normal distribution. Each household was then assigned a score for each asset and the scores were summed for each household. Individuals were ranked according to the total score of the household in which they reside. The sample was then divided into quintiles from one (poorest) to five (richest).

2.2 Statistical Analysis

Modelling the total children ever born to non-married women can be handled using any of the following models: Poisson, Negative Binomial, zero-inflated and hurdle models (Kazembe 2013; Miranda 2014, Santos Silva and Covas 2000, Moffat and Peters 2000). All have the flexibility and power of parametric models, handling repeated measures, multiple covariates, and various configurations of fixed and random effects, without assuming that the outcome is normally distributed (Hu, Pavlicova and Nunes, 2011), and were explored in this study.

The basic model for count data is the Poisson regression. Define y_i as the number of children ever born then

$$f(y_i) = P(Y_i = y_i) = \frac{\lambda_i^{y_i} \exp(-\lambda_i)}{y_i!}, y_i = 0,1,2,\cdots$$

Conditional on explanatory variables x_i, the mean number of children born can be modelled as

$$ln\lambda_i = x_i{}'\beta \qquad (1)$$

The Poisson model assumes equi-dispersion, that is, $E[Y_i|X_i] = Var[Y_i|X_i] = \lambda_i = \exp(x_i^{'}\beta)$. This assumption is restrictive and can be difficult to attain for over-dispersed data. In case of over-dispersion, the negative binomial regression model has been proposed as an alternative. This is obtained by adding an error term to the Poisson regression model to give

$$ln\lambda_i = x_i^{'}\beta + \varepsilon_{i'} \qquad (2)$$

such that $\exp(\varepsilon_i)$ follows a gamma distribution of mean 1 and variance α. With some algebraic manipulation by substituting equation (2) into (1) one has

$$f(y_i) = P(Y_i = y_i) = \frac{\Gamma(\theta + y_i)}{\Gamma(\theta) y_i!} u_i{}^{\theta}(1 - u_i)^{y_i},\ y_i = 0,1,2,\cdots$$

such that $u_i = \frac{\theta}{\theta + \lambda_i}, \theta = \frac{1}{\alpha}\ and\ \Gamma(.)$ is a gamma function.

Although Poisson and Negative Binomial regression models are suited to model count observations, in some situations fertility decisions are a mechanism of two way tied process characterizing a large part of women who do not go into non-marital child-bearing. The two-part model decomposes the number of births one has, (y_i), into two observed random components: $y_i > 0$ and $y_i|y_i > 0$ and specify appropriate regression component to each part. These two-part models are also referred to as zero-hurdle models (Winkelmann, 2004, Winkelmann, 2008). For the Poisson hurdle model we have

$$P(Y_i = 0) = 1 - p_i, 0 \leq p_i \leq 1$$

$$P(Y_i = k) = p_i \frac{\lambda^k e^{-\lambda}}{k!\,[1 - e^{-\lambda}]}, k = 1, 2, \cdots\infty, 0 \leq \lambda \leq \infty$$

where Y_i indicates the response for woman $i = 1,2,\cdots,n$ and λ is the mean for the truncated Poisson distribution. An alternative to the Poisson hurdle is a hurdle negative binomial which is given by

$$P(Y_i = 0) = 1 - p_i, 0 \leq p_i \leq 1$$

$$P(Y_i = k) = p_i \frac{\Gamma(k + \theta)}{k!\,\Gamma(\theta)} \left(1 + \frac{\lambda}{\theta}\right)^{-\theta} \left(1 + \frac{\lambda}{\theta}\right)^{-k}, k = 1, 2, \cdots\infty, 0 \leq \lambda \leq \infty$$

with parameters $\lambda \geq 0$ for the mean and $\theta > 0$ for over-dispersion. The component p is a fertility propensity, while the count part models the fertility intensity of the woman. A special case of the models above is the zero-inflated Poisson or zero-inflated Negative binomial. These models have a degenerate distribution at zero with untruncated Poisson or Negative binomial distribution. A zero-inflated Poisson is denoted by $Y_i|\eta_i, \lambda \sim ZIP\ (\eta_i, \lambda)$. Combining zero inflation and over-dispersion gives a zero inflated negative binomial defined as $Y_i|\eta_i, \theta, \lambda \sim ZINB\ (\eta_i, \theta, \lambda)$, where η and θ are the predictor and over-dispersion parameters respectively.

The zero-hurdle model can be extended to accommodate covariates. Since we have two parts, the propensity component assumes a logit link while the intensity component we proposed a log link:

$$\eta = \begin{pmatrix} logit(p_i) \\ logit(\lambda_i) \end{pmatrix} = \begin{pmatrix} \alpha_1 \\ \alpha_2 \end{pmatrix} + X_{ij}^T \begin{pmatrix} \beta_1 \\ \beta_2 \end{pmatrix}$$

where α_l is the intercept for process l, the terms $\beta = (\beta_1, \beta_2)^T$ are vectors of regression parameters corresponding to the set of covariates, X_{ij}.

Now in our analysis, all types of models overviewed were fitted. In total, seven models were estimated for non-marital fertility data using the *pscl* package (Zeileis, Kleiber and Jackman, 2009) in the R statistical software. Over-dispersion in the data was evaluated using the Likelihood ratio test. Goodness of fit between pairs of competing models was assessed using the Voung statistic (Park, 2005). All models included the same set of independent variables: current age of the respondent, place of residence, highest educational level, religion, socio-economic status, age at first birth, contraceptive use, relationship status and employment status.

3. Results

3.1 Descriptive Summary statistics

The average age of the sampled women was 25.48 years with a standard deviation of 8.43 years and ranged from 15 to 49 years. The total number of children ever born to non-married women averaged 1.41 with a standard deviation of 1.81 with a range of 0 to 13 children. The other sample characteristics are summarized in Table 1.

The distribution of the women by age group was 15-19 (30.5%), 20-24 (24.2%), 25-29 (16.9%), 30-34 (12.4%), 35-39 (7.8%), 40-44 (5.2%), and 45-49 (3.1%). The sample of non-married women consisted mainly of young women, the majority being aged between 15 to 24 and the numbers decreased by age, most of them had secondary education and lived in rural areas.The percentage of women residing in urban areas was 44.8% and the rest were residing in rural areas. The highest educational levels of the women ranged from no formal education (6.4%), primary education (25.0%), secondary education (64.9%) and higher education. In terms of religion, most of the women (76.8%) belonged to Protestant and other

Table 1 Background characteristics of non-married women from the survey

Variable	Number (%)
Age-group (years)	
15-19	2168 (30.5)
20-24	1719 (24.2)
25-29	1200 (16.9)
30-39	1439 (20.2)
40-49	591 (8.3)
Type of place of residence	
Urban	3190 (44.8)
Rural	3927 (55.2)
Highest Educational level	
No Education	453 (6.4)
Primary	1782 (25.0)
Secondary	4619 (64.9)
Higher	263 (3.7)
Religion	
Roman Catholic	1644 (23.2)
Protestant and Others	5457 (76.8)
Wealth Index	
Poorest	1134 (15.9)
Poorer	1320 (18.5)
Middle	1670 (23.5)
Richer	1855 (26.1)
Richest	1138 (16.0)
Current Marital Status	
Never Married	5545 (77.9)
Living Together (Cohabiting)	1572 (22.1)
Employment Status	
Not Employed	4354 (61.5)
Employed	2720 (38.5)
Contraceptive Use	
Never Used	2313 (61.5)
Used Traditional or Modern Methods	4804 (67.5)

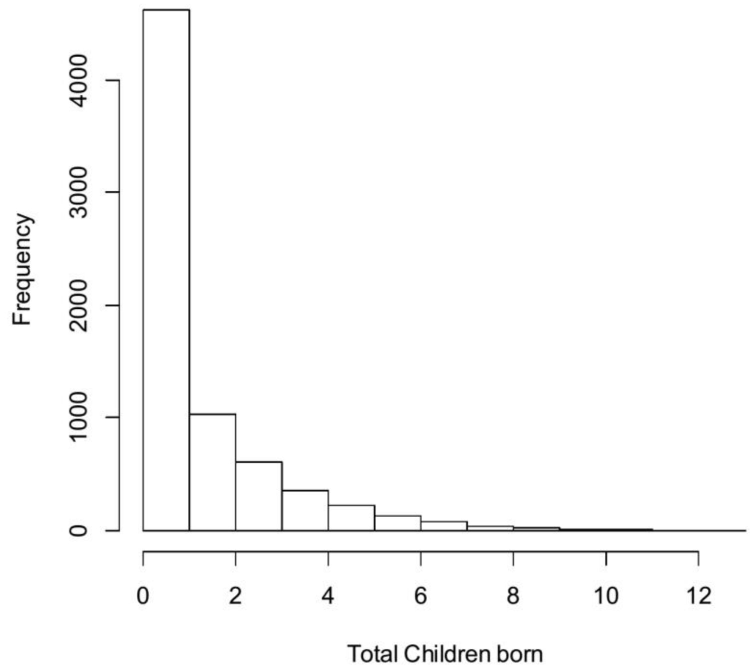

Fig 1. Histogram of Total number of Chldren born.

religions while the remainder (23.2%) were Roman Catholics. The women were almost evenly distributed among the wealth quintiles with 15.9% in the poorest category, 18.5% in the poorer category, 23.5% in the middle category, 26.1% in the richer category and 16.0% in the richest category. Most of the women had never married before (77.9%) and the rest were cohabiting (22.1%) at the time of the survey. The majority of the women were unemployed (61.5%). With regards to contraceptive use, most of the women used contraceptives (67.5%).

Figure 1 shows the histogram of the total children born to unmarried women. The graph indicates a high frequency of zeros and long right tail giving evidence of over-dispersion in the data. Of the 7117 women who were not married, a considerable percentage (42.8%) had never given birth. The mean (1.41) and the variance (1.81) are also unequal as should be the case for an ideal Poisson random variable. The Chi-squared test for goodness of fit test for Poisson distribution confirmed departure from equi-dispersion ($^2_{0.01,11d.f} = 72416.57, p < 0.01$), thus Poisson is not ideal for this data.

3.2 Model Comparison

Table 2 gives a summary of model comparisons based on the Voung statistic for the seven candidate regression models explored.

The goodness of fit tests showed that the hurdle regression models were overall superior to all other regression models according to the following ranking:

Poisson < Negative Binomial < Zero-Inflated Poisson < Zero-Inflated Negative Binomial <Hurdle Poisson <Hurdle Negative Binomial Regression.

In particular Hurdle Negative Binomial regression model offered the better fit compared to the Hurdle Poisson Regression model (Voung Statistic =-4.933, p<0.001). This best model was therefore chosen as the final model to fit to the non-marital fertility probability as well as determination of the factors

Table 2 Model comparisons based on the Voung statistic

	Poisson	Quasi-Poisson	Negative Binomial	Zero-Inflated Poisson	Zero Inflated Negative Binomial	Hurdle Poisson	Hurdle Negative Binomial
Poisson	na						
Quasi-Poisson	-	na					
Negative binomial	0.7433, p=0.2286		na				
Zero-Inflated Poisson	0.7188, p=0.2377			na			
Zero Inflated Negative Binomial	0.7436, p=0.2285				na		
Hurdle Poisson	-11.022*, p<0.001					na	
Hurdle Negative Binomial	-12.808*, p<0.001					-4.933*, p<0.001	na

*significant at 0.1% level.

Table 3 Regression Estimates from the Hurdle Negative Binomial Regression Model

Independent Variables	Hurdle Negative Binomial Regression model			
	Fertility Probability (Presence of children)		Fertility Intensity (Number of children)	
	OR	95% CI	RR	95% CI
Constant	0.166***	(0.099, 0.277)	0.461***	(0.366, 0.581)
Age of the Woman				
<=20	1.000		1.000	
21-30	12.079***	(8.526, 17.113)	3.915***	(3.160, 4.851)
31-40	59.145***	(30.902, 113.203)	8.268***	(6.684, 10.227)
41-49	162.476***	(60.431, 436.835)	10.883***	(8.778, 13.492)
Place of Residence				
Urban	1.000		1.000	
Rural	1.417**	(1.140, 1.761)	1.006	(0.948, 1.068)
Highest Educational level				
No Education	1.000		1.000	
Primary	0.750	(0.474, 1.188)	0.935*	(0.875, 0.999)
Secondary	0.255***	(0.158, 0.4122	0.637***	(0.590, 0.688)
Higher	0.061***	(0.030, 0.123)	0.516***	(0.421, 0.633)
Wealth Index				
Poorest	1.000		1.000	
Poorer	0.645**	(0.484, 0.859)	0.942	(0.877, 1.012)
Middle	0.903	(0.681, 1.198)	0.891**	(0.829, 0.956)
Richer	0.634**	(0.466, 0.863)	0.817***	(0.751, 0.888)
Richest	0.417***	(0.287, 0.604)	0.699***	(0.620, 0.787)
Marital Status				
Never married	1.000		1.000	
Living Together (Cohabiting)	2.601***	(2.080, 3.253)	1.145***	(1.118, 1.174)
Employment Status				
Not Employed	1.000		1.000	
Employed	1.049	(0.878, 1.254)	0.978	(0.931, 1.028)
Contraceptive Use				
Never Used	1.000		1.000	
Used Traditional and Modern Methods	8.579***	(6.268, 11.741)	1.027	(0.9648, 1.093)

*significant at 5% level, **significant at 1% level, ***significant at 0.1% level influencing non-marital fertility counts, measured by the total children born.

3.3 Model estimates under the Hurdle Negative Binomial Model

Table 3 summarizes the results Hurdle Negative Binomial regression. Non-marital fertility prevalence was found to be associated with the age of the woman. Fertility generally increased with age with women aged between 41 and 49 years 162 times more likely to have non-martial births than those at 15-19 years (OR=162.48, 95% CI: 60.43-436.85), while those aged 31 to 40 have a chance of 59 times than those aged 15 to 19 years (OR=59.15, 95% CI: 30.90-113.20). Women aged 21 to 30 years also had a higher chance of pre-marital fertility (OR=12.08, 95% CI: 8.53-17.11) compared to those women aged between 15 and 20 years of age. There was no significant difference in fertility incidence between those with primary education and those with no formal education (p=0.2203). Fertility probability generally decreased with increasing educational level of the woman. Those women with secondary education (OR=0.255, 95% CI: 0.158-0.4122) or higher education (OR=0.06, 95% CI:0.030-0.12) had lower probability of fertility compared to women with no formal education. Fertility probability was 1.4 times higher in rural compared to urban women. In general, the likelihood of non-marital birth decreased with increasing levels of wealth index, with OR=0.417 (95% CI:0.287-0.604) for the richest category and OR=0.645 (95%CI:0.484-0.859) for the poorer. With regard to employment, there was no significant difference in fertility probability between employed and unemployed women (p=0.597). Based on the marital status of the women, cohabiting women had relatively higher fertility probability compared to never married women (OR=2.601, 95% CI:2.08-3.25). Results also indicated that those using either traditional or modern contraceptive methods had higher fertility probability than those who had never used contraceptives (OR=8.579, 95% CI:6.268-11.74).

Results from the model further showed that the intensity of non-marital fertility increased with the age of the woman, with women aged 41-49 (RR=10. 88, 95% CI: 8.78-13.4), women aged 31 to 40 (RR=8.23, 95% CI:6.68-10.23), and those aged 21 to 30 (RR=3.92, 95% CI:3.16-4.85) likely to have more children compared to those in the 15 to 20 years reference category (Table 3, last column). Unlike for fertility probability, the woman's place of residence (p=0.845) had no significant effect on the number of children born to the unmarried woman, even though rural women were likely to have more children compared to their urban counterparts. The fertility intensity of woman significantly decreased as her educational level increased. Women with primary education (RR=0.94, 95% CI:0.88-0.99), secondary education (RR=0.64, 95% CI:0.59-0.69), and those women with higher education level (RR=0.52, 95% CI:0.42-0.63) were likely to have fewer children compared to those with no formal education.

With regard to the economic status of the women, fertility intensity seemed to diminish from the poorest women to the richest women. There was no significant difference in fertility intensity between the poorer and the poorest women (p=0.1043). Women with middle economic status (RR=0.89, 95% CI: 0.83-0.96), richer women (RR=0.82, 95% CI: 0.75-0.89), and the richest women (RR=0.70, 95% CI:0.62-0.79) had fewer children compared to the poorest women. When it came to the intimate relationship status of the no-married women, cohabiting women were likely to have more children than their never married counterparts (RR=1.15, 95% CI:1.12-1.17). The employment status of the woman had no significant effect on the total children born to the woman (p=0.379).

4. Discussion

In this study we investigated determinants of non-marital fertility in Namibia and proposed a two-part model to explain both the presence and number of non-marital children through a logit and truncated count models. Results suggest that the two-part model offers a better insight of the non-marital fertility decisions as opposed to a single model for the presence of children only [logit model] as suggested elsewhere (Mzimande 2007, Mturi 2005). There is evidence that the degree of association for the same determinants in the logit model and count model were different, and although in our study these point in the same direction, in some studies the direction of association for the presence and count models may differ (Kazembe 2013, Chipeta et al. 2013, Santos Silva and Covas 2000, Miranda 2014).

Findings from this study indicated that non-marital fertility was higher among cohabiting women compared to never married women. These findings are in agreement with Waldssmith(2006) explained that the higher fertility in cohabitating unions could be a suggestion that these unions are now being viewed as more surrogate marriages based on informal unions. In Namibia this could also be because of the effects of the disruption of traditional marriage settings during the apartheid era (Orieji, 1997). The popularity of child-bearing in cohabiting unions was also observed in many developed countries and some African countries (Klusener, Perelli-Harris and Garsen, 2012; Musick, 2007; Mturi, 2005). Non-marital fertility propensity was higher in rural areas than urban areas but no significant differences in fertility intensity in rural and urban areas were observed. The decrease in fertility levels in urban areas, and differentials in education can be explained by the fact that women delay child-bearing because of schooling and those in rural areas are out of school earlier and therefore more prone to teenage and non-marital pregnancies, and have limited access to contraceptives and other reproductive health services.

These findings differ from those from South Africa where rural women had lower risk of non-marital childbearing compared to their urban counterparts (Nzimande, 2007) and findings from Kenya where the urban areas contribution to non-marital fertility was highest (Chabeda, 2009).

Results also indicated that in Namibia, non-marital fertility decreased with increasing educational level of the woman. Surprisingly in Russia, women with lower vocational schooling had even higher non-marital conception rates than those with secondary education because women with higher education were more likely to marry once they conceived a child outside of marriage (Perelli-Harris and Garber, 2008). In Kenya, women with secondary education contributed highly to non-marital fertility. Results also indicated that in Namibia, richer women had fewer children compared to their poorer counterparts. These findings are consistent with those from the developed world where women in highly concentrated, resource deprived neighbourhoods and those who lacked positive role models in their family and community, and those whose parents had lower educational and income levels were more likely to experience non-marital child-bearing (Miller, park and Thomas, 2003; Wildssmith and Paley, 2006; Musan, Kisovi, and Tinoui, 2012).

The employment status of the woman had no significant effect on non-marital fertility in Namibia. This is in contrast to study findings on Mexican American women which showed that employment deterred non-marital fertility more for women with lower economic backgrounds relative to those with higher economic backgrounds (Wildssmith and Paley, 2006). Again contraceptive use did not have a significant effect on non-marital fertility. This could be explained by study findings from the Kavango region of Namibia where rates of teenage pregnancy were high yet very little of the teenage fertility was wanted , and most probably non-marital, due to the risky nature of the sexual activities in that region. These sexual risks were due to delays and inconsistent contraceptive use (Elendou-Enyengue and Magazi, 2011). The same pattern was also observed in Kenya where most of the non-marital pregnancies were reported to be accidental or unplanned (Musan, Kisovi and Tonui, 2012). In Rural South Africa, premarital fertility was ultimately due to lack of contraception among young women and was also associated with the risk of contracting sexually transmitted diseases (Zwang and Garenne, 2008).

5. Conclusion

Results indicate that non-marital fertility in Namibia is associated with the age of the woman, her level of education, economic status, place of residence. Non- marital fertility was higher among cohabiting women compared to never married women. Fertility probability was higher in rural areas compared to urban areas even though there were no significant differences in fertility intensity between non-married women from rural and urban areas. Both non marital fertility propensity and intensity decreased with increased educational level. Intervention efforts should focus on promoting education among girls and young women especially in rural areas to reduce teenage pregnancy and non-marital fertility. There is need to strengthen programs like "My future is my choice" and other life skills programs in schools.

Acknowledgements

The authors thank the Ministry of Health and Social Welfare and Measure DHS for making the data available and the University of Namibia for financial support.

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Explaining Marital Patterns and Trends in Namibia: A Regression Analysis of 1992, 2000 and 2006 Demographic and Survey Data

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Abstract

Background: Marriage is a significant event in life-course of individuals, and creates a system that characterizes societal and economic structures. Marital patterns and dynamics over the years have changed a lot, with decreasing proportions of marriage, increased levels of divorce and co-habitation in developing countries. Although, such changes have been reported in African societies including Namibia, they have largely remained unexplained.

Objectives and Methods: In this paper, we examined trends and patterns of marital status of women of marriageable age: 15 to 49 years, in Namibia using the 1992, 2000 and 2006 Demographic and Health Survey (DHS) data. Trends were established for selected demographic variables. Two binary logistic regression models for ever-married versus never married, and cohabitation versus married were fitted to establish factors associated with such nuptial systems. Further a multinomial logistic regression models, adjusted for bio-demographic and socio-economic variables, were fitted separately for each year, to establish determinants of type of union (never married, married and cohabitation).

Results and Conclusions: Findings indicate a general change away from marriage, with a shift in singulate mean age at marriage. Cohabitation was prevalent among those less than 30 years of age, the odds were higher in urban areas and increased since 1992. Be as it may marriage remained a persistent nuptiality pattern, and common among the less educated and employed, but lower odds in urban areas. Results from multinomial model suggest that marital status was associated with age at marriage, total children born, region, place of residence, education level and religion. We conclude that marital patterns have undergone significant transformation over the past two decades in Namibia, with a coexistence of traditional marriage framework with co-habitation, and sizeable proportion remaining unmarried to the late 30s. A shift in the singulate mean age is becoming distinctive in the Namibian society.

Citation: Pazvakawambwa L, Indongo N, Kazembe LN (2013) Explaining Marital Patterns and Trends in Namibia: A Regression Analysis of 1992, 2000 and 2006 Demographic and Survey Data. PLoS ONE 8(8): e70394. doi:10.1371/journal.pone.0070394

Editor: John P. Hart, New York State Museum, United States of America

Received January 29, 2013; **Accepted** June 18, 2013; **Published** August 15, 2013

Funding: The authors acknowledge funding from the University of Namibia. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing Interests: The authors have declared that no competing interests exist.

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Introduction

Marriage and family formation are the cornerstone of every society, but are based on individuals choice and preferences which are significantly shaped by societal norms [1]. Marriage patterns vary considerably across countries and over time [1–10]. Such dynamics are also being experienced in African societies. Many studies, based on census and surveys, however, put emphasis on trends that have occurred. However, more important is to offer explanations to differences among individuals and trends over time. This paper aims to examine marital trends and patterns in Namibia and offer explanations to what has emerged since attaining independence in 1990. Particularly, we use national surveys based on the demographic and health surveys (DHS) data of 1992, 2000 and 2006 to establish factors that explain marital status patterns and trends. We hypothesize that there is considerable regional variation in marital status because of diverse cultural or ethnic differences in Namibia. We further postulate that education, religiosity, socio-economic status and place of residence are such factors that explain differences in marriage patterns among individuals and trends over time [4–10].

Research in understanding and modeling the formation of marriages and marital dissolutions has increased [4]. Nevertheless this area of research is old and global, and the processes that define nuptiality processes are multifaceted with social, behavioural and demographic factors which simultaneously influence marital status and trends [2–4]. Studies in the sub-Saharan Africa, Arab world, America, and Europe showed that women are staying single longer, or not marrying at all because of high costs associated with marriage, improved gender roles, educational expansion and secularization [5–9]. However, in many African societies, marriage is almost universal and early [5]. Within the same context, the percentages of marriages where both husband and wife are uneducated are decreasing [6]. An analysis of data on young American men and women from the National Longitudinal

Survey of Youth from 1979 to 1992 showed that high earning capacity increased the probability of marriage and decreased the probability of divorce for young men [7]. In Europe, marriage patterns have mainly been explained by educational expansion, employment, secularization and changing gender roles [8]. An equivalent study in Norway reported that a large proportion of cohabiters indicated economic reasons for their hesitation to marry and in particular the costs of the wedding [9].

Recently, a considerable bulk of demographic research has reported increased cohabitation in Western and developed countries, with notable prevalence in developing countries. Ermisch and Francesconi [10] examined the dramatic increase in cohabiting unions in Great Britain. They analyzed entry into first partnership, the stability of cohabiting unions and re-partnering after dissolution of cohabitation. The shift to cohabitation as the dominant mode of first partnership played an important role in the delay of first marriage and motherhood. In a study based on the 2001 Nepalese Demographic and Health Surveys, Coltabiano and Castiglioni [11] described a significant downward shift in age at marriage, and delayed celebrated marriage in case of cohabitation. Cohabitation is also a common form of union in many southern African societies. For example in Botswana and South Africa, it is considered as a transitional stage before a bride price is paid, as such a consensual union may exist [5]. In Namibia, national surveys indicate that one in five adults are in cohabitation, and the prevalence is increasing [2,3]. However factors affecting such marital processes have not been examined.

Various other factors affecting marriage, singlehood, cohabitation or divorce have been explored. Steel et al. [12,13] have examined the effect of parenthood on whether non-marital unions led to marriage or parting. Their findings showed that the proportion of cohabiting couples who married before a birth decreased and the risk of dissolution declined during pregnancy. Lehrer [14] indicated that early age at first marriage is known to be associated with high risk of divorce. Another study in Britain established that education was a key factor influencing the age of entry into first partnership and whether or not the respondent would experience pregnancy before forming the partnership. Furthermore, religiosity, experience of parental separation, and the geographical region of residence were more important in affecting the decision to cohabit rather than to marry directly [15].

With regards to marriage dissolution, Bracher et al. [16] analyzed structural and temporal predictors of marriage dissolution. Their results indicated that the risk of marriage dissolution increased dramatically over the lives of the respondents. Year of birth, and age at marriage provided the most parsimonious characterization of the temporal correlates of marriage dissolution. Characteristics that were fixed by the time of marriage dissolution were related to characteristics of the unfolding marriage itself; namely patterns of employment, home-ownership, and region of residence. A review of research on the premarital factors associated with later marital quality and stability in first marriages was conducted by Larson and Holman [17]. Three major categories of factors were described including background and context, individual traits and behaviours, and couple interactional processes. They cited implications of their findings for family life education, premarital counseling and the need for further research.

The effect of such factors on the distribution and dynamics of intimate relationships in Namibia needs to be explored. The three survey data points spanning 1992 to 2006 present a unique opportunity to determine emerging trends and patterns in marital status. It is evident that not much research has been done to date, except in fertility studies [2–3], and in this study we focus exclusively on the association between different forms of unions and social-demographic variables. An attempt is also made to explore geographical variability in marital patterns in the country.

Methods

Data

This study is based on Namibian DHS of 1992, 2000 and 2006. DHS is a national survey drawn on using a multistage cluster sampling. At first stage, a random sample of enumeration areas (EA), which are primary sampling units, was chosen from the census sampling frame. From the selected EAs, households were systematically drawn. Only women of reproductive age (15–49 years), in the selected households, were interviewed using a face-to-face questionnaire. The questionnaire included variables on individual bio-demographic factors, household characteristics, history of marital unions and births. Final samples included in the analysis were respectively 5420 from the 1992 survey, 6755 from the 2000 survey and 9800 women, from the 2006/7 round of surveys.

Outcome: Marital Status

All women involved in the survey were asked questions about their current marital status. The response was a multi-categorical variable of four categories: 1) never married, 2) married, 3) living together (co-habitation), and 4) others (widowed, separated and others). We also generated two binary outcomes: (i) coded 1 if ever married versus 0 if never married; and (ii) cohabiting versus married so that we assess the association between union formation, cohabitation and different socio-demographic covariates.

Individual and household characteristics

Bio-demographic characteristics related to a woman included current age, age at first birth, age at first intercourse, total children born, employment status, religion and education level. Household characteristics consisted of region, place of residence (rural or urban) and wealth index. The region variable was recorded differently across the three surveys. The 1992 data recorded four broad geographic areas: northeast, northwest, central and south, while the 2000 and 2006 recorded 13 regions (Caprivi, Erongo, Hardap, Karas, Kavango, Khomas, Kunene, Ohangwena, Omaheke, Omusati, Oshana, Oshikoto, Otjozondjupa). To avoid errors introduced by aggregation/disaggregation we used the four regional groupings of 1992 in the subsequent analyses of all three waves of surveys. Again, 1992 data did not record a wealth index variable, but using the techniques as used for the 2000 and 2006 data we generated a wealth index for 1992. In brief, the wealth index was used as a proxy for the standard of living of the household. It is based on household ownership of consumer goods; dwelling characteristics; type of drinking water source; toilet facilities; and other characteristics related to household socio-economic status [20]. To construct the index, each of the assets was assigned a weight (factor score) generated through principal component analysis and the resulting asset scores were standardized in relation to the standard normal distribution. Each household was then assigned a score for each asset and the scores were summed for each household. Individuals were ranked according to the total score of the household in which they reside. The sample was then divided into quintiles from one (lowest) to five (highest) [18].

Statistical Analysis

Firstly, we analyzed trends and computed percentage change in marital status between 1992 and 2006, particularly for the never married, married and living together categories by residence, age and education levels. We further investigated regional patterns in marital status by computing and mapping percentages and percentage changes for each category (never married, married and living together) using 2000 and 2006 data. This provides an exploratory analysis of the changes that have happened between 2000 and 2006, since similar geographical divisions were not available in the 1992 data.

Secondly, we examined the association between union formation (ever married) and socio-demographic variables using a binary logistic regression. We also explored if there was any shift towards cohabitation than marriage and investigated possible determinants by fitting a binary logistic regression. In a binary response, the variable $Y \sim \text{Bernoulli}(p(v_i,a))$ with

$$\text{logit}(p(v_i,\alpha)) = \eta_{ij} = v'\alpha_j,$$

given some covariates $v=(v_1,\ldots,v_p)'$ and corresponding parameter set α. Third, we estimated factors that explained marital status by fitting a multinomial logistic regression model. A multinomial random variable applies where an event, Y, ends up with three or more outcomes $1,\ldots,J$ $(J>2)$. Specifically suppose Y has unordered categories, we assume [19]

$$Y \sim \text{multinomial}(1, \quad p(v_i,\alpha)) \quad \text{for} \quad i=1,\ldots,n,$$

such that $p(v_i,\alpha)=(p_1(v_i,\alpha),\cdots,p_J(v_i,\alpha))'$, and $P(y_i=j|\alpha) = p_j(v_i,\alpha)$, where α and v are as defined before. The most common approach to estimate multinomial probabilities is through the logistic model

$$p(v_i,\alpha)=P(y_i=j|\alpha)=\begin{cases}\dfrac{\exp(\eta_{ij})}{1+\sum_{h=1}^{J-1}\exp(\eta_{ih})} & j=1,\cdots,J-1\\[2ex] \dfrac{1}{1+\sum_{h=1}^{J-1}\exp(\eta_{ih})} & j=J\end{cases}$$

where $\eta_{ij}=v'\alpha_j$ is the linear predictor. The last category J is considered as a reference classification outcome. In this classical multinomial logit model all covariates are assumed to be independent of the category while effects are category-specific.

The binary logistic regression models for ever married (vs single) and cohabitation (vs marriage) were fitted by combining all the data between 1992 and 2006. For the multinomial logistic, we fitted three models for the years 1992, 2000 and 2006 respectively. The last multinomial category (others) was assigned as a reference category. Put differently, we examined the likelihood of being: 1) never married versus others, 2) currently married versus others, and 3) currently living together (cohabitation) versus other forms of marital status. A p-value less than or equal to 0.05 was considered as significant. In all models, current age of the woman, age of the woman at first intercourse, age of the woman at first birth, and total number of children ever born to the woman were estimated as continuous variables, while region, education, religion, employment, wealth index and residence were estimated as categorical independent variables. Maximum likelihood estimation was applied. All models were fitted in SPSS version 19.

Results

Trends in marital status

Over half of the women interviewed in all the years were never married (50.0% in 1992, 50.3% in 2000 and 56.6% in 2006). This showed an increase of 6.6% for the period 1992–2006. The proportion married which consisted of 29.0% in 1992, 23.4% in 2000 and 20.4% in 2006, declined by 8.4% in the same period. Women who were cohabiting with their partners were 13.4% in 1992 and this increased to 18.4% in the 2000 survey, but dropped 16.0% in 2006. The other forms of marital status showed a slight downward change between 1992 and 2006. A chi-square test for trend showed a significant change in marital patterns in Namibia between 1992 and 2006 ($\chi^2=35.2, p=0.0029$).

Table 1 shows bivariate associations between never married, ever married, cohabitation and background characteristics. The percentage ever married shows a decline while cohabitation shows an increase in association with age ($\chi^2=250, p<0.05$) and between 1992 and 2006 ($p<0.05$). There was also evidence of differences in proportion ever married and cohabiting by region, residence and education level ($p<0.05$).

Table 1. Bivariate associations of never married, ever married and cohabitation by background characteristics.

Variable	Category	Never married	Ever married	Cohabiting	Total (n)
Year	1992	50.0	50.0	31.6	5421
	2000	50.3	49.7	44.0	6755
	2006	56.6	43.4	44.0	9804
Education	None	25.2	74.8	48.3	2370
	Primary	47.5	52.5	44.9	7462
	Sec/higher	61.8	38.2	34.5	12148
Religion	Protestant	54.2	45.8	38.6	16762
	Catholic	49.2	50.8	47.2	5218
Employment	Unemployed	58.8	41.2	43.6	12486
	Employed	45.4	54.6	37.8	9399
Residence	Rural	53.4	46.6	39.1	12588
	Urban	52.5	47.5	42.9	9398
Wealth index	Poorest	55.0	45.0	41.7	4139
	Poor	50.8	49.2	49.8	4526
	Medium	54.9	45.1	50.9	5054
	Rich	53.6	46.4	45.8	3857
	Richest	50.3	49.7	20.0	4044
Region	Northwest	66.5	33.5	35.1	8021
	Northeast	39.2	60.8	33.1	3878
	Central	45.7	54.3	52.0	5087
	South	49.5	50.5	40.7	4994
Age	15–19	92.5	7.5	68.7	4926
	20–24	70.1	29.9	62.8	4325
	25–29	49.9	50.1	51.4	3548
	30–34	33.4	66.6	38.8	3149
	35–39	24.8	75.2	33.2	2412
	40–44	19.7	80.3	27.4	2111
	45–49	15.1	84.9	22.7	1509

Given are percentage unless stated.
doi:10.1371/journal.pone.0070394.t001

Next, we explored changes in trends by residence, age and education. Figures 1 to 3 give results. Among the never married, the proportion in the urban areas was relatively lower than in the rural areas between 1992 and 2000, but this changed in 2006 (Figure 1a). Similar trend was observed among the married (Figure 1b). For the living together, the proportion was higher in urban areas than rural areas, with increased trends for both areas between 1992 and 2000. This pattern changed in 2006, with relatively more partners living together in rural than urban areas (Figure 1c).

With regards to education level, the never married were relatively higher in proportion among those who attained secondary or higher education than among those with primary education or none. This higher trend persisted for all the years

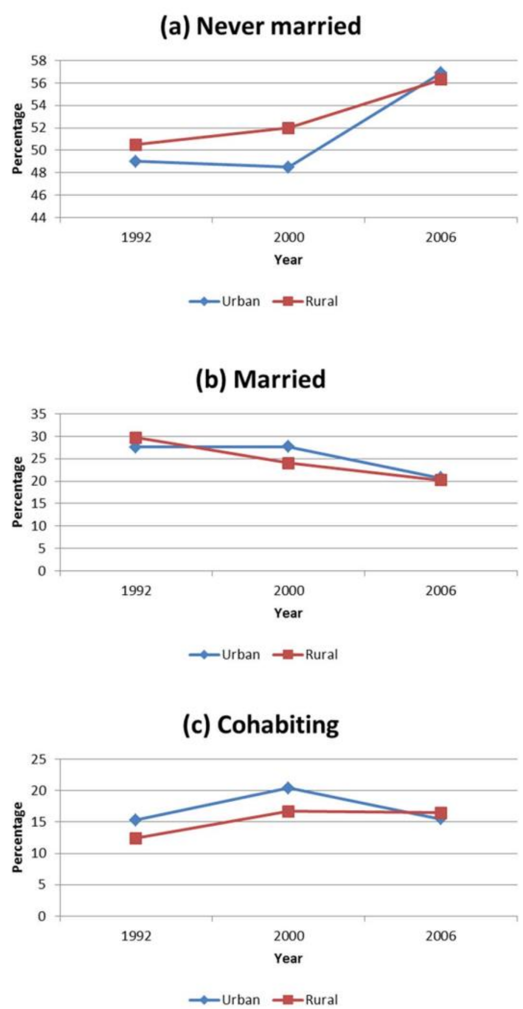

Figure 1. Trends in marital status. (a) never married; (b) married and (c) cohabiting between 1992 and 2006 by rural/urban place of residence.
doi:10.1371/journal.pone.0070394.g001

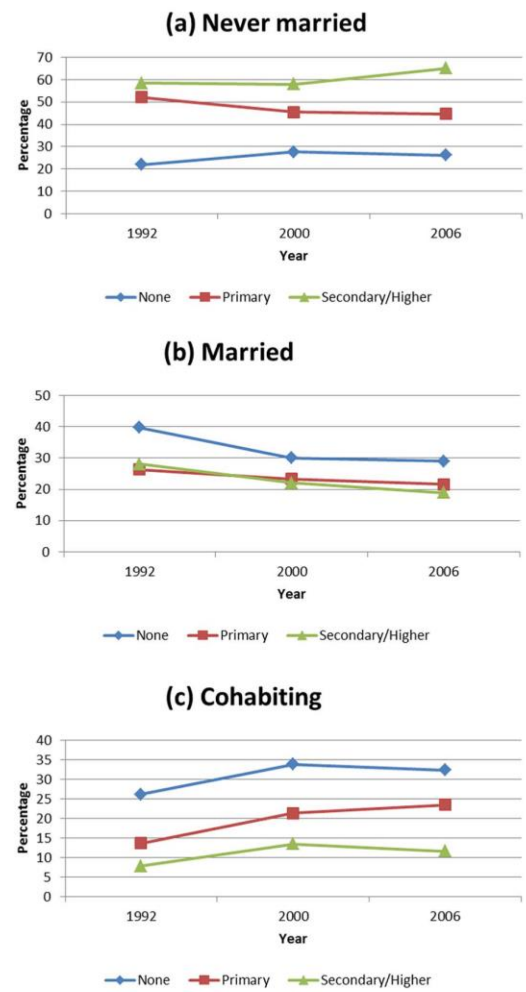

Figure 2. Trends in marital status. (a) never married; (b) married and (c) cohabiting between 1992 and 2006 by education level.
doi:10.1371/journal.pone.0070394.g002

(Figure 2a). However, among the married women those with primary education were relatively more, followed by those without any formal education. Lower proportions of marriage were observed for those who achieved secondary or higher education levels and the trend was steady for the years (Figure 2b). The pattern observed among those living together was similar to those who were married (Figure 2c).

Turning to the effect of age on the trend of marriage patterns, we observed as expected that those below age 20 mostly remaining unmarried with decreasing percentages as age increased (Figure 3a). In Figure 3b, as expected, we had a reverse in trends among the married, with increased rates as age increased persistently from 1992. A mixed pattern was notable among those living together, however, the proportion cohabitating with age below 20 years remained lower than 5% from 1992 (Figure 3c). However overall, there is a shift in modal age at marriage between

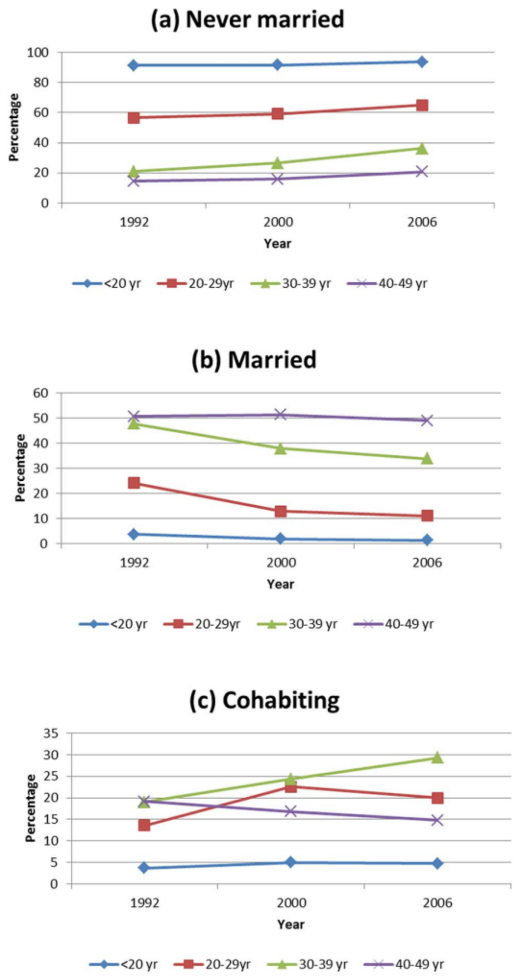

Figure 3. Trends in marital status. (a) never married; (b) married and (c) cohabiting between 1992 and 2006 by current age.
doi:10.1371/journal.pone.0070394.g003

1992 and 2006 (Figure 4). In 1992, this was at 23 years, while in 2000 this shifted to 27 and as of 2006 this was at 29 years of age. This is in agreement with what has been discussed before (Figures 1 to 3).

Geographical patterns in marital status

Figure 5 shows regional variation in marriage patterns. In 2000, a higher percentage living together was observed in the northern provinces of Kunene, Kavango, and Otjozondjupa, while in 2006 the highest rates were observed in central regions, particularly in Erongo, Khomas and Omaheke. For the married group, there were no significant differences across the regions for both 2000 and 2006 surveys, although Caprivi registered a relatively higher percentage married than other regions at both times. Significant regional differences were observed among the never married, particularly in the north and south (Figure 5, bottom panel). An

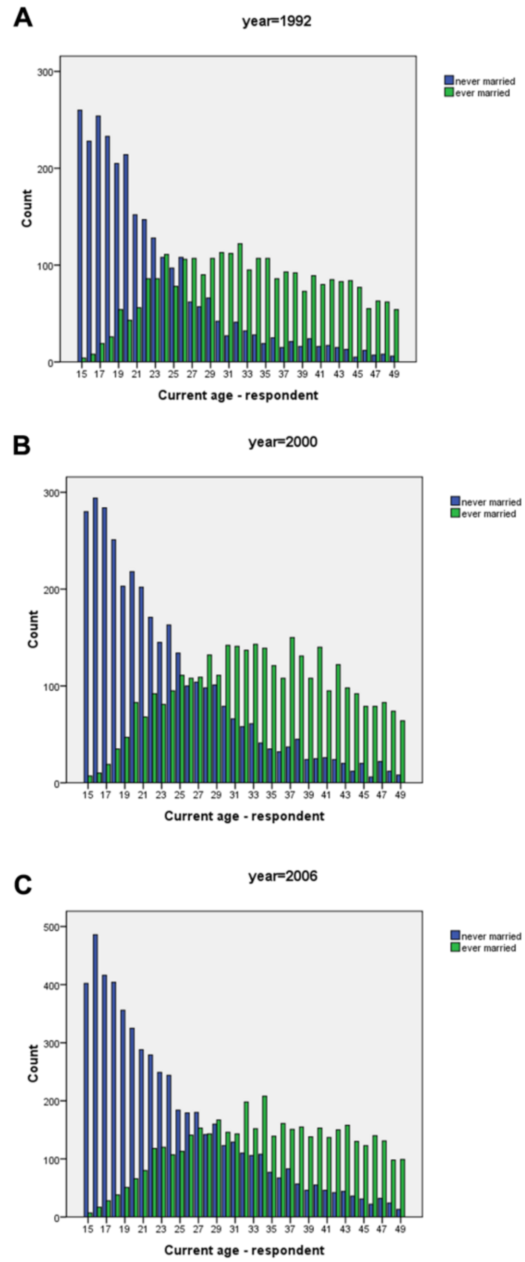

Figure 4. Cumulative number of women aged between 15–49 ever married or never married for: (a) year 1992; (b) year 2000 and (c) year 2006.
doi:10.1371/journal.pone.0070394.g004

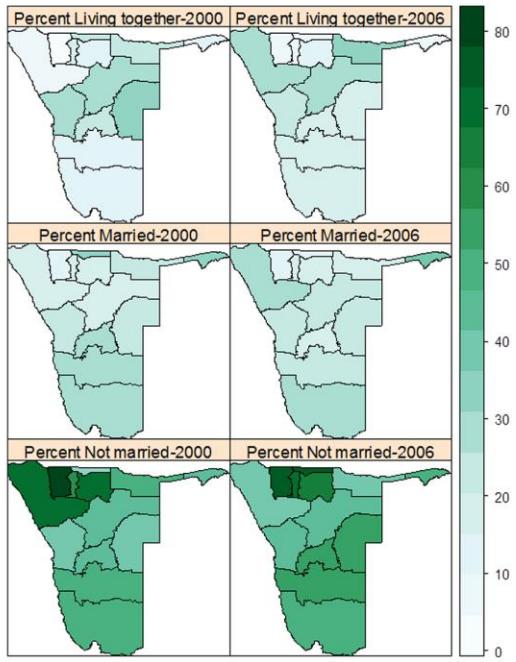

Figure 5. Regional proportions in marital status (never married, married and living together) in 2000 and 2006.
doi:10.1371/journal.pone.0070394.g005

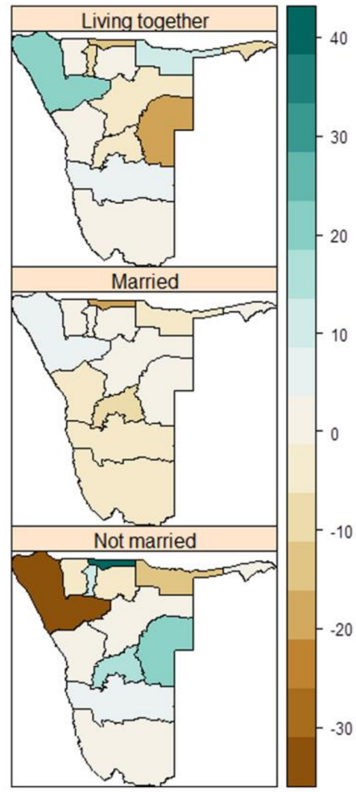

Figure 6. Percentage changes in marital status by region between 2000 and 2006 in Namibia.
doi:10.1371/journal.pone.0070394.g006

assessment of percentage change in marital patterns shows a decline among the never married in Kunene, while an increase among the living together in the same region (Figure 6). A relative decline in percent married was registered in many regions, especially in the central and southern regions. Among those living together, an increased change was notable in Kunene and Kavango whereas a corresponding decline was observed in Omaheke (Figure 6).

Ever in union and its determinants

Table 2 gives results of the model that predicts the probability of being in the union as a function of year, current age, region, education, religion, employment and residence. The probability of ever married was 33% higher in 1992 compared to 2006 but decreased to 29% in 2000. The proportion of women ever having been in a union increased with age, while the odds of ever been in a union was much higher in the North-east (OR = 2.31, 95% CI: 2.06, 2.59) and central (OR = 1.17, 95% CI: 1.06, 1.29) regions of Namibia compared to the south, but much lower in Northwest (OR = 0.45, 95% CI: 0.41, 0.49). Results further show that the chance of married was much higher for those with no formal education or lower education level than those who attained secondary or higher (OR = 2.47 and 1.70 respectively). The effect of employment was marginal and that of wealth index was largely non-significant. Finally the effect of urban residence was lower, as expected, for the ever in union group compared to those in rural areas.

Cohabitation and its determinants

Table 2 again shows factors associated with cohabitation union versus being in traditional marriage. As one can observe, the propensity of cohabitation increased by 50% between 1992 and 2000, and 85-fold between 1992 and 2006 and at same time by 23% between 2000 and 2006. However, cohabiting decreased with increasing age. In other words, most cohabitation unions ended up in formal marriage. We also noted that cohabitation was much higher in the central region compared to the south (OR = 1.21, 95% CI: 1.06, 1.39). This is the region where Windhoek, the capital city is located. What was surprising, though, from our findings is that being less educated was associated with increased probability of cohabitation compared to those who were of secondary or higher education levels (OR = 2.24 for no education and OR = 1.71 for primary education respectively). Furthermore, we observed that living in urban areas increased the chance of cohabitation compared to living in rural areas (OR = 1.93, 95%CI: 1.70, 2.18).

Individual and household characteristics associated with never been married

Table 3 presents results from the multinomial regression model. Being single was significantly associated with current age, total

Table 2. Logistic regression results for ever in union (vs single) and cohabitation (vs marriage).

		Ever married vs Never married		Cohabiting vs Married	
Variable	Category	OR	95% CI	OR	95% CI
Year	1992	1.33	(1.22, 1.45)	0.54	(0.47, 0.61)
	2000	1.29	(1.19, 1.39)	0.81	(0.73, 0.91)
	2006	1.00		1.00	
Education	None	2.47	(2.18, 2.79)	2.24	(1.92, 2.61)
	Primary	1.70	(1.57, 1.84)	1.71	(1.52, 1.93)
	Sec/higher	1.00		1.00	
Religion	Protestant	1.19	(1.01, 1.29)	1.39	(1.25, 1.56)
	Catholic	1.00		1.00	
Employment	Unemployed	1.00		1.00	
	Employed	1.08	(1.00, 1.16)	0.95	(0.85, 1.05)
Residence	Rural	1.00		1.00	
	Urban	0.78	(0.72, 0.85)	1.93	(1.70, 2.18)
Wealth index	Poorest	1.00		1.00	
	Poor	1.01	(0.91, 1.13)	1.01	(0.86, 1.18)
	Medium	1.10	(0.98, 1.23)	1.16	(0.99, 1.35)
	Rich	0.94	(0.83, 1.07)	1.05	(0.88, 1.26)
	Richest	1.27	(1.10, 1.47)	0.27	(0.22, 0.34)
Region	Northwest	0.45	(0.41, 0.49)	0.71	(0.61, 0.82)
	Northeast	2.31	(2.06, 2.59)	0.38	(0.32, 0.44)
	Central	1.17	(1.06, 1.29)	1.21	(1.06, 1.39)
	South	1.00		1.00	
Age	15–19	0.013	(0.011, 0.016)	9.53	(7.06, 12.86)
	20–24	0.08	(0.06, 0.09)	8.01	(6.49, 9.87)
	25–29	0.19	(0.16, 0.23)	4.65	(3.83, 5.65)
	30–34	0.39	(0.33, 0.46)	2.55	(2.11, 3.07)
	35–39	0.58	(0.49, 0.69)	1.88	(1.55, 2.29)
	40–44	0.78	(0.65, 0.94)	1.44	(1.18, 1.76)
	45–49	1.00		1.00	

doi:10.1371/journal.pone.0070394.t002

children ever born, age at first birth and age at first sex. The odds of remaining single decreased with increasing age, number of children the woman borne, and with increased age at first sex, while being single increased with increasing age at first birth. The effect of region varied in between the years. Between 1992 and 2006, women were likely to remain single in the northeast and south compared to the northwest. For those from the central region, the likelihood of being single was lower in 1992, but higher in the year 2000 and 2006 compared to those in the northwest region.

Education showed significant association with the never married in 2000, that is those with primary education were likely to remain single much longer than those with no education. No association with region was found, but being employed compared to being unemployed increased the likelihood of remaining single (RR = 1.38 in 1992, RR = 1.36 in 2000 and RR = 1.25 in 2006 respectively). Social status was also associated with decreased likelihood of remaining single. For instance in 2000, this decreased with increasing status (RR = 0.67, 0.64 and 0.63 for the medium status, rich and richest respectively compared to the poorest). A similar pattern was obtained for 2006, although this was not significant.

Individual and household characteristics associated with currently married

Among those women who were married compared to others, results indicated that current age, total children born, age at first birth and age at first intercourse were related to marriage. Increase in age was associated with lower probability of marriage in all the years (RR = 0.94, 0.98 and 0.95 for 1992, 2000 and 2006 respectively), while total children born were positively associated with being married. Similarly association was obtained for age at first sex and birth (Table 3).

Significant regional differences for those married were observed in the northeast in 1992 (RR = 1.39, 95% CI = 1.01, 1.95) and in the central region again in 1992 (RR = 0.38, 95% CI: 0.19, 0.75). Having obtained secondary or higher education in 1992 showed a reduced chance of marriage (RR = 0.67, 95% CI: 0.45, 0.99), while results indicated an increased chance of marriage in 2000 (RR = 1.54). Religiosity differences were noted in 2006, with Protestants less likely to be married. Being employed increased the chance of marriage for all the survey years. Similar to the never married, results indicated that social status was likely to reduce the odds of being married. In particular those in the upper social class were less likely to be married, and this was persistent in all survey years (RR = 0.37, 0.15 and 0.16 for the years 1992, 2000 and 2006 respectively). Women who were residing in urban areas compared to being in rural areas had a high probability of being married (RR = 1.59 [95% CI: 1.12, 2.26], 1.72 [95% CI: 1.31, 2.26] and 2.01 [95% CI: 1.57, 2.56] in the year 1992, 2000 and 2006 respectively).

Individual and household characteristics associated with living together

In the case of women cohabitating, current age significantly reduced the likelihood of cohabitation, whereas total children born, age at first birth, education level and employment status increased the chance of living together. Results indicated that women who attained primary education or secondary and higher education were at increased risk of living together. In fact the risk increased with increased education level. For instance in 1992 the risk increased from 1.45 to 2.44 as one moves from primary to secondary or higher levels of education, and in 2000 the risk changed from 2.19 to 2.68 for the same change in educational level, whereas in 2006 the risk varied between 1.15 and 1.68 for an increased educational level.

Discussion

There is a clear indication that in any society marriage is dynamic, and Namibia is not an exception (Table 1, Figures 1 to 3). The analysis revealed that marital patterns in a Namibian society is predominantly of never married women, and the rates are increasing, while the proportion of those getting married is falling, nevertheless, these proportions decline as age increases. The proportion of cohabitating couples has remained almost constant, below 20%, for the period 1992 to 2006, but persistently within the same range as those currently married. Comparison with other countries in the region show similarities with South Africa, while for Malawi, Mozambique and Zambia, marriage patterns are dominated by the married group [17,20].

The inverse relationship of marriage patterns with current age is as expected (Figures 3a–3c, Table 1). As age increases, there is transition from singlehood to marriage or other forms of

Table 3. Multinomial regression results on marital status based on 1992, 2000 and 2006 DHS data.

		1992		2000		2006	
Variable	**Category**	**RR**	**95% CI**	**RR**	**95% CI**	**RR**	**95% CI**
NOT MARRIED							
Current Age		0.87	(0.85, 0.89)	0.91	(0.89, 0.93)	0.89	(0.88, 0.90)
Total children born		0.89	(0.82, 0.96)	0.85	(0.79, 0.92)	0.79	(0.74, 0.84)
Age at first birth		1.05	(1.01, 1.10)	1.03	(1.00, 1.06)	1.03	(1.00, 1.06)
Age at first intercourse		0.96	(0.95, 0.97)	0.98	(0.97, 0.99)	0.96	(0.95, 0.97)
Region	Northwest	1.00		1.00		1.00	
	Northeast	25.8	(17.33, 38.39)	1.72	(1.18, 2.51)	7.72	(5.84, 10.22)
	Central	0.74	(0.37, 1.48)	1.49	(1.11, 1.99)	2.27	(1.72, 3.01)
	South	3.05	(1.85, 5.02)	1.49	(1.08, 2.06)	1.71	(1.26, 2.32)
Education	None	1.00		1.00		1.00	
	Primary	0.82	(0.57, 1.20)	1.43	(1.00, 2.06)	0.89	(0.64, 1.23)
	Secondary or higher	0.77	(0.49, 1.20)	1.09	(0.74, 1.59)	0.71	(0.50, 1.01)
Religion	Catholic	1.00		1.00		1.00	
	Protestant	0.93	(0.69, 1.25)	0.83	(0.64, 1.06)	0.97	(0.78, 1.21)
Employment	Unemployed	1.00		1.00		1.00	
	Employed	1.38	(1.03, 1.85)	1.66	(1.31, 2.09)	1.25	(1.03, 1.53)
Wealth index	Least poor	1.00		1.00		1.00	
	Poor	0.99	(0.65, 1.50)	1.00	(0.72, 1.38)	0.95	(0.69, 1.29)
	Medium	1.18	(0.78, 1.78)	0.67	(0.47, 0.96)	0.86	(0.62, 1.20)
	Richer	1.37	(0.85, 2.22)	0.64	(0.44, 0.93)	0.79	(0.54, 1.16)
	Richest	1.19	(0.65, 2.17)	0.63	(0.39, 1.02)	0.81	(0.51, 1.30)
Residence	Rural	1.00		1.00		1.00	
	Urban	0.8	(0.54, 1.19)	1.29	(0.99, 1.70)	1.18	(0.92, 1.50)
MARRIED							
Current Age		0.94	(0.92, 0.96)	0.98	(0.97, 1.00)	0.95	(0.93, 0.96)
Total children born		1.23	(1.16, 1.32)	1.20	(1.12, 1.28)	1.25	(1.18, 1.32)
Age at first birth		1.09	(1.05, 1.13)	1.06	(1.03, 1.10)	1.10	(1.07, 1.12)
Age at first intercourse		1.00	(1.00, 1.00)	1.00	(1.00, 1.01)	1.00	(0.99, 1.00)
Region	Northwest	1.00		1.00		1.00	
	Northeast	1.39	(1.00, 1.94)	0.94	(0.65, 1.36)	1.01	(0.78, 1.31)
	Central	0.38	(0.19, 0.75)	1.27	(0.94, 1.70)	1.00	(0.75, 1.31)
	South	1.03	(0.64, 1.65)	1.01	(0.73, 1.39)	1.01	(0.75, 1.38)
Education	None	1.00		1.00		1.00	
	Primary	0.95	(0.70, 1.29)	1.54	(1.09, 2.17)	1.12	(0.83, 1.51)
	Secondary or higher	0.67	(0.45, 0.99)	1.17	(0.81, 1.69)	0.85	(0.61, 1.18)
Religion	Catholic	1.00		1.00		1.00	
	Protestant	1.08	(0.83, 1.41)	0.95	(0.74, 1.22)	0.62	(0.50, 0.77)
Employment	Unemployed	1.00		1.00		1.00	
	Employed	1.75	(1.35, 2.28)	1.55	(1.23, 1.95)	1.08	(0.89, 1.32)
Wealth index	Least poor	1.00		1.00		1.00	
	Poor	0.84	(0.58, 1.19)	1.00	(0.73, 1.37)	0.81	(0.60, 1.10)
	Medium	0.91	(0.64, 1.29)	0.78	(0.55, 1.11)	0.58	(0.42, 0.80)
	Richer	0.91	(0.59, 1.40)	0.78	(0.53, 1.14)	0.41	(0.28, 0.59)
	Richest	0.37	(0.21, 0.64)	0.15	(0.10, 0.24)	0.16	(0.10, 0.25)
Residence	Rural	1.00		1.00		1.00	
	Urban	1.59	(1.12, 2.26)	1.72	(1.31, 2.26)	2.01	(1.57, 2.56)
LIVING TOGETHER							
Current Age		0.91	(0.89, 0.93)	0.92	(0.90, 0.94)	0.89	(0.87, 0.90)

Table 3. Cont.

Variable	Category	1992 RR	1992 95% CI	2000 RR	2000 95% CI	2006 RR	2006 95% CI
Total children born		1.08	(1.00, 1.16)	1.07	(1.00, 1.15)	1.12	(1.05, 1.19)
Age at first birth		1.05	(1.01, 1.09)	1.03	(1.00, 1.06)	1.04	(1.01, 1.07)
Age at first intercourse		0.99	(0.99, 1.00)	1.00	(1.00, 1.01)	0.99	(0.99, 1.00)
Region	Northwest	1.00		1.00		1.00	
	Northeast	8.79	(5.86, 13.20)	1.00	(0.67, 1.48)	1.18	(0.89, 1.57)
	Central	0.31	(0.16, 0.63)	0.79	(0.58, 1.07)	0.49	(0.37, 0.66)
	South	1.11	(0.67, 1.86)	1.19	(0.85, 1.68)	0.46	(0.33, 0.63)
Education	None	1.00		1.00		1.00	
	Primary	1.45	(1.03, 2.05)	2.19	(1.55, 3.09)	1.15	(0.85, 1.56)
	Secondary or higher	2.44	(1.55, 3.83)	2.68	(1.85, 3.90)	1.68	(1.20, 2.35)
Religion	Catholic	1.00		1.00		1.00	
	Protestant	1.12	(0.83, 1.53)	1.25	(0.97, 1.61)	1.25	(1.00, 1.55)
Employment	Unemployed	1.00		1.00		1.00	
	Employed	1.27	(0.95, 1.71)	1.71	(1.35, 2.17)	1.42	(1.15, 1.74)
Wealth index	Least poor	1.00		1.00		1.00	
	Poor	1.12	(0.73, 1.73)	0.71	(0.51, 0.99)	1.11	(0.80, 1.53)
	Medium	0.94	(0.62, 1.42)	0.43	(0.30, 0.62)	0.81	(0.58, 1.13)
	Richer	0.83	(0.51, 1.36)	0.51	(0.35, 0.76)	0.74	(0.50, 1.10)
	Richest	0.92	(0.49, 1.72)	0.77	(0.46, 1.30)	1.05	(0.64, 1.72)
Residence	Rural	1.00		1.00		1.00	
	Urban	1.13	(0.76, 1.67)	0.77	(0.58, 1.01)	1.26	(0.99, 1.62)

doi:10.1371/journal.pone.0070394.t003

relationships. Similarly, there is a transition from cohabitation to marriage as age increased. It remains to be explored if such transition differs by birth cohort or marriage cohort. What is clear from Figure 1 is that this transition is much slower in 2006 than earlier years suggesting a period effect. As Steel et al. [12] observed in the British study, patterns of cohabitation into marriage differed by cohort, with the 1950–60 cohort more likely to form marriages than much later cohorts. This was lacking in our study and may be worthwhile to investigate. Their results further indicate that childbearing increased the probability of forming marital union. Since our analysis controlled for number of children ever-born, and the results display a positive association with marriage or cohabitation, we argue that a similar effects as found in the British society are being observed in the Namibian society.

Now much as an increase in age is most likely to lead into marriage, notable, however, is that a plateau of this transition is at 30 to 39 years of age. This differs from other societies in the region, where marriage is entered at a relatively young ager and the plateau occurs much early at 23–27 years. The policy of education for all introduced after independence meant more women became educated, thus delaying marriage [21–22]. It is also during this time period that Namibia advocated more about gender equality and women empowerment, encouraging women to exercise their rights including rights to decide when to get married unlike in the past when women were forced into marriage [22]. Evidently delayed transition to marriage has an effect of fertility rate [2–3,12–13], nevertheless, the positive relationship with total children born may indicate a catch-up phenomenon within the Namibian society. Be as it may, a total fertility rate of 3.22 shows that late entry into marriage has a big impact.

Our observations further reveal differences in marital status by place of residence, education level and age group. Interesting is a reversal of trends between 2000 and 2006 in all marriage categories. Between 2000 and 2006, there were more singles and fewer married in urban areas, a reverse of what was observed between 1992 and 2000. This is a clear indication that aspects of culture, marriage practices and customs change over time. It seems that this change is rapid in Namibia, especially after gaining stability brought about by attainment of independence in 1990. The effect of urbanization may explain the current trend, but a combined effect of increased educational level could moderate this change in patterns [20,23]. Historical family studies on in Western European do suggest rapid urbanization, as that experienced in Namibia, does affect marriage patterns. There is a shift in the mean age at marriage, spouse choices change with educated men marrying educated women, and more also other forms of marital status, like cohabitation emerged and singlehood increased [24]. Perhaps, we can argue that the three survey data points: 1992, 2000 and 2006, spanning 14 years is not a long enough series of data to conclude that this is the transition being experienced in Namibia.

The binomial and multinomial analyses indicate that individual and household characteristics contribute significantly towards explaining marriage patterns. The effects of demographic and social differences emerged not only for a single year but were persistent over the years. For example, the effects of total number of children born and age at first intercourse on the singles remained the same, suggesting the non-changing societal attitude towards non-marital child bearing or early sexual interaction being seen as non-traditional behaviour [25]. Different perspectives have merged with regards the timing of first birth. Forms of sexual partnering have been positively related to timing of first birth. Van Roode et al [26] showed that marriage and cohabitation were positively associated with birth timing, a finding which agrees with our results. Similar conclusions were drawn by Steel et al. [11]. However, among singles, early sexual initiation promotes protracted periods of singlehood, and in some cases cause relationship instability at your ages [26].

Education level explains a large proportion of being in singlehood, or marriage or cohabitation. The trend and its effect are similar for the singles and married in that the risk is higher at lower level of education and lower at secondary and higher levels of education. However, the risk of cohabitation is increased with increased education level. Overall, there exists a transformative relationship between education and marital status, with decreasing likelihood of marriage among educated women than the less educated women [27–28]. Along with gains in education, womens employment more than doubled over the 10- year period [22]. Employment status, however, has an opposing effect to that of education. Gainful employment solidifies marriage relationships. Being employed increased the chance of being single or marriage or in cohabitation. The effect is similar in all categories in that it generates economic independence, thus a woman can maintain her current status. According to a recent study by Sayer et al. [29], a woman's employment status has no effect on the likelihood that her husband will opt to leave the marriage. An employed woman is more likely to initiate a divorce than a woman who is not employed, only when she reports being highly unsatisfied with the marriage.

With regards regional differences in marriage patterns, our findings suggest that marriage in Namibia is not universal, but display heterogeneity. These results agree with a study done in Mozambique [20], and we attribute such heterogeneous tendencies to variability in ethnic or cultural norms and socio-economic differences. For instance, the central region is more multicultural compounded with the effect of urbanization, while the northeast and northwest are more rural dominated, culture and traditional norms are vital [3]. These disparities may require a multilevel or random effects model that includes regional variables to capture contextual effects. Such models would be an interesting extension to the regression model we fitted here and would be worth exploring.

Religiousness, as an indicator of social control, shows a varying effect among the married and those within cohabitation, and that its effect is changing with time [25]. Of interest is the fact that protestants were less likely to be married that Catholics, as evident in 2006, a fact than has been observed elsewhere, for example in Latin America and USA [30]. The liberal gospel and doctrines as purported by protestants may explain such an association. Vignoli and Ferro [25] argued that Catholic values imposed on Italian society have a positive effect on marriage coherence, compared to north European countries and the USA which have seen rising marital disruption. The effect of religion should be interpreted to have the same effect on marriage patterns as culture has. Beliefs and norms do change over time, and religion has an influence on both of these, which in turn has an impact on marriage practices [17,20].

In conclusion, our study has demonstrated the fact that demographic and socio-economic characteristics have important and similar effects for all marriage patterns. The role played by these factors is important to inform policy. We are aware that these explanatory factors are limited to explain the complex and dynamic processes that define marriage decisions and practices. However, literature persistently reports on these key factors, and our study has been defined within such general theoretical framework. Moreover, as pointed out by Vignoli and Ferro [25], some of these variables may raise selection bias and endogeneity, and appropriate techniques are required to model the relationship that may exist between our response variable and the explanatory variables. For instance, mixed regression model that incorporates random effects may be appropriate. Random effects may capture some of the unobserved and unmeasured population effects that influence marriage practices. Be as it may, there is an apparent social change in the Namibian society as reflected in the emerging marital patterns.

Acknowledgments

We acknowledge permission granted by MEASURE DHS to use the Namibian DHS data under the Project: Statistical modeling of demographic and population health indicators in Southern Africa.

Author Contributions

Conceived and designed the experiments: LNK LP NI. Performed the experiments: LP NI LNK. Analyzed the data: LP NI LNK. Contributed reagents/materials/analysis tools: LP NI LNK. Wrote the paper: LP NI LNK.

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