Birth spacing and child mortality in Mozambique: Evidence from two Demographic and Health Surveys

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ABSTRACT

A short preceding birth interval is associated with high risk of child mortality. The high mortality risk is reduced for mothers of high socio-economic status with access to child health care services and adequate resources for the child. A health system providing accessible, affordable and adequate child health care also reduces the high mortality risk.

The legacy of colonialism and two almost successive wars in Mozambique resulted in a health system currently experiencing a critical shortage of health personnel. In addition, Mozambican women are exposed to widespread poverty, low literacy and low contraceptive use. Under conditions of low socio-economic status and inadequate child health care services, children born following a short preceding birth interval are hypothesized to experience a higher risk of child mortality.

This research examines child mortality risk associated with short preceding birth intervals in Mozambique in quinquennial periods between 1978 to 1998 using data from the 1997 and 2003 DHS. A log rate model for piecewise constant rates is applied. The piecewise hazard function assumes a constant hazard rate of child mortality in each 6 month category of the preceding birth interval. The negative binomial regression model is applied to account for the overdispersion present in the Poisson model.

The effects of a short preceding birth interval are strongest in the neonatal period in Mozambique signifying that pre-natal mechanisms of maternal depletion can be attributed as the dominant pathway through which short preceding birth intervals magnify child mortality in Mozambique. An optimal birth spacing period for neonatal mortality was approximated at 42 months or three and a half years. The subsequent conception interval, survival status of previous birth by age five, the mother's age at birth, region of residence, and mother's education attainment were found to be consistent significant factors of child mortality in Mozambique.

This research suggests an extra 6 months under the optimal spacing banner of "Three to five saves lives". A waiting period of "three and a half to five years" should be promoted among couples in Mozambique.

DECLARATION

I declare that "**Birth spacing and child mortality in Mozambique: Evidence from two Demographic and Health Surveys**" is my own work, that it has not been submitted for degree or examination at any other university, and that all the resources I have used or quoted, and all work which was the result of joint effort, have been indicated and acknowledged by complete references.

Sandra D. Gonçalves

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1 INTRODUCTION

1.1 Introduction

The relationship between birth spacing and child mortality is one of the strongest and most important associations in demography (Hobcraft, McDonald and Rutstein 1985, Cleland and Rutstein 1986, Pebley and Millman 1986, Rutstein 2005). A short birth spacing period is associated with increased risk of child mortality (Hobcraft, McDonald and Rutstein 1983, Hobcraft, McDonald and Rutstein 1985, Pebley and Millman 1986, Retherford, Choe, Thapa *et al* 1989, Boerma and Bicego 1992, Miller, Trussell, Pebley *et al* 1992, Whitworth and Stephenson 2002, Rutstein 2005, Conde-Agudelo, Rosas-Bermúdez and Kafury-Goeta 2006). An estimated 35 per cent of deaths of children under the age of 5 could have been averted through spacing births by at least 36 months in developing countries (excluding China) in 2003 (Rutstein 2005).

Lengthy spacing periods of 5 years and longer also expose children to higher child mortality risk, although the association is much weaker compared with shorter spacing, lacks clear biological mechanisms and is more often a result of reproductive complications of the mother (Winikoff 1983, Pebley and Millman 1986, Setty-Venugopal and Upadhyay 2002, Rutstein 2005, Conde-Agudelo, Rosas-Bermúdez and Kafury-Goeta 2006). This study is limited to the hazardous effects of short birth spacing on child mortality.

A birth interval defined as the interval between two consecutive live births is used to measure the birth spacing period. A birth interval can be preceding or subsequent to a child under study referred to as an index child (Hobcraft, McDonald and Rutstein 1985, Koenig, Phillips, Campbell *et al* 1990). This analysis focuses on the association of child mortality with a short preceding birth interval. The length of the preceding birth interval is the main explanatory variable and child mortality is the outcome variable.

Child mortality analysis is limited to children under the age of five since mortality rates beyond age five are relatively low (Hill and Pebley 1989). Age at death categories of less than 1 month (neonatal mortality), 1 to 11 months (postneonatal mortality), 0 to 11 months (infant mortality), 12 to 59 months (child mortality) and 0 to 59 months (underfive mortality) are analyzed.

A short preceding birth interval can be avoided by preventing conception through the uptake of effective contraceptive methods and/or adherence to traditional birth spacing practices like prolonged breastfeeding and postpartum abstinence. For a child born following a short preceding birth interval, access to adequate medical technology and favourable social, economic and cultural conditions mitigate the negative effects of a short preceding birth interval on child survival (Rawlings, Rawlings and Read 1995, Setty-Venugopal and Upadhyay 2002). Educated, employed women have been found to have a higher proportion of short birth intervals not translating into increased child mortality risk as they can afford resources like hired child help and access to quality health service, which mitigate the negative effects of closely spaced births (Setty-Venugopal and Upadhyay 2002). On a macro level, the availability of accessible and affordable child health care services reduces child mortality risk associated with a short preceding birth interval.

Child mortality attributable to short birth spacing has declined significantly in developed countries due to improvements in neonatal medical technology including the availability of quality neonatal intensive care units and of doctors specializing in neonatal and obstetric care (Miller 1991, McCormick and Richardson 1995). The contribution of short birth spacing to child mortality is however still a significant problem in developing countries (Norton 2005). Mozambique is one of the developing countries where the contribution of short birth spacing to child mortality is hypothesized to be significant.

The legacy of colonialism and two wars in quick succession crippled socio-economic development and health service delivery (Kaplan 1984, Cliff and Noormahomed 1988a, Cliff and Noormahomed 1988b, UNICEF 1989). Mozambique has consistently had one of the lowest United Nations Human Development Index[1] (HDI) rankings since 1980, and is currently ranked 172 out of 177 countries in 2005 (UNDP 2007b). The WHO (2006) describes Mozambique as having a critical shortage of medical personnel with a density of 0.03 physicians, 0.21 nurses and 0.12 midwives for each 1000 Mozambicans in 2004.

In addition, low contraception use, low literacy levels and widespread poverty among Mozambican women indicate that favourable socio-economic conditions necessary to mitigate the hazardous effect of a short preceding birth interval are absent in the majority of the women. Current contraception use of both modern and traditional methods among all

[1] The United Nations Human Development Index is a composite measure incorporating mortality, education and income.

women is estimated at 18.2 per cent in 2003, having improved from very low levels of 6 per cent in 1997 (Gaspar, Cossa, Santos *et al* 1998, Instituto Nacional de Estatística and Ministério de Saúde 2005). Female literacy is estimated at 36 per cent in 2006 compared to male literacy of 68 per cent (UNDP 2007a). Over half of the Mozambican population (54%) were estimated to be living below the national poverty line between 2002 and 2003 (INE 2004a).

Against a background of war, inadequate medical service, limited contraceptive use, illiteracy and poverty, children born following a short preceding birth interval are hypothesized to be at a higher risk of dying in Mozambique.

1.2 Background to study

1.2.1 Mozambique country profile

Mozambique is located in the eastern part of southern Africa. It has territorial borders with South Africa and Swaziland in the Southern region, with Zimbabwe in the Central region and with Malawi, Tanzania and Zambia in the Northern region.

The country is divided into ten provinces constituting three major regions; Southern, Central and Northern Mozambique. Southern Mozambique is composed of Maputo Province, Inhambane Province and Gaza Province. Central Mozambique comprises of Manica Province, Sofala Province, Zambézia Province and the province of Tete. Northern Mozambique is composed of Nampula Province, Niassa Province and Cabo Delgado Province (Figure 1.1). The Southern region is the most urbanized followed by the Central region; with the Northern region being the least urbanized (Arnaldo 2003).

Wide socio-economic and demographic disparities between the capital city (Maputo) and the rest of Maputo Province motivate socio-economic and demographic analysis (including Demographic and Health Survey reports) to be split into Maputo City and the rest of Maputo Province. Likewise, in this study, Maputo Province is split into Maputo City and Maputo Province.

Figure 1.1 Map of Mozambique

Source: Direcção Nacional de Geografia e Cadastre (DINAGECA) data.

1.2.2 Population distribution, structure and growth

Preliminary results of the latest population census conducted in 2007 indicate a total population of 20,530,714 persons composed of 10,743,579 females (52%) and 9,787,135 males (48%) (Table 1.1) (INE 2007). The provinces of Nampula and Zambézia are the most populated with a population distribution of 20 per cent and 19 per cent respectively (Table 1.1).

Table 1.1 Mozambique 2007 Population and Housing Census preliminary results

Province	Population		Total Population	Sex Ratio
	Male	Female		
Niassa	573,768	604,349	1,178,117	94.9
Cabo Delgado	783,235	849,574	1,632,809	92.2
Nampula	1,999,958	2,076,684	4,076,642	96.3
Zambezia	1,862,091	2,030,763	3,892,854	91.7
Tete	885,311	947,028	1,832,339	93.5
Manica	674,257	744,670	1,418,927	90.5
Sofala	801,417	852,746	1,654,163	94.0
Inhambane	559,843	707,192	1,267,035	79.2
Gaza	541,866	677,147	1,219,013	80.0
Maputo Province	573,595	686,118	1,259,713	83.6
Maputo City	531,794	567,308	1,099,102	93.7
Total	**9,787,135**	**10,743,579**	**20,530,714**	**91.1**

Source: Instituto Nacional de Estatística (INE) 2007

The high population distribution in Zambézia and Nampula provinces is a legacy of the colonial era when the region was economically strong and when maintaining high population numbers was a military defence strategy against territorial threats (Gaspar 2002). Coastal provinces are generally more populated than inland provinces as a result of internal migration from inland areas to the more urbanized coastal towns (Arnaldo 2003). Mozambique is predominantly rural, with 71 per cent of the population resident in rural areas in the 1997 population census (INE 1999a).

An overall sex ratio of 91 males per 100 females is estimated in 2007 (Table 1.1). The relatively lower sex ratios of 79 and 80 males per 100 females in the Southern provinces of Inhambane and Gaza respectively, result from a culture of male labour migration from Southern Mozambique to work in South Africa (Gaspar 2002).

The total population of Mozambique increased by 27.7 per cent in the past decade (1997 to 2007) comparing results of the 1997 census and 2007 preliminary results (INE 2007). Life expectancy at birth in 2006 is estimated at 45.5 years for males and 49.3 years for females (total life expectancy of 47.4) (INE 2004b). In general, fertility has been declining in Mozambique since the 1950's although a post independence fertility increment of 8 per cent was reported between 1970 and 1980 (Arnaldo 2003). Total fertility declined from an estimated 7 children per woman in 1960, to 5.5 in the 2003 DHS (INE 1999b).

1.2.3 Historical setting of birth spacing and child mortality in Mozambique

Mozambique obtained sovereign rule from Portugal in 1975 following a 10-year liberation war that began in 1964. The armed struggle was led by the Front for the Liberation of Mozambique (FRELIMO) (*Frente de Libertação de Moçambique*). Under colonial rule, the Portuguese colonists denied African Mozambicans adequate access to health services, family planning services, education and economic development: aspects which mitigate the hazardous effects of short birth spacing on child mortality or which motivate adequate birth spacing (Kaplan 1984). Following independence, the FRELIMO government embarked on improving the social and economic conditions of Mozambicans.

However, shortly after independence, Mozambique became engaged in a 16-year civil war that lasted from 1976 to 1992 between FRELIMO and the Mozambique National Resistance (*Resistência Nacional Moçambique*: RENAMO) (Johnson and Martin 1986). RENAMO sabotaged regional trade routes through Mozambique, state farms, railway lines, national roads, schools and hospitals (Johnson and Martin 1986). Thus the civil war eroded post-independence gains in essential service delivery including health and family planning services and education and furthermore prevented social and economic development in Mozambique (Cliff and Noormahomed 1988a, Cliff and Noormahomed 1988b, UNICEF 1989, Cliff 1991).

Historical trends of key mitigating factors of the hazard of child mortality associated with a short preceding birth interval: health care access, family planning services, education and economic development are described in the section below.

Health care access

Over 70 per cent of the African population in Mozambique was estimated to live out of reach of any form of health care in 1975 (Kaplan 1984, UNICEF 1989, Baden 1997). In an effort to increase access to health services, the government increased primary health care units from 426 units in 1975 to 1171 units in 1982 (Cliff and Noormahomed 1988b, Cliff 1991). The government also embarked on training for basic health workers and midwives leading to an increase in the number of midwives from 457 in 1980 to 971 in 1986 and hired foreign doctors to ease the shortage of medical personnel (Kaplan 1984, Cliff and Noormahomed 1988a, Cliff 1991).

However, the civil war disrupted improvements in health service provision. Health personnel were subject to attacks by RENAMO militants and health posts were targeted and destroyed (Cliff and Noormahomed 1988a, Cliff and Noormahomed 1988b, Cliff and Noormahomed 1993). Cliff and Noormahomed (1993) indicate that almost half of the primary health care network was destroyed between 1982 and 1990. The state budget allocation for health was reduced from 10.7 per cent in 1981 to 4.6 per cent in 1986 due to increased military spending, with a slight increase to 5.5 per cent in 1989 (Cliff and Noormahomed 1993). Furthermore, health service charges introduced in 1987 as part of the Economic Rehabilitation Program resulted in a 30 per cent drop in attendance at health centres (Cliff and Noormahomed 1993, Baden 1997).

Statistics indicate that the number of people per medical personnel increased from 1592 in 1998 to 2213 in 2002 (Table 1.2). As a result, Mozambique is characterized as having a critical shortage of medical personnel with a density of 0.03 physicians, 0.21 nurses and 0.12 midwives for each 1000 Mozambicans in 2004 (WHO 2006). The latest Human Development Report for Mozambique notes that the National Health Service offers health care to between 40 to 50 per cent of the population (UNDP 2007a).

Table 1.2 Number of people per medical personnel

Year	Number of people per medical personnel
1998	1592
1999	1730
2000	1958
2001	1969
2002	2213

Source: INE 2000, INE 2003

Family planning services

Provision of family planning services for birth spacing purposes was one of the priorities of the sovereign government in 1977 in an effort to curb high child and maternal mortality rates (Kaplan 1984, Raisler 1984, Cliff 1991). The underfive mortality rate during the period 1972 to 1977 is estimated at 250 deaths per 1000 live births (Gaspar, Cossa, Santos *et al* 1998). Attacks on health centres and health personnel during the civil war disrupted the provision of family planning services since family planning services were integrated with maternal and child health services (Cliff 1991). In an 1987 survey on the Reproductive Behaviour of Mozambican Women, family planning provision was the least developed of maternal and child health services, except in Maputo City where family planning provision was reasonable (Monreal 1991 cited in Arnaldo 2003).

Low contraception use of 6 per cent largely composed of modern contraceptive use (5.4 per cent) was reported in the 1997 DHS (Gaspar, Cossa, Santos *et al* 1998). The low contraceptive prevalence is most likely a consequence of the civil war simultaneously disrupting the provision of modern contraceptive methods and the maintenance of traditional birth spacing practices. Contraceptive use increased threefold from the 1997 DHS to the 2003 DHS from 6 per cent to 18.2 per cent. (Gaspar, Cossa, Santos *et al* 1998, Instituto Nacional de Estatística and Ministério de Saúde 2005). The increase may reflect post war recovery in family planning services. The National Population Policy adopted in 1999 included improved coverage of family planning provision (Arnaldo 2003). Use of traditional contraceptive methods increased from 0.6 per cent in 1997 to 4 per cent in the 2003 DHS, which may be a reflection of post war restoration of traditional birth spacing practices and traditional contraceptive methods.

Provincial differences however exist in levels of contraception use. Women in Maputo Province and Maputo City reported higher contraceptive use even in 1997 when the national contraceptive prevalence was low. Minimal effects of the civil war in and around the capital city may explain the higher prevalence (Arnaldo 2003) (see chapter 2).

Education

Adult literacy levels in Mozambique were estimated between 5 per cent and 7 per cent in 1975 (Kaplan 1984, UNICEF 1989, Baden 1997). Government efforts increased literacy levels to 25 per cent by the early 1980s, although over 86 per cent of females were still illiterate compared to 60 per cent of males (Kaplan 1984). Although adult literacy rates have been improving in Mozambique (estimated at 48 per cent in 2006), sex differentials in literacy still persist in Mozambique with male literacy rates almost double female literacy rates in 2006 (Table 1.3).

Table 1.3 Adult literacy rates 2000 to 2006, disaggregated by sex

	2000	2001	2002	2003	2004	2005	2006
Male	59.8	59.8	63.3	63.3	69.7	65.6	67.9
Female	28.8	28.8	32.0	33.8	33.8	33.8	35.5
Total	**43.3**	**44.9**	**46.4**	**46.4**	**47.2**	**47.2**	**48.0**

Source: UNDP 2006, UNDP 2007a.

Provincial differentials in literacy indicate that the highest literacy levels are in Maputo City province where 92.5 per cent of males are literate compared to 78 per cent literacy among females in 2003. The highly populated provinces of Zambézia and Nampula have among the lowest female literacy levels rates of 19.4 per cent and 18.6 per cent respectively in 2003.

Economic development

On a macroeconomic level, Mozambique currently has one of the fastest growing economies in Africa with average annual growth in GDP per capita estimated at 4.6 per cent between 1990 and 2005 (UNICEF 2007). The trend in economic growth has however been fluctuating. Mozambique experienced positive economic growth in the period after independence, from 1977 to 1981 (Johnson and Martin 1986, Baden 1997). The impact of the civil war led to negative economic growth during the period 1980 to 1988 (UNICEF 1991). Sabotage of strategic infrastructure in Mozambique including tea, sugar and cashew factories, state farms, railway lines and national roads reduced production and total exports which consequently reduced GDP growth (Baden 1997). Unsuccessful socialist economic policies of centralized state control of products and a pricing system monopoly also contributed to the negative growth (Kyle 1991). The introduction of a liberal market in 1985 and the Economic Rehabilitation Program in 1987 reversed the negative growth in GDP (Kyle 1991).

Despite the increasing economic growth, poverty still persists among Mozambicans. With poverty rooted in the colonial legacy of deprived economic development, the civil war exacerbated the situation by disrupting food production and causing a massive stock loss; thus destroying the livelihood of the largely rural-based population (Johnson and Martin 1986, UNICEF 1989). Johnson and Martin (1986) estimate that the Mozambique national herd was reduced by 40 per cent from an estimated total of 1,500,000 cattle in 1980 to 900,000 cattle in 1985. RENAMO attacks on communal rural villages led to crops and farmhouses being burnt (UNICEF 1989). The 1987 economic structural adjustment program resulted in the reduction or removal of government subsidies on staple foods and living utilities, with increases in staple food prices of between 400 to 600 per cent in 1988 which were not matched by income increments (Cliff 1991).

69 per cent of Mozambicans were estimated to be living below the national poverty line in 1996 and 1997 (INE 2004a). However poverty is on the decline in Mozambique with 54 per cent of Mozambicans estimated to be living below the national poverty line in 2002 and 2003 (INE 2004a).

1.3 Birth spacing and child mortality in Mozambique

Child mortality rates for preceding birth interval categories of less than 2 years, 2 to 3 years, 3 to 4 years and 4 years or longer are presented in Table 1.4 to illustrate the high rates of child mortality associated with a short preceding birth interval. Child mortality is computed at age at death categories of less than 1 month (neonatal), 1-11 months (postneonatal), 0-11 months (infant), 12-59 months (child) and 0-59 months (under five) for the five years preceding the 1997 DHS and the 2003 DHS.

The highest mortality rates at each age at death correspond to the shortest preceding birth interval category of less than two years (Table 1.4). Mortality rates for children with preceding birth intervals of less than 2 years are in the magnitude of between 1.1 and 7.1 times mortality rates of longer preceding birth intervals for each age at death category. In general, mortality rates have declined across categories of preceding birth intervals at each age at death from the period 1992 to 1997 to the period 1998 to 2003 (Table 1.4).

The bivariate analysis illustrated in Table 1.4 is however simplifies the association of child mortality with the length of the preceding birth interval. A multivariate analysis is required to isolate the influence of short preceding birth intervals on child mortality by controlling for other covariates of child mortality.

Table 1.4 Neonatal, postneonatal, infant, child and under five mortality rates by preceding birth interval categories for the five years preceding the survey, 1997 and 2003 DHS

DHS Reference	Period	Neonatal	Postneonatal	Infant	Child	Under 5
1997 DHS	<2 years	95	119	214	93	287
	2-3 years	57	75	132	77	198
	3-4 years	47	30	77	84	154
	>=4 years	13	67	80	59	134
2003 DHS	<2 years	64	107	171	69	228
	2-3 years	31	53	84	64	142
	3-4 years	24	39	64	43	104
	>=4 years	17	45	62	39	98

1.4 Statement of research problem

A short preceding birth interval is associated with high risk of child mortality. The high mortality risk is reduced for mothers of high socio-economic status with access to child health care services and adequate resources for the child. A health system providing accessible, affordable and adequate child health care also reduces the high mortality risk. The legacy of colonialism and two almost successive wars in Mozambique resulted in a health system currently experiencing a critical shortage of health personnel. In addition, Mozambican women are exposed to widespread poverty, low literacy and low contraceptive use. Low contraception use (both modern and traditional methods) increases the probability of short preceding birth intervals. Under conditions of low socio-economic status and inadequate child health care services, children born following a short preceding birth interval are exposed to a high risk of child mortality. Inadequate

This study examines the risk of child mortality associated with 6-month categories of the length of the preceding birth interval. Child mortality is calculated at ages at death of less than 1 month (neonatal mortality), 1-11 months (postneonatal mortality), 0-11 months (infant mortality), 12-59 months (child mortality) and 0-59 months (underfive mortality). The analysis is conducted in quinquennial birth periods between 1978 and 1998 using data from the Mozambique 1997 and 2003 DHS.

A multivariate analysis of the association of short preceding birth intervals with child mortality has never been conducted in Mozambique; hence this analysis contributes to the dearth of research on the association of short birth spacing and child mortality.

The government of Mozambique adopted Millennium Development Goals (MDGs) which include a goal of reducing underfive mortality by two-thirds of 1990 levels by 2015 (UNDP 2006). Government institutions and non-governmental organizations in Mozambique have been promoting optimal birth spacing campaigns, aimed at increasing awareness of the detrimental effects of short birth spacing among communities (Beracochea and Pruyn 2005). Results of this multivariate analysis will predict the mortality risk of short preceding birth intervals and highlight mechanisms of short preceding birth intervals. These results can inform policy and thus contribute to the reduction of child mortality rates in Mozambique.

1.5 Methodology

The log rate model for piecewise constant rates is used to model the risk of child mortality associated with the length of the preceding birth interval. The length of the preceding birth interval is the main explanatory variable and child mortality is the outcome variable.

The index child or child under study is defined as a single live birth of second birth order or higher. First order births are excluded from the analysis as they have no preceding birth. All multiple births are excluded from the analysis since multiple births are associated with excess mortality. Furthermore, definitional problems of a birth interval between multiple births that are normally born within moments of each other leads to their exclusion as index births (Hobcraft, McDonald and Rutstein 1983). Non-live birth outcomes from induced abortions, miscarriages and stillbirths are excluded since the mechanisms of a preceding birth interval cannot be investigated on a non-live birth outcome.

The log rate model for piecewise constant rates assumes that the risk period; defined as the period during which a child is at risk of dying, can be categorized into mutually exclusive and exhaustive segments with a constant hazard rate in each segment (Yamaguchi 1991, Laird and Olivier 1981). A hazard rate is defined as the "…instantaneous risk of having the event at time *t, given that the event did not occur before time t*" (Yamaguchi 1991:9). The piecewise constant hazard function is thus an approximation of the continuous hazard function calculated as a step function or a piecewise function (Yamaguchi 1991, Friedman 1982).

A saturated log rate model for piecewise constant rates with two explanatory categorical variables A and B can be represented as follows (Yamaguchi 1991:72):

$$\ln(F_{tij}^{TAB}/W_{tij}^{TAB}) = \lambda + \lambda_t^T + \lambda_i^A + \lambda_j^B + \lambda_{ti}^{TA} + \lambda_{tj}^{TB} + \lambda_{ij}^{AB} + \lambda_{tij}^{TAB}$$

where T is the time variable indicating time since last birth (length of the preceding birth interval) split into t categories
A and B are time independent explanatory variables with i and j categories respectively
F_{tij}^{TAB} is the expected frequency of events for cell (t, i, j) in the cross-classification table
W_{tij}^{TAB} is the total exposure to the risk of event occurring during time interval t for group (i,j)
$F_{tij}^{TAB}/W_{tij}^{TAB}$ is the rate of occurrence of the event during time interval t for group (i, j)
λ is the constant parameter representing the average level of the log rate
$\lambda_t^T, \lambda_i^A, \lambda_j^B$ are main effects of variables T, A and B on log rates
$\lambda_{ti}^{TA}, \lambda_{tj}^{TB}, \lambda_{ij}^{AB}$ are two factor interaction effects of variables log rates
λ_{tij}^{TAB} represents three factor interaction effects of variables on log rates

The log rate model for piecewise constant rates assumes that hazard rates are different among different groups and that differences between the groups are captured by a set of time-independent categorical explanatory variables (Yamaguchi 1991). In this research, the hazard rate is assumed to be constant for 6 month categories of the length of the preceding birth interval. The analysis of the hazard rate is conducted at each age at death and quinquennial birth periods extending over the period 1978 to 1998.

The application of log rate models for piecewise constant rates to the study of child mortality and preceding birth intervals is advantageous for the following two reasons. First, applying the Poisson modelling (as the log rate model) to calculate piecewise constant rates, allows data from two surveys to be aggregated (Moultrie 2002). Children born in matching periods from the 1997 and 2003 DHS datasets are combined which allows narrow categories of preceding birth intervals to be modelled with sufficient data. Second, a proportional hazard assumption of the commonly modelled Cox proportional hazard model is not necessary for piecewise constant log rate models (Moultrie 2002). A proportional hazard function assumes that the ratio of the hazard rate among different groups is independent of time and thus constant over time, an assumption that is unreasonable for this research (Yamaguchi 1991). Although time dependent covariates can be modelled in the Cox proportional hazard model, the process is not as analytically simple as the piecewise constant log rate model (Moultrie 2002).

1.6 Limitations of study

Unavailability of data on the occurrence of abortions, miscarriages and stillbirths in between live births is a limitation of the study. A miscarriage, abortion or stillbirth will have an effect on intrauterine growth of the index child conceived in the subsequent interval particularly if it is a short interval (Boerma and Bicego 1992). Uncontrolled effects of a miscarriage, abortion or stillbirth result in an artificially increased preceding birth interval associated with higher child mortality which erodes the association of short preceding birth intervals with child mortality. However it stands to reason that short birth intervals whose detrimental effects is the main focus of this study have reduced chances of containing stillbirths, miscarriages or abortions within the short interval (Conde-Agudelo, Rosas-Bermúdez and Kafury-Goeta 2006).

The inclusion of pre-term births in categories of short preceding birth intervals inflates the risk of child mortality for those categories as pre-term babies are associated with higher risks of mortality relative to full term babies (Hobcraft, McDonald and Rutstein 1983, Winikoff 1983). Assuming a normal gestation length of 9 months, births with a preceding birth interval of less than 9 months are excluded from the analysis to avoid pre-term births inflating mortality risk. Excluding pre-term births raises the possibility of eliminating effects of a preceding birth interval on length of gestation, as the pre-term birth might be a precipitation of a short preceding birth interval (Hobcraft, McDonald and Rutstein 1983). However, the aim of this research is to establish the effect of a short preceding birth interval on child mortality and not on the length of gestation.

Data quality concerns with regards to age misreporting, omission of births and birth displacement limit reliance on model results. Retrospective data are prone to omission errors and misplacement of dates (Potter 1977, Hobcraft, Goldman and Chidambaram 1982). Age heaping was detected in the both the 1997 and 2003 DHS datasets. Birth displacement into periods closer to the survey date (Potter effects) was detected in the 1997 DHS data.

Data quality concerns are also introduced from imputing dates. Using imputed dates to calculate preceding birth intervals may affect results if imputed dates are significantly different from the true date. According to Croft (1991:20), "...short birth intervals may be a result of the imputation process and not necessarily the real situation." On one hand, if actually short intervals are imputed to be longer and the index child dies, the risk of child mortality associated with short birth intervals is diminished. On the other hand, if actually long intervals are imputed to be shorter and the index child survives, child mortality risk associated with short birth intervals is also diminished. It is however not possible to separate data quality effects from real effects in model results.

The use of retrospective birth history data implies that dead mothers cannot be interviewed (Winikoff 1983). As a result, if the average pattern of birth spacing and occurrence of child mortality among dead mothers is different from that of surviving mothers, model results will be biased towards the responses of surviving mothers. Increasing adult mortality from AIDS related deaths contributes to this bias in child mortality estimates (Mahy 2003).

The impact of HIV and AIDS is not modelled since the 1997 and 2003 Mozambique DHS did not collect individual level HIV data. HIV and AIDS is hypothesised to affect the association of child mortality with short preceding birth intervals through its effect on breastfeeding patterns (in the case of an HIV positive mother) and foetal loss in pregnant HIV positive women (Du Plessis 2003).

Competing risks of child mortality might diminish or remove the association of child mortality with the length of the preceding birth interval. A longitudinal study in Bangladesh (Koenig, Phillips, Campbell *et al* 1990) concluded that effects of a famine that had been experienced in the year of the study may have removed post-neonatal effects of the impact of short birth intervals on child mortality. Besides the civil war, Mozambique has also experienced a drought and a series of other natural disasters during the study period 1978 to 1998 which include flooding of the Zambezi, Limpopo and Incomati rivers in 1978; cyclone Justine in the north of the country in 1979; a prolonged five year drought from 1979 to 1984 which resulted in a famine between 1983 and 1984 in the Southern and Central regions of Mozambique (Kaplan 1984, Johnson and Martin 1986, UNICEF 1989).

1.7 Thesis outline

The thesis is divided into 7 chapters. This chapter has provided an introduction to birth spacing and child mortality, stating the research problem, motivation and limitations of the research. Chapter 2 provides a review of the literature on birth spacing and child mortality and outlines the theoretical framework on which the modelling of child mortality with preceding birth intervals is based. Chapter 3 presents a discussion of log rate models for piecewise constant rates to be applied in the modelling of child mortality with preceding birth intervals. Chapter 4 examines data quality of the 1997 and 2003 DHS data sources. Chapter 5 discusses steps taken in data analysis and provides descriptive statistics of model covariates. Model results are presented and discussed in Chapter 6 with conclusions presented in the final chapter 7.

2 LITERATURE REVIEW AND STATEMENT OF THEORY

"Birth spacing is a well-known, underutilized, and admittedly not fully understood health intervention" Norton (2005:S2)

This chapter begins with a review of the literature on birth spacing and child mortality followed by a discussion on mechanisms of association of a short preceding birth interval with child mortality. An outline of the Mosley and Chen (1984) framework of child mortality to be adopted in this research is presented section 2.3 with a discussion on child mortality rates in Mozambique. A discussion on birth spacing in Mozambique; traditional birth spacing and current birth intervals is provided in the final section.

2.1 Literature on birth spacing and child mortality

The negative effect of short birth spacing on child mortality has been a subject of study since the 1920s Hughes (1923) and Woodbury (1925) cited in Rutstein (2005). The definition of a birth spacing period is however varied. Birth spacing can be measured as the interval between consecutive live births (referred to as a birth interval), or alternatively as an inter-pregnancy interval (defined either as the time elapsing between successive pregnancies, or as the interval from the birth of one child to the conception of the next), and finally birth spacing can be defined as an average birth interval of birth counts over a time interval (Koenig, Phillips, Campbell *et al* 1990, Setty-Venugopal and Upadhyay 2002, Conde-Agudelo, Rosas-Bermúdez and Kafury-Goeta 2006).

Based on birth registration records of 1916 from Gary, Indiana; Hughes (1923) established higher infant mortality rates among children born following a preceding birth interval of less than 15 months of 169.1 per 1000 live births compared to an infant mortality rate of 102.8 for children with a preceding birth interval of two years and longer.

Yerushalmy, Bierman, Kemp *et al* (1956) conducted one of the earliest population based studies using retrospective birth reports to calculate neonatal, postneonatal and child mortality on the island of Kauai in Hawaii. Children with a pregnancy interval (interval between the termination of one pregnancy and the beginning of the next pregnancy) of less than 4 months were subject to higher risks of mortality, particularly steep for neonatal and postneonatal mortality in the magnitude of three to five times mortality rates of children with a pregnancy interval of three years or longer. Neither study controlled for confounding variables.

In a review of literature on birth spacing and child mortality published between 1956 and 1981, Winikoff (1983) concludes that methodological difficulties (discussed later) limit the validity of results although the general trend between infant mortality and the length of the preceding birth interval is a negative relationship. The non-inclusion of potentially confounding variables such as prematurity, intra-familial mortality risks, the length of the succeeding interval, parity, age of the mother at birth and socio-economic status precludes the drawing of reliable conclusions (Winikoff 1983).

The launching of the World Fertility Surveys (WFS) in 1972 and the follow-up Demographic and Health Surveys (DHS) in 1984 provide comprehensive and nationally representative retrospective birth history data including individual socio-economic, socio-cultural and biomedical variables. Furthermore, the commencement of Demographic Surveillance Sites in 1960 allowed the collection of longitudinal data with the first DSS set up in Matlab, Bangladesh (Clark 2004). Simultaneous methodological advancements in multivariate modelling techniques with the classic paper by Cox (1972) on the proportional hazard model and other multivariate modelling techniques (Holford 1976, Laird and Olivier 1981) enhanced the modelling of preceding birth intervals with child mortality.

Trussel and Hammerslough (1983) using Sri Lanka WFS data, conclude that short preceding birth intervals of less than 19 months, have death rates 75 per cent higher at birth orders two and three and deaths rates 100 per cent higher at birth orders four or higher when compared to preceding birth intervals longer than 40 months. A log rate hazard model was used to model the data controlling for; education of the mother and father, age of mother at birth, sex, birth order, period of birth, current residence, toilet facility and water supply (Trussel and Hammerslough 1983).

Using World Fertility Survey data from 26 countries, Hobcraft, McDonald and Rutstein (1983) established the universality of the association of short birth spacing and child mortality. Applying a Poisson model, the authors controlled for mother's education (socio-economic status), birth order and the succeeding birth interval to conclude that a preceding birth interval of less than two years is the most hazardous to child survival to age five. The effects of a preceding birth interval were found to be more hazardous in the first year of life. Taking a child with one prior sibling born two to six years ago as a baseline group, index children with three prior siblings born two to six years ago, with one sibling born within the past two years and a subsequent sibling born within 30 months had double or triple risk of under five mortality with rates of at least 150 in all countries and over 300 in 11 countries (Hobcraft, McDonald and Rutstein 1983).

In a subsequent publication, Hobcraft, McDonald and Rutstein (1985) using WFS data from 36 countries, present a more comprehensive model which includes controls for the survival status of the prior sibling, age of the mother at birth and sex of the child. Index children with an older sibling under two years of age who is alive at the birth of the index child experienced median excess risk of 80 per cent in the postneonatal period compared to a median excess risk of 50 per cent in the neonatal period (baseline category of no prior siblings within two years of the index child's birth). Intra-familial mortality risks also lead to excess risks of index child mortality if the older sibling (born within two years or two to four years prior to the index child's birth) was dead at the birth of the index child. Index children with no excess mortality risks had an older sibling (born two to four years before) alive at the birth of the index child.

Several studies on birth spacing and child mortality have since been published (Pebley and Millman 1986, Retherford, Choe, Thapa *et al* 1989, Koenig, Phillips, Campbell *et al* 1990, Miller, Trussell, Pebley *et al* 1992, Whitworth and Stephenson 2002, Rutstein 2005, Conde-Agudelo, Rosas-Bermúdez and Kafury-Goeta 2006). Although varying in data sources, methods, cut-off points for "short" birth spacing and geographical location; similar conclusions were reached on the effects of a short preceding birth interval on child mortality: children born following a short preceding birth interval are at a higher risk of dying. The hazardous effects of a short preceding birth interval have been found to be strongest during the first year of life, particularly in the postneonatal period.

Hobcraft, McDonald and Rutstein (1985) and Pebley and Millman (1986) found higher excess mortality during the postneonatal period of 90 and 96 per cent and excess neonatal risk of 50 and 58 per cent respectively for preceding birth intervals of less than 24 months. Using data from Hungary, Sweden and the United Sates, Miller (1991) concludes that avoiding a preceding birth interval of less than two years reduced the risk of neonatal death by five to ten per cent. Boerma and Bicego (1992) found age-specific effects of a preceding birth interval to be stronger in the early postneonatal period (1-6 months) compared to the neonatal for intervals of less than 24 months using DHS data from 17 countries. Whitworth and Stephenson (2002) analyzed data from India and concluded that short preceding birth intervals of less than 18 months increased the odds of postneonatal mortality by 237 per cent and the odds of neonatal mortality by 84 per cent.

Kuate Defo (1997), using data from the 1978 Cameroon WFS found higher increased relative risks of mortality at early postneonatal ages of one to three months of 73 per cent, compared to neonatal mortality (46 per cent). Using the 1991/92 Tanzania DHS data, Mturi and Curtis (1995) found that children with a preceding birth interval of less than two years were at a higher risk of dying in the neonatal period, more pronounced for higher order births of five and above (increased relative risk of 19 per cent) compared to first order births. However the higher mortality associated with first order births as a reference group may have lessened calculated relative risks of neonatal mortality. Madise and Diamond (1995) conclude that the effects of a short preceding birth interval in Malawi are limited to the postneonatal period. Longer preceding intervals of more than 18 months result in a 40 per cent reduction in postneonatal mortality risk. The authors analyzed data from the 1988 Malawi Traditional and Modern Methods of Child Spacing Survey.

Boerma and Bicego (1992), caution that the absence of stronger preceding birth interval effects in the neonatal period may be a result of selective underreporting of neonatal deaths in retrospective data used in the bulk of the studies. Selective underreporting is less pronounced in longitudinal surveys with one such study concluding on stronger mortality risk in the neonatal period (Koenig, Phillips, Campbell *et al* 1990).

An optimum birth spacing period of 24 months has traditionally been recommended as non-hazardous (Hobcraft, McDonald and Rutstein 1983, Hobcraft, McDonald and Rutstein 1985, Pebley and Millman 1986, Miller 1991, Mturi and Curtis 1995). More recent analyses however established a preceding birth interval length of 36 months as the most advantageous, advocating for an extra 12 month spacing period (Setty-Venugopal and Upadhyay 2002, Rutstein 2005).

Although considered one of the strongest and most important associations in demography, the association of short preceding birth intervals with child mortality has been contested on the grounds of: spurious association, not controlling for the length of gestation, not controlling for breastfeeding, the model type applied in the analysis, the quality of retrospective data used and on the hypothesized mechanisms. Conde-Agudelo, Rosas-

Bermúdez and Kafury-Goeta (2006) summarize the limitations of past studies of child mortality and birthspacing in the following way:

> Furthermore, previous research in this area has several methodological limitations, such as sample size, lack of control for potentially confounding factors, dichotomization of the measure of birth spacing on the basis of an arbitrarily defined cut point, use of birth interval (time elapsed between the woman's last delivery and birth of the index child) instead of interpregnancy interval (time elapsed between the woman's last delivery and the conception of the next pregnancy) as a measure of spacing. (Conde-Agudelo, Rosas-Bermúdez and Kafury-Goeta 2006:1809).

Spurious association

Potter (1988) puts forward the hypothesis that models of child mortality and the length of the preceding birth interval capture effects health services use and contraception use and not direct effects of short preceding birth intervals on child mortality. Thus the association is spurious and not real. However effects of a short preceding birth interval have remained significant even after controlling for the use of health services (Boerma and Bicego 1992, Rutstein 2005). Boerma and Bicego (1992) found the effects of controlling for health service utilization to be negligible on relative risks of child mortality.

Not controlling for the length of gestation

The bias introduced by not controlling the length of gestation is significant for studies measuring birth spacing as a birth interval as opposed to an inter-pregnancy interval (Winikoff 1983, Hobcraft, McDonald and Rutstein 1985, Conde-Agudelo, Rosas-Bermúdez and Kafury-Goeta 2006). Categories of short birth intervals including births with a length of gestation of less than nine months include pre-term babies associated with higher risk of neonatal mortality relative to full term babies (Hobcraft, McDonald and Rutstein 1983, Winikoff 1983).

Not controlling for premature births results in an artificially inflated association (Rutstein 2005). Miller (1991) found a reduction of between 45 and 58 per cent in the relative risk of neonatal mortality after controlling for the length of gestation. Similarly, Miller, Trussell, Pebley *et al* (1992) concluded that confounding by prematurity accounts for between 21 to 28 per cent of excess infant mortality with short preceding birth intervals of less than 15 months.

Not controlling for breastfeeding

Breastfeeding duration of the index child has a dual mortality reduction effect on the index child since breast milk contains nutrients and also provides immunity against disease infection (Gray 1981, Huffman and Lamphere 1984). Breastfeeding duration of the index child furthermore affects the subsequent birth interval by prolonging the period of postpartum amenorrhea (Perez, Vela, Potter *et al* 1971, Gray 1981, Santow 1987). Similarly the breastfeeding duration of the immediately prior child affects the preceding birth interval of the index child.

The association of index child breastfeeding with the length of the preceding birth interval has been found either negligible or with minimal effects (Palloni and Millman 1986, Retherford, Choe, Thapa *et al* 1989, Boerma and Bicego 1992). This would be expected since it is the breastfeeding of the prior child that affects the length of the preceding birth interval. However the association of breastfeeding with child mortality is significant through the length of the subsequent conception.

Model type

Hazard rate models or log rate models (commonly applied to modelling the association of preceding birth intervals with child mortality) assume that observations are independent. However with birth history data, a single mother can contribute to multiple child deaths, resulting in a clustering of child deaths around the mother thus violating the independence assumption. This violation results in reduced standard errors and consequently an overstatement of significant covariates (Madise and Diamond 1995, Whitworth and Stephenson 2002).

However, Lantz, Partin and Palloni (1992) compare model results of a piecewise logistic model, a hazard model with a Gompertz parametric form for the baseline hazard, a piecewise hazard model and a Cox's proportional hazard model and conclude that (except for the case of Nepal) the association of birth spacing and child mortality is not model dependent.

Quality of retrospective data

The quality of retrospective data commonly applied in modelling the association of preceding birth intervals with child mortality has been attributed as a source of bias (Potter

1988). Retrospective data are prone to omission errors and misplacement of dates (Potter 1977, Hobcraft, Goldman and Chidambaram 1982). However, Lantz, Partin and Palloni (1992) use various arguments and models to show that in spite of limitations in data quality, the relationship between a short preceding birth interval and child mortality still persists.

Hypothesized mechanisms

The mechanisms through which a short preceding birth interval affects child mortality have never been concretely proven (Winikoff 1983). However circumstantial evidence suggests several pathways of the effects of a short preceding birth interval discussed in the following section.

2.2 Mechanisms of a short preceding birth interval on child mortality

A short preceding birth interval is hypothesized to affect index child mortality in several ways. First, maternal depletion caused by inadequate nutritional recovery of the mother from the preceding birth coupled with breastfeeding impairs fetal intrauterine growth of the index child (Hobcraft, McDonald and Rutstein 1985, Boerma and Bicego 1992). Impaired intrauterine growth is associated with low birth weight and increased chances of a pre-term birth (Hobcraft, McDonald and Rutstein 1985, Boerma and Bicego 1992). Low birth weight babies and pre-term births have higher mortality risks (Miller 1991, Rawlings, Rawlings and Read 1995). Maternal depletion has also been suggested to affect breast milk quality, thus reducing breastfeeding benefits to the index child (Pebley and Millman 1986).

Second, sibling competition for scarce household resources essential for the index child's survival including food, health and time exposes the index child to the risk of poor nutrition, inadequate prenatal and postnatal health care, and inadequate child minding respectively (Boerma and Bicego 1992). Poor nutrition and inadequate prenatal and postnatal health care increase the occurrence of illnesses which expose the index child to mortality risk (Boerma and Bicego 1992, Huffman and Martin 1994). Inadequate child minding increases the chances of accidents (Boerma and Bicego 1992).

Third, exposure of the index child to an older, closely-aged sibling facilitates the spread of infectious diseases from the older sibling to the index child (Boerma and Bicego 1992). Around the age of 2, the older sibling is prone to infectious diseases like measles and chicken pox, which have more severe secondary infection effects when transmitted to the index child (Whitworth and Stephenson 2002).

The effects of sibling competition and exposure of the index child to infectious diseases are attributed as more dominant pathways of the influence of a short preceding birth interval on child mortality compared to the maternal depletion hypothesis (Madise and Diamond 1995, Whitworth and Stephenson 2002). However Boerma and Bicego (1992) and Koenig, Phillips, Campbell *et al* (1990) conclude that the maternal depletion hypothesis is a stronger explanatory mechanism.

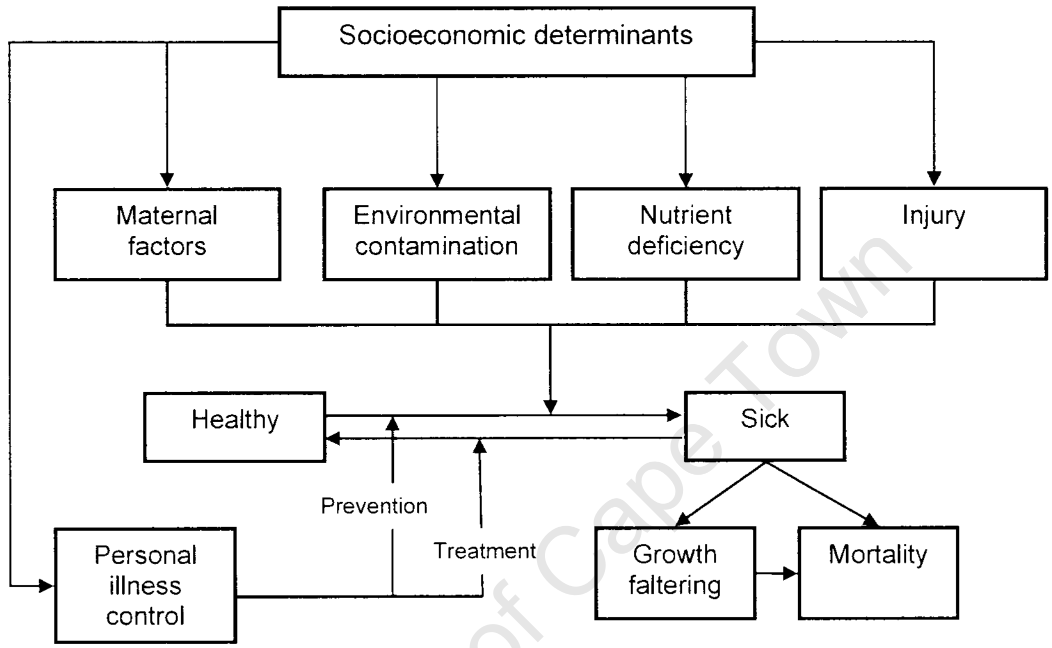
Irrespective of its exact mechanisms, the effect of a short preceding birth interval on child mortality remains one of the significant competing risks of child mortality in developing countries from results of studies discussed above. The following provides a discussion of Mosley and Chen's (1984) theoretical framework for the study of child mortality in developing countries. Model covariates will be based on the framework.

2.3 Child mortality

2.3.1 Mosley and Chen framework

This research adopts the Mosley and Chen (1984) framework on determinants of child mortality in developing countries in the modelling of child mortality. Mosley and Chen (1984) separate determinants of child mortality into proximate determinants and socioeconomic determinants. Proximate determinants directly influence child mortality, whilst socioeconomic determinants have an indirect effect on child mortality operating through the proximate variables. Five proximate variables are identified in the model: maternal factors, environment contamination, nutrient deficiency, injury and personal illness control (Figure 2.1). Maternal factors, environment contamination, nutrient deficiency and injury influence the transition from a healthy state to a sick state, whilst personal illness control has a bidirectional influence on the healthy/sick status through disease prevention and treatment. Disease prevention maintains a healthy status, whilst disease treatment ensures reversal from a sick state to a healthy status (Figure 2.1).

Figure 2.1 Mosley and Chen framework of determinants of child mortality in developing countries



Adapted from Mosley and Chen (1984)

Proximate determinants

Maternal factors include the mother's age, parity and the length of the birth interval either operating in isolation or simultaneously. Teenage motherhood is associated with inadequate prenatal care, preterm delivery and low birth weight babies: factors associated with high child mortality (Klitsch 2003). Teenage motherhood is also a risk factor for maternal mortality. A study of adolescent maternal mortality in Maputo indicated a 30 per cent higher maternal mortality ratio in adolescents compared to non-adolescents (Granja, Machungo, Gomes *et al* 2001). Inadequate prenatal and postnatal child care practices by the younger mothers further elevate child mortality risks (Klitsch 2003). Children born to older women also face added biological risks of mortality, for instance the occurrence of Down's syndrome increases with mother's age (Hobcraft, MacDonald and Rutstein 1985).

According to Winikoff (1983), high parity births exhibit excess mortality, most probably a result of synergism with short birth intervals. The birth interval can be preceding or subsequent to the index child (Mosley and Chen 1984). Short preceding birth intervals are associated with increased risks of child mortality from mechanisms described above (Hobcraft, McDonald and Rutstein 1983, Hobcraft, McDonald and Rutstein 1985, Pebley and Millman 1986, Retherford, Choe, Thapa *et al* 1989, Boerma and Bicego 1992, Miller, Trussell, Pebley *et al* 1992, Whitworth and Stephenson 2002, Rutstein 2005, Conde-Agudelo, Rosas-Bermúdez and Kafury-Goeta 2006).

A subsequent conception by a breastfeeding mother has the effect of curtailing breast milk production thus affecting the breastfeeding of an index birth (McNeilly 1977). Studies have confirmed the association of breastfeeding of the index child with the subsequent birth interval (Palloni and Millman 1986, Retherford, Choe, Thapa *et al* 1989). Furthermore effects of divided care between the index child and the subsequent child during pregnancy and after birth influence child mortality risks of the index child with a short subsequent birth interval (Boerma and Bicego 1992). Hobcraft, McDonald and Rutstein (1985) found effects of a subsequent birth to be significant in the second year of life of an index child.

Transmission of infections through environmental contamination is facilitated through four main transmission routes. First, by air resulting in the transmission of respiratory diseases and contact type diseases. Second, through food, water and human hands causing the spread of diarrhoea and other intestinal diseases. Third, through "skin, soil and inanimate objects" leading to skin infections (Mosley and Chen 1984: 27). Finally through insects that transmit parasitic and viral diseases for instance malaria.

Nutrient deficiency relates to the deficiency of calories, protein and micronutrients in the diet of the mother and child. A nutrient deficient diet during pregnancy affects birth weight whilst nutrient deficiency during breastfeeding affects the quantity and quality of breast milk. Nutrient deficiency in the child's diet leads to growth faltering and reduced immunity to diseases (Mosley and Chen 1984). Malnourished children are more predisposed to occurrences of leading cause of death diseases like diarrhoea and acute respiratory infections and experience higher case fatalities (Institute of Medicine 1992, Huffman and Martin 1994). The relationship between disease occurrence and malnutrition is also bi-directional (Institute of Medicine 1992).

Injury refers to intentional and accidental bodily harm to the child, including physical injuries, burns and poisoning. Personal illness control includes preventive and curative illness control. Preventive control refers to disease prevention practices like immunization whilst curative control relates to disease treatment both essential to maintaining a healthy status (Mosley and Chen 1984).

Socioeconomic determinants

Mosley and Chen (1984) stratify socioeconomic determinants into three levels; individual level variables, household level variables and community level variables. Individual level variables are determined by individual productivity of the child's parents, cultural practices and traditional norms.

Individual productivity encompasses skills, health and time. Skills are strongly correlated with education levels hence the level of education is used to measure skills (Cochrane 1979, Mosley and Chen 1984). A father's education is the main paternal characteristic affecting child mortality through its influence on employment and consequently household income. The influence of a father's education level is more pronounced when the mother's education level is relatively lower (Mosley and Chen 1984). Education also has a socializing aspect related to exposure and assimilation of new social values including use of health services and contraception use (Cochrane 1979). A father's education level affects household income decisions related to child health including the child's diet and use of health care services

The mother's individual productivity influences the proximate determinants directly as a result of the biological link between a mother and child during pregnancy and breastfeeding (Mosley and Chen 1984). The mother's education has a significant influence on individual choices related to child survival. Educated mothers are associated with increased use of health facilities, providing a quality lifestyle for their children, increased hygiene, and a later age at marriage which avoids teenage childbirth (Hobcraft 1993).

In Mozambique, mother's education was not significantly associated with neonatal, postneonatal or child mortality, although the father's education was found to be significant for postneonatal and child mortality using the 1997 DHS (Macassa, Ghilagaber, Bernhardt *et al* 2003a). Mother's education was however found to be significantly associated with child growth in a case-control study in Manica Province, Central Mozambique (Pfeiffer, Gloyd and Li 2001). Furthermore, mother's education was associated with having discussed family planning and knowledge of modern contraception method in Mozambique (Agadjanian 2001).

The dedication of time by the mother to her own health, to child health, child minding and child care activities influences prenatal and postnatal care, breastfeeding and general child care, which consequently affects the child's health at birth, nutrient intake, hygiene, disease prevention and treatment. The effect of a mother's employment on child health however depends on the economic situation of the household. In financially struggling households, a working mother can mean that less time is dedicated to the care of the child. On the other hand, households in favourable economic situations can hire a child minder negating any hazardous effects of a working mother (Mosley and Chen 1984, Setty-Venugopal and Upadhyay 2002).

Traditional norms and cultural practices at the individual level influence power relationships in the household, the value associated with children, disease causation beliefs and food preferences. Power relationships within the household establish decision making structures influential to the allocation of food and health care resources to the mother and child. Increased education attainment among women empowers them to make autonomous decisions regarding child health (Hobcraft 1993).

Culturally based gender preference attaches different value to male and female children, resulting in higher sex specific child mortality rates. Although biological factors prejudice survival at birth of male children, the relative biological vulnerability of males is frequently (especially in Asia) surpassed within a few months of birth as a result of socio-cultural male preference which results in higher mortality among female children (Waldron 1983, Mosley and Chen 1984, Muhuri and Preston 1991, Arnold, Choe and Roy 1998). The direction of dowry payment, either from male to female or vice versa is one of the influential determinants of gender preference (Mosley and Chen 1984). Son preference has been recorded in East Africa, although no mortality differentials were calculated (Mwageni, Ankomah and Powell 2001). In contrast daughter preference was found in a matrilineal society of Zambia with socio-culturally induced differentials in child mortality favouring female survival (Clark, Colson, Lee *et al* 1995). Child sex preference was not indicated during a qualitative survey in Maputo city (Agadjanian 2001).

Gender preference can also have an effect on child mortality by influencing the length of the birth interval. For instance; if male preference is present and the index child is a female, gender preference may influence a shortened time to the next birth in an attempt to have another trial at conceiving the preferred child and vice versa.

Beliefs of disease causation in traditional settings affect usage of modern health facilities as people resort to alternative treatment methods and perform disease prevention rituals. Food preferences among societies are detrimental to child health if the mother is exposed to a nutrient deficient diet during pregnancy and whilst breastfeeding. Furthermore, an unbalanced dietary intake during a mother's childhood can have prolonged effects which can affect her child during pregnancy (Mosley and Chen 1984). Food taboos during pregnancy and breastfeeding and the withholding of food and fluids in instances when a child has episodes of diarrhoea increase child mortality risks (Mosley and Chen 1984).

Other individual level socio-cultural factors which can be included in the traditions/norms/attitudes group are a mother's childhood place of residence, a mother's field language (as a proxy for ethnicity) and religion.

Rituals and ceremonies into womanhood which include aspects of birth spacing and child mortality occur in the women's place of residence (Wembah-Rashid 1995, Arnaldo 2003). Thus a mother's childhood place of residence captures institutional forces that can influence proximate determinants of child mortality.

Differences in birth spacing practices (periods of postpartum abstinence, postpartum taboos) amongst ethnic groups in Mozambique motivate the inclusion of a mother's first language as a social determinant (Wembah-Rashid 1995, Arnaldo 2003). A mother's first language has been shown to explain child mortality differentials in Mozambique (Macassa, Ghilagaber, Bernhardt *et al* 2006).

Religious affiliation was found significant in explaining contraceptive use differences among women in Mozambique, with Catholics and mainstream Protestants more likely to have ever used a Western contraceptive method and discussing family planning with a friend or neighbour compared to women reporting affiliation to a Zionist or similar religious and women reporting no religious affiliation (Agadjanian 2001a). Agadjanian (2001a) concludes that religious affiliation in a socio-culturally diverse congregation (Catholics and mainstream Protestants) influences social interaction which facilitates diffusion of contraception use ideas. Furthermore religious affiliation has an influence on traditional birth spacing. Islamic communities in Mozambique reported a minimum post partum abstinence period of forty days during the period 1965 to 1995 (Wembah-Rashid 1995).

Socioeconomic determinants at the household level are influenced by household income or wealth status. Household income affects child health through its effect on resource availability of essential goods and services like food, water, clothing/bedding, housing, fuel/energy, transportation, hygienic/preventative care, sickness care and information dissemination through the radio, television or print media. The effect of household wealth is on both the quantity and quality of goods and services (Mosley and Chen 1984).

Community level variables affecting proximate determinants of child mortality operate through the ecological setting, the political economy and health system variables (Mosley and Chen 1984). Ecological factors of soil type, rainfall patterns, temperature, climate, altitude and seasonality influence the presence of disease transmission vectors in the surrounding environment and largely determine crop productivity; the main food source in subsistence farming communities. Furthermore, the ecological setting of an area influences socio-economic development and hence access to jobs and availability of medical facilities (Mosley and Chen 1984).

Aside from the ecological setting, the political economy also affects proximate determinants of child mortality. The political economy refers to government influence through policy design, infrastructure provision at the local level and organization of production. Local level policies designed for health, legal, security and leadership systems influence the success of health related projects. Physical infrastructure including roads, railways, electricity, water, sewerage and telephone systems, facilitate access to health service and information and influence the price of goods (Mosley and Chen 1984). Access to electricity (independent of income) is one of the main determinants of child mortality decline in the 1990s in developing countries (Rutstein 2000, Wang 2003). Electricity is a cleaner fuel source which decreases respiratory infections and creates conditions for refrigeration (Wang 2003). Sanitation is also significant although the impact on child mortality decline is relative less compared to electricity access (Wang 2003). The organization of production influences the mode of production and the distribution of products, which affects food availability, stability of food availability and distribution. A socialist based communal organization of production with centralized state control of products and a pricing system monopoly contributed to food shortages in Mozambique in the 1980s (Kyle 1991).

Health system variables at the community level are influenced by mandatory disease control measures, government subsidies of health costs, educational campaigns on the benefits of health care and the availability and effective use of technology in reducing child mortality (Mosley and Chen 1984). Mandatory disease control ensures population health measures like immunization, epidemic controls and sanitary regulations in the food and health sector. However these disease control measures are limited by financial constraints, dependant on a government's health spending budget allocation. Cost subsidies reduce the cost of health services and medicine making health goods and services affordable to impoverished households. Health related educational and motivational campaigns have three spheres of influence. At government level by promoting health related spending, at institutional level geared toward traditional healers or health workers and at the individual level providing child health information particularly influential to mothers (Mosley and Chen 1984).

2.3.2 Child mortality trends and HIV prevalence

Child mortality rates are calculated and represented as probabilities normally expressed per 1000 live births for neonatal, infant and under 5 mortality and expressed per 1000 survivors to age 1 month and to age 12 months for postneonatal and child mortality respectively. The probabilities are based on the notion of a hypothetical or synthetic cohort which "…attempts to show what would happen to a cohort if it were subjected for all its life to the mortality conditions of that period" (Preston, Heuveline and Guillot 2001:42). The opposite of a synthetic cohort is a true birth cohort followed from birth to calculate mortality experience. True birth cohorts are not ideal as they do not include the most recent mortality in the calculation of probabilities and furthermore rates do not capture period effects as these effects are spread over the cohort (Rutstein and Rojas 2003).

The general trend in child mortality rates is captured in the statement of the demographic transition which states that populations move from a pre-transitional period of high mortality and high fertility to a post-transitional era characterized by low mortality and low fertility as a result of modernization (Thompson 1929, Notestein 1945). Modernization is associated with processes of socio-economic development including industrialization, urbanization and education (Thompson 1929, Notestein 1945, Beaver 1975). Child mortality levels decline from improved nutrition, better sanitation, improved preventative and curative medical treatment; outcomes of the agricultural, industrial and medical revolutions (Beaver 1975, Kirk 1996, Ziehl 2002). The spread of products of agricultural, industrial and medical revolutions from the developed countries to the developing countries has resulted in child mortality declines in the absence of significant socio-economic development in developing countries (Mostert, Hofmeyr, Oosthuizen *et al* 1998).

The emergence of a non curable HIV epidemic is however increasing child mortality rates. The classic demographic transition is thus being restricted to a historic trend in countries worst affected by the epidemic, prompting a new term to signifying the era of HIV and AIDS: the AIDS transition (Matanyaire 2004). Sub-Saharan Africa has the highest burden of HIV and AIDS with 67 per cent of HIV positive people living in the region in 2007 and 72 per cent of AIDS deaths recorded in the region in 2007 (UNAIDS 2008).

In addition to the HIV epidemic, economic crises, political instability, and civil war in Sub-Saharan Africa have contributed to a slow down in the pace of child mortality decline since 1985 (Amouzou and Hill 2004). The worst affected countries have registered increased child mortality rates since 1990 (Table 2.1). Restricting the analysis to Mozambique and its neighbouring countries, Zambia recorded the highest underfive mortality rate in 2005 of 182 deaths per 1000 live births and South Africa had the lowest rate of 68 deaths per 1000 live births. Under five mortality in Mozambique was ranked third highest in 2005 relative to its 6 neighbouring countries (Table 2.1).

Table 2.1 Under five mortality rates per 1000 live births in 1970, 1990 and 2005 and adult HIV prevalence, Southern African countries

Country	2007 Adult HIV Prevalence	Under five mortality rates			
		1970	1990	2005	% Change (1990 to 2005)
Malawi	11.9	341	221	125	-43
Mozambique	12.5	278	235	145	-38
Tanzania	6.2	218	161	122	-24
Zambia	15.2	181	180	182	1
South Africa	18.1	-	60	68	13
Swaziland	26.1	196	110	160	45
Zimbabwe	15.3	138	80	132	65

Source: UNICEF 2007, UNAIDS 2008

The highest per cent increase in child mortality (65%) between 1990 and 2005 was recorded in Zimbabwe, which has a high adult HIV prevalence coupled with political instability. Adult HIV prevalence is prevalence among persons aged 15 years and older. Swaziland, with the highest global HIV prevalence, recorded a 45 per cent increase in underfive mortality. Underfive mortality rates for Zimbabwe and Swaziland in 2005 were approaching 1970 levels (Table 2.1). Malawi, Mozambique and Tanzania recorded reductions in underfive mortality between 1990 and 2005, most likely influenced by a higher base value. HIV prevalence in Mozambique has however been increasing, implying increasing AIDS attributed child mortality (UNAIDS 2008).

Adult HIV prevalence in Mozambique is higher in the Southern region with HIV prevalence of 21 per cent, followed by the Central region with 18 per cent, whilst the Northern region has a much lower prevalence of 9 per cent in 2007(Table 2.2).

Table 2.2 Provincial, regional and national adult HIV prevalence in Mozambique 2001 to 2007

	Surveillance rounds			
Province	**2001**	**2002**	**2004**	**2007**
Maputo City	17% (12%-20%)	18% (13%-23%)	21% (16%-26%)	23% (18%-29%)
Maputo Province	16% (10%-24%)	18% (12%-26%)	22% (15%-31%)	26% (18%-34%)
Gaza	19% (12%-26%)	21% (14%-29%)	25% (17%-33%)	27% (18%-35%)
Inhambane	8% (6%-14%)	9% (6%-15%)	10% (7%-16%)	12% (7%-16%)
Southern Region	**15% (10%-17%)**	**16% (12%-18%)**	**19% (14%-21%)**	**21% (16%-23%)**
Sofala	25% (15%-31%)	24% (16%-32%)	24% (17%-33%)	23% (17%-33%)
Manica	18% (10%-23%)	17% (10%-23%)	16% (10%-23%)	16% (10%-23%)
Tete	16% (11%-21%)	15% (11%-21%)	14% (11%-21%)	13% (11%-21%)
Zambézia	16% (9%-23%)	17% (10%-25%)	18% (12%-28%)	19% (12%-29%)
Central Region	**18% (16%-20%)**	**18% (17%-20%)**	**19% (17%-21%)**	**18% (17%-21%)**
Niassa	6% (3%-11%)	7% (4%-12%)	8% (4%-14%)	8% (4%-14%)
Nampula	8% (5%-10%)	9% (6%-11%)	9% (6%-12%)	8% (6%-12%)
Cabo Delgado	8% (4%-12%)	9% (5%-13%)	9% (6%-14%)	10% (6%-14%)
Northern Region	**7% (6%-8%)**	**8% (6%-9%)**	**9% (7%-10%)**	**9% (7%-10%)**

Source: GTM 2008

Population mobility into neighbouring countries (Zimbabwe and South Africa) with more mature epidemics with higher HIV prevalence rates may explain the HIV levels in border provinces of Manica, Gaza and Maputo. Furthermore, transport links between Maputo City Province and Sofala Province with regional countries may explain the high prevalence observed (UNAIDS and WHO 2005). The HIV epidemic in Mozambique is mainly driven by unprotected heterogeneous sexual activity (Gaspar 2002).

2.3.3 Child mortality rates in Mozambique

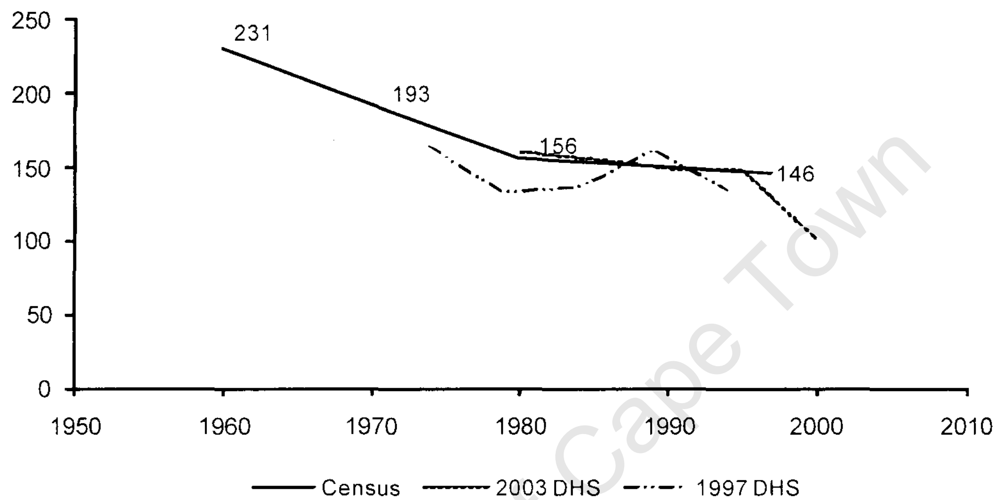
Infant mortality rates from 1960 onwards will be used to show the trend in child mortality in Mozambique. The infant mortality rates are derived from population censuses conducted in Mozambique in 1960, 1970, 1980 and 1997, and from the 1997 and 2003 DHS (mid points of quinquennial periods) (Figure 2.2). The 1991 Mozambique Demographic and Health Survey is excluded from analysis because of biased results as sampling was restricted to regions not affected by the civil war (Gaspar 2002).

Although the first census in Mozambique was conducted in 1940, age classification problems in the 1940 census prevented use of the data (Heisel 1968). In the following census of 1950, understatement of surviving children led to child mortality rates being derived from the Coale and Demeny North model life table (Heisel 1968). The underfive mortality rate for Mozambique was estimated at 367 deaths per 1000 live births in 1950, and an infant mortality rate of 221 deaths per 1000 live births was interpolated using the combined North model life table. Coale (1966) estimated an infant mortality rate of 212 deaths per 1000 live births in 1950 whilst Carvalho (1983) calculated a rate of 174 deaths per 1000 live births. Due to discrepancies in estimates, no figure for the 1950 infant mortality rate is included in the trend analysis (Figure 2.2).

Overall, infant mortality has been on the decline in Mozambique, with a 32 per cent decline recorded over the twenty year period from 1960 to 1980. Infant mortality decline from 1960 to 1980 is attributed to economic growth during the period 1960 to 1970 and post independence gains in the health and education sectors translating into increased preventative and curative health care use (Gaspar 2002). The much reduced (nearly stalled) decline in infant mortality between the 1980 and 1997 census estimates and the 2003 DHS estimates until 1998 is most likely the result of civil war effects. The 1997 DHS shows rising mortality from 1980 which peaks in 1989 indicating effects of the civil war (Figure 2.2). The decline in infant mortality to 101 deaths per 1000 live births for the period 1998 to 2003

(2003 DHS) is most probably a reflection of the gains in heath service delivery and health care during the post civil war era in Mozambique (Figure 2.2).

Figure 2.2 Infant mortality rates expressed per 1000 live births for the 1960, 1970, 1980 and 1997 Mozambique census, 1997 and 2003 DHS



Sources: Gaspar, Cossa, Santos *et al* (1998), Gaspar (2002), and Instituto Nacional de Estatística and Ministério de Saúde (2005).

Child mortality rates from the 1997 and 2003 DHS were recalculated using an SPSS program downloaded from the DHS website and translated into STATA. Some of the calculated rates for the 2003 DHS are slightly different from published rates. Mortality rates were calculated at ages at death of less than 1 month (neonatal mortality), 1-11 months (postneonatal mortality), 0-11 months (infant mortality), 12-59 months (child mortality) and 0-59 months (under five mortality) (Table 2.3).

Considerable declines in mortality rates during the post-independence period (1977 to 1982) are illustrated in the 1997 DHS, which reports pre-independence mortality (1972 to 1977) (Table 2.3). In the 2003 DHS, post independence gains are also reflected in mortality declines from the period 1978 to 1983 to the period 1983 to 1988; although much reduced in magnitude as the civil war had already began (Table 2.3). Health care service delivery and health care use increased in the post independence era. Antenatal clinic attendance increased from 40 to 49 per cent between 1979 and 1981, whilst clinic attendance of children under the age of five increased from 7 per cent to 16 per cent for the same period (Cliff and Noormahomed 1988b, Cliff 1991).

Table 2.3 Neonatal, postneonatal, infant, child and under five mortality rates per 1000 survivors at the beginning of the age range, 1997 and 2003 DHS

DHS Reference	Period	Neonatal	Postneonatal	Infant	Child	Under 5
	1972-1977	87	77	164	103	250
	1977-1982	46	87	133	72	195
1997 DHS	1982-1987	57	79	136	78	204
	1987-1992	60	102	161	92	238
	1992-1997	54	81	135	77	201
	1978-1983	59	102	161	112	254
	1983-1988	65	91	156	90	232
2003 DHS	1988-1993	58	91	150	88	225
	1993-1998	59	89	148	68	206
	1998-2003	37	64	101	58	152

Mortality rise effects of the civil war which began in 1976 can be noted from the stalled decline in postneonatal mortality and reduced decline in child mortality and mortality of children below the age of five between the period 1983 to 1988 and 1988 to 1993 in the 2003 DHS (Table 2.3). The devastation of the civil war reached its peak in the late 1980s (Baden 1997). The 1997 DHS mortality rates clearly reflect the impact of the civil war with mortality rates increasing from the period 1977 to 1982 to the period 1987 to 1992. The highest mortality rates in the 1997 DHS are recorded in the period 1987 to 1992, which coincides with the peak of the civil war (Table 2.3). Neonatal mortality rates in the 2003 DHS and postneonatal rates in the 1997 DHS however move against the tide of the civil war, in some quinquennial periods possibly reflecting sensitivity to other risk factors.

The civil war resulted in increased child mortality rates mainly from the disruption of health service delivery, health care access, food shortages and lack of access to safe water (UNICEF 1989). Cliff and Noormahomed (1988b) estimate that 729 primary health centres were either destroyed or forced to close between 1982 and 1987. UNICEF (1989) estimates that 25% of health facilities were destroyed by the end of 1985 with 82 000 excess deaths estimated among children under the age of five in 1985 as a result of the civil war. Immunization programs were disrupted in intensive war zones (Cliff and Noormahomed 1988a, Cliff and Noormahomed 1988b). Child mortality rates of children aged 12 to 59 months among former Mozambican refugees displaced to South Africa as a result of the war were higher than child mortality rates in South African households (Hargreaves, Collinson, Kahn *et al* 2004). Mortality rates among children under the age of five in Maringué District, Sofala Province (where RENAMO had its base), increased from 262 deaths in 1978 to 473 deaths per 1000 live births in 1986, a direct result of the civil war (Garenne, Coninx and Dupuy 1997).

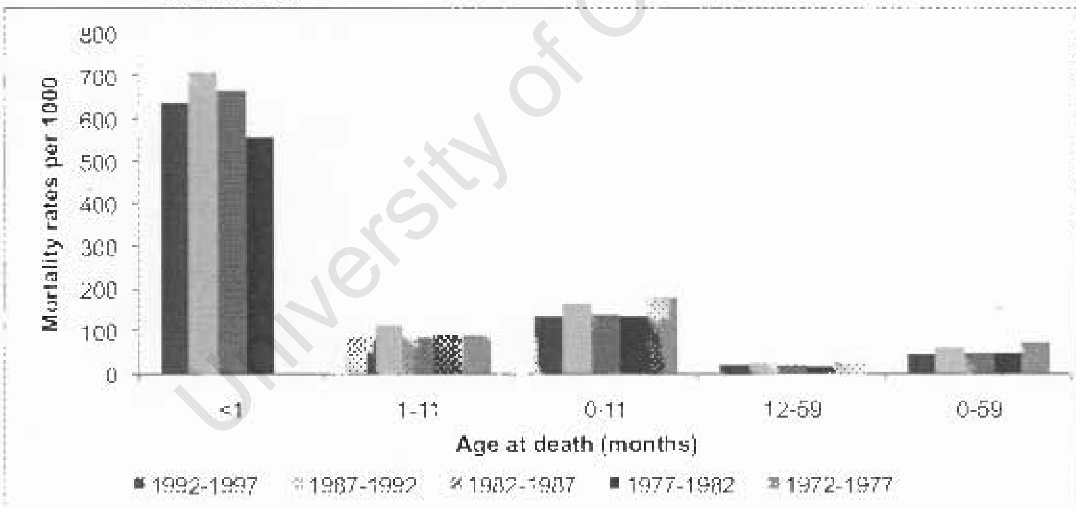
Child mortality was also affected by worsening socioeconomic conditions and environmental calamities. The Economic Structural Adjustment Program introduced by the Mozambique government in 1987 led to the withdrawal of food subsidies and an increase in food prices and health medicine costs (Cliff and Noormahomed 1993). A five year drought from 1979 to 1984 resulted in a famine between 1983 and 1984 in the south and centre of the country (Kaplan 1984, Johnson and Martin 1986). Civil war destruction of transport networks and food production in subsistence and state farms worsened the effects of the drought (UNICEF 1989, Baden 1997). Malnutrition accounted for the highest child morbidity (46 per cent) and child mortality (42 per cent) cases among children aged one to four years in a 1983 study of displaced persons in Gaza and Inhambane provinces (Rutherford and Mahanjane 1985). The country has also been experiencing floods with the most recent floods occurring in 2000 and 2007. The floods in 2000 inflicted the worst flood damage in Mozambique in the past 50 years (Kondo, Seo, Yasuda *et al* 2002). Adjusting for the increase in population size from people displaced by floods in the Chokwe district of Gaza Province, the incidence of malaria increased 1.5 to 2 times, whilst the incidence of diarrhoea increased 2 to 4 times in the aftermath of the floods in 2000 (Kondo, Seo, Yasuda *et al* 2002).

Mortality rates in the 2003 DHS for the five years preceding the survey show the most significant declines in child mortality across all ages at death (except for child mortality (12 to 59 months)). It is possible that the observed decline reflects the increase in health service delivery and utilization after a decade since the end of the Mozambique civil war in 1992. However the possibility of omission of dead children cannot be ignored.

Mortality probabilities ($_nq_x$) allow a trend analysis at each age at death over time. However a comparison of the various age specific mortality rates is not viable as wider age groups are exposed to longer periods of mortality consequently increasing their risk of succumbing to mortality. To harmonize exposure average annual rates (over 5 year periods) will be calculated. Annual mortality rates are computed by dividing the number of deaths in each age group by the person years lived within each age group for each 5 year period (Preston, Heuveline and Guillot 2001).

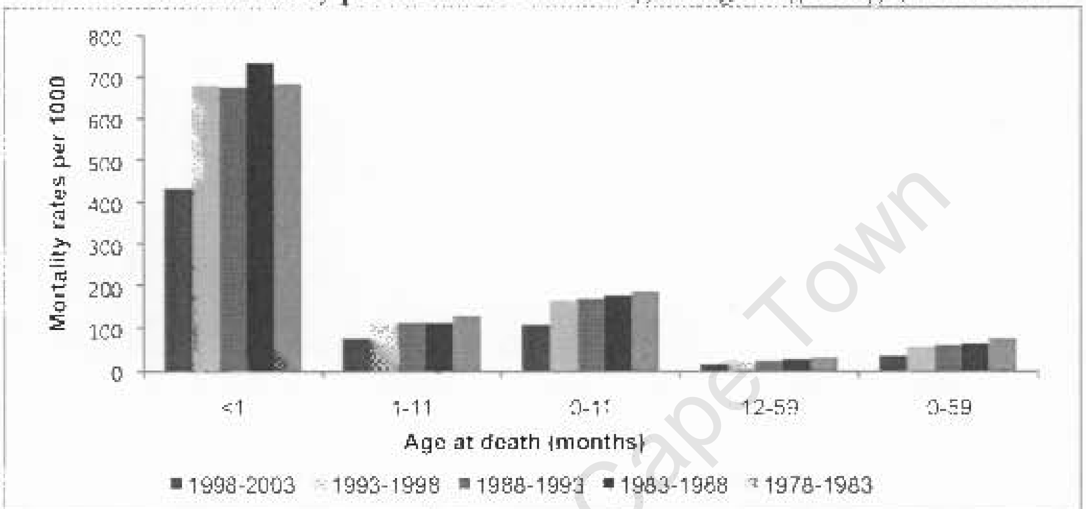
Child mortality is concentrated at the neonatal age in Mozambique (Figure 2.3 and Figure 2.4). The hazardous first month of life has annual mortality rates on average four times the magnitude of infant mortality, the subsequent higher annual rate. Once a Mozambican child survives the first month of life, mortality risk is reduced significantly as indicated by much reduced annual mortality rates of postneonatal, and child mortality (Figure 2.3 and Figure 2.4). Mortality rates calculated inclusive of the first month of life have higher annual rates relative to those calculated exclusive of the first month. The lowest annual mortality rate is between the ages of 12 to 59 months, indicating that survival of the first month of life guarantees a higher life expectancy of survival to age five.

Figure 2.3 Average annual mortality rates for neonatal, postneonatal, infant, child and under five mortality per 1000 survivors at beginning of age range, 1997 DHS



The average annual rates also exhibit patterns and trends discerned in the discussion of mortality probabilities, for instance the significant decline of annual mortality for the period 1998 to 2003 across all ages (Figure 2.4). Mortality increase as a result of the civil war is illustrated in higher annual rates during the peak period of the war, 1987 to 1992 and 1983 to 1988 for the 1997 and 2003 DHS respectively (Figure 2.3 and Figure 2.4). Reasons for the considerably lower neonatal mortality for the period 1998 to 2003 are once again debatable between a real observed decline and omission of dead children. A comparison of the distribution of deaths at age zero across the birth periods did not reveal considerable differences that might support the omission of dead children hypothesis.

Figure 2.4 Annual mortality rates of neonatal, postneonatal, infant, child and under five mortality per 1000 survivors at beginning of age range, 2003 DHS



The trend of average annual rates of child mortality in Mozambique is confirmed by the cause of death profile of children under the age of five. According to the WHO (2006), neonatal deaths are the leading cause of mortality for children under the age of five years in Mozambique. The five leading causes of underfive mortality for the period 2000 to 2003 are: neonatal deaths (29%), pneumonia (21%), malaria (19%), diarrhoea (17%), and HIV/AIDS (13%) (WHO 2006). A Burden of Disease (BOD) study in 1994 of Maputo, the capital city of Mozambique found that perinatal disorders were the overall leading cause of death accounting for 20.2% of the deaths, followed by malaria (11.4%) and diarrhoeal diseases (10%) (Dgedge, Novoa, Macassa *et al* 2001).

2.4 Birth spacing in Mozambique

2.4.1 Traditional birth spacing methods in Mozambique

Schoenmaeckers, Shah, Lesthaeghe *et al* (1981) documented knowledge of the contributory role of short birth spacing to child mortality in African communities since the early twentieth century. Traditional birth spacing practices of postpartum abstinence and prolonged breastfeeding have been used for birth spacing (Lesthaeghe, Ohadike, Kocher *et al* 1981). Traditional medicinal contraceptives and the *coitus interruptus* or withdrawal method were also used to complement traditional birth spacing practices (Schoenmaeckers, Shah, Lesthaeghe *et al* 1981, Wembah-Rashid 1995).

Postpartum sexual abstinence

Data compiled on postpartum abstinence in sub-Saharan Africa dating from 1905 to 1979 illustrates erosion of the practice with time, as more recent years exhibit shorter abstinence periods. For instance, use of the *coitus interruptus* or withdrawal method, allowed earlier resumption of postpartum sexual activity, resulting in the erosion of long periods of postpartum sexual abstinence in Sub-Saharan Africa (Schoenmaeckers, Shah, Lesthaeghe *et al* 1981, Wembah-Rashid 1995). Notwithstanding, postpartum sexual abstinence varied from a minimum of 40 days encouraged by Islamic communities to periods of greater than 2 years recorded mainly in the West African region (Murdock 1967, Schoenmaeckers, Shah, Lesthaeghe *et al* 1981).

In Northern Mozambique, postpartum abstinence of between one to two years was observed among the Yao in 1920 (Murdock 1967). A more recent review in the Northern region between 1965 and 1995 of the Yao, Makua and Makonde found a minimum abstinence of forty days (Wembah-Rashid 1995). Northern Mozambique is predominantly Muslim, thus widespread Islamism may explain the minimal abstinence observed in the region. In Central Mozambique, abstinence of between four and twelve months was observed among the Lomwe, whilst the Sena were reported to abstain until the baby's navel heals (Magalhães 1960, Ivens-Ferraz de Freitas 1971 and Pequenino 1995, cited in Arnaldo 2003). Among the Tsonga found in Southern Mozambique, postpartum abstinence of about one year was reported in 2001 (Arnaldo 2003).

Postpartum sexual abstinence is enforced in societies through postpartum taboos on sexual intercourse. Non-adherence to postpartum taboos is believed to result in the recently born child getting sick or dying (Caldwell and Caldwell 1981, Wembah-Rashid 1995, Arnaldo 2003). In Mozambique, the Makua, Lomwe and Tsonga believe that a man's semen (through sexual intercourse), contaminates breast milk which puts a breastfed child at risk of getting sick or dying (Arnaldo 2003). The same belief was also reported among the Yoruba of Nigeria in the 1970s (Caldwell and Caldwell 1981). Contact of the new born child with sexually active persons is also prohibited as it is believed to endanger the child's health (Wembah-Rashid 1995, Arnaldo 2003).

Rituals are performed for the parents to engage in non-harmful sexual relations, marking the end of the abstinence period (Wembah-Rashid 1995, Arnaldo 2003). Spousal separation observed among the Yao, Makua and Makonde of Northern Mozambique is effected to ensure adherence to postpartum sexual abstinence and to also enable older women to assist the younger mother with child rearing (Wembah-Rashid 1995).

Prolonged breastfeeding

Prolonged breastfeeding is recognized primarily for child health purposes (Lesthaeghe, Ohadike, Kocher *et al* 1981). Women are aware that an early pregnancy curtails breastfeeding, putting an index child at risk of malnutrition (Lesthaeghe, Ohadike, Kocher *et al* 1981, Schoenmaeckers, Shah, Lesthaeghe *et al* 1981). Prolonged breastfeeding is widespread in Mozambique (Arnaldo 2003). The effects of breastfeeding are three fold: first breast milk contains nutrients, second breast milk provides immunity to disease infection through "...multiple anti-infective, anti-inflammatory, and immunoregulatory factors..." (Morrow and Rangel 2004:221), third breastfeeding enhances the period of postpartum amenorrhea (Perez, Potter and Masnick 1971, Gray 1981, Lesthaeghe, Ohadike, Kocher *et al* 1981, Santow 1987).

Postpartum amenorrhea refers to a period following birth characterized by an absence of ovulation and menstruation. Although the resumption of ovulation and menstruation generally coincides, ovulation has commenced without menstruation in some women (Perez, Potter and Masnick 1971). The absence of menstruation is the indicator used by women to associate postpartum amenorrhea with contraceptive effects (Winikoff and Mensch 1991, Wembah-Rashid 1995). In Northern Mozambique, *coitus interruptus* was practiced in postpartum sexual relations if the mother had experienced menstruation (Wembah-Rashid 1995).

The regulation of postpartum amenorrhea is through the hormone prolactin, responsible for suppressing the normal function of ovaries (Santow 1987). After birth a woman has high prolactin levels which decline to pre-pregnancy levels if breastfeeding is absent. Prolactin levels are regulated by nipple stimulation during breastfeeding (Perez, Potter and Masnick 1971, Santow 1987). A non-breastfeeding woman will experience an average postpartum amenorrhea period of between one and a half months to two months (Perez, Potter and Masnick 1971, Lesthaeghe, Ohadike, Kocher *et al* 1981). Postpartum amenorrhea length is about 60 to 75 per cent of the breastfeeding period (Perez, Potter and Masnick 1971, Lesthaeghe, Ohadike, Kocher *et al* 1981). However, the relationship between breastfeeding postpartum amenorrhea is non-linear (Lesthaeghe, Ohadike, Kocher *et al* 1981).

Use of medicinal contraceptives used after child weaning among the Yao, Makua and Makonde of Northern Mozambique, "…consisted of a specially twisted bark string onto which were strung some pieces of wood…" further lengthened the birth spacing period (Wembah-Rashid 1995:55).

Social control

In traditionally close knit communities, the responsibility for spacing births adequately was not the sole responsibility of the parents. In Northern Mozambique, early pregnancy before weaning a child resulted in the community punishing the couple (Wembah-Rashid 1995). Name calling, beatings by members of the community, isolation from community activities and re-initiation with younger couples on birth spacing rites (considered as the most severe and humiliating), were forms of punishment inflicted on couples that failed to space births (Wembah-Rashid 1995).

Social control is therefore necessary for an effective maintenance of social practices like birth spacing practices (Schoenmaeckers, Shah, Lesthaeghe *et al* 1981, Caldwell and Caldwell 1981). A social control hypothesis defined in the context of "...a mechanism to insure compliance with norms..." (Meier 1982:35) is put forward as an explanatory hypothesis of differences in reported knowledge of the effects of short birth spacing and observed birth spacing. Social control has however been attributed as a source of deviance from expected behaviour, and also ascribed as a state control mechanism (Meier 1982). A Giddensian analysis would suggest that social control (or at least the threat of social sanction), while necessary, is not sufficient to maintain social practices (Giddens 1984). Social control is facilitated through social cohesion (Meier 1982).

Population movement and displacement of traditional communities in Mozambique as a result of the civil war is hypothesized to have disrupted social control mechanisms maintaining birth spacing practices. Three quarters of the rural Mozambican population is estimated to have been displaced by the end of the civil war mainly to urban areas and coastal towns (Baden 1997). Furthermore, disruption of family planning services (from civil war effects) aggravated the situation by curtailing contraceptives to women hypothesized to have weakened or eroded birth spacing practices. The end result is that birth spacing has become an underutilized health intervention, as Norton (2005:S2) states, "Birth spacing is a well-known, underutilized, and admittedly not fully understood health intervention." Current birth spacing in Mozambique is discussed in the following section.

2.4.2 Current birth spacing in Mozambique

Median birth intervals in the five years preceding each DHS declined slightly from 35 months in 1997 to 34 months in 2003 (Table 2.4). Women in the Northern provinces of Niassa and Cabo Delgado experienced reduced median birth intervals, whilst median birth intervals in Nampula were constant. In contrast, women in Southern Mozambique experienced increased median birth intervals from 1997 to 2003, more striking for women resident in Maputo Province and Maputo City (Table 2.4). Women resident in Central Mozambique experienced increased median birth intervals except for women from Sofala Province who experienced reduced median intervals from 38 months to 34 months.

Table 2.4 Median birth intervals in the five years preceding the survey, current status median duration (in months) of postpartum amenorrhea and postpartum abstinence, 1997 and 2003 DHS

Province	Median birth intervals		Postpartum amenorrhea		Postpartum abstinence	
	1997	2003	1997	2003	1997	2003
Niassa	35	33	14.4	16.6	11.6	6.7
Cabo Delgado	35	34	13.6	16.3	21.2	21.8
Nampula	33	33	14.5	16.3	15.8	17.3
Zambézia	32	34	9.7	12.8	4.3	7.5
Tete	32	33	12.4	11.9	9.2	6.4
Manica	33	35	15.8	11.5	13.9	19.6
Sofala	38	34	13.6	14.6	11.6	13.6
Inhambane	36	36	12.9	14.1	18.7	13.7
Gaza	36	37	14.4	14.4	12.8	10.3
Maputo Province	36	40	14.1	11	14.6	9.1
Maputo City	38	43	8.1	10	7.8	7
Total	**35**	**34**	**13.7**	**13.7**	**11.6**	**11.8**

Source: MEASURE DHS STATCompiler

Current status median duration of postpartum amenorrhea has remained constant between 1997 and 2003, at just above one year (13.7 months). Except for women in Maputo Province, Tete and Manica, the median duration of postpartum amenorrhea has increased between 1997 and 2003. Women in the Northern region reported longer postpartum amenorrhea periods of over 16 months, with the lowest period of postpartum amenorrhea reported in Maputo Province and Maputo City of 11 months and 10 months respectively.

Current status postpartum abstinence increased slightly from 11.6 months to 11.8 months from 1997 to 2003 although it remains at a median duration of one year (Table 2.4). A consistent decline in the median length of postpartum abstinence is noted for women resident in Southern Mozambique. An opposite trend is observed for women from the Central provinces where except for Tete, current status postpartum abstinence increased from 1997 to 2003. Postpartum abstinence also increased for women from Nampula and Cabo Delgado with the exception of Niassa which had a reduced abstinence period in 2003.

An increase in current status postpartum amenorrhea and postpartum abstinence may be a reflection of the restoration of social control in communities dispersed during the civil war years (also reflected in increased reported use of traditional contraceptive methods (Table 2.5). Women resident in Maputo City, Maputo Province, Gaza and Tete reported relatively higher current use of modern contraceptives in 2003 which explains the declining median length of postpartum abstinence (Table 2.5).

Table 2.5 Use of modern contraceptive methods and traditional methods by province, 1997 and 2003 DHS

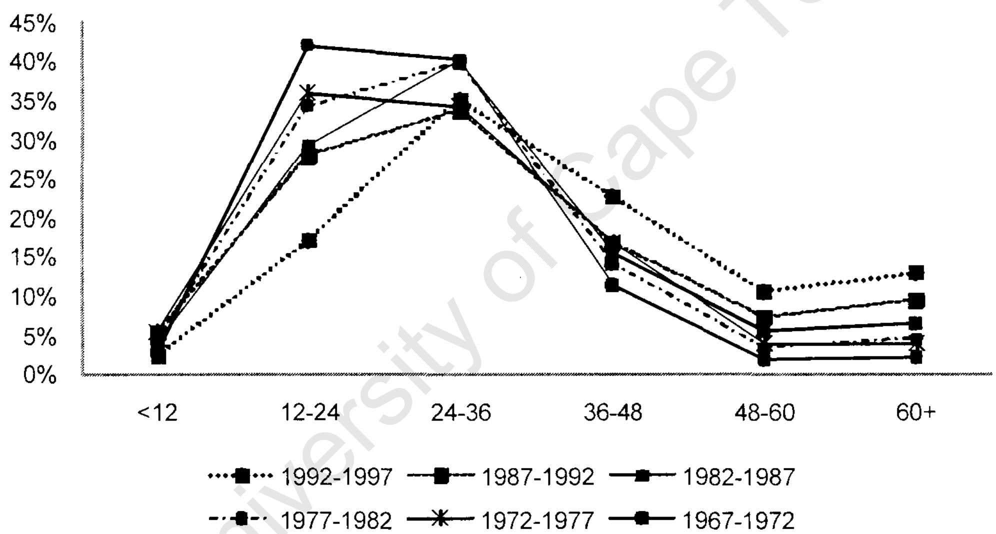
	1997			2003		
Province	Modern methods	Traditional methods	Total	Modern methods	Traditional methods	Total
Niassa	4.3	3.7	8.1	5.8	18.9	24.7
Cabo Delgado	0.7	0.2	0.8	4.5	5.4	9.9
Nampula	2.0	0.2	2.2	7.2	3.1	10.3
Zambezia	4.7	0.1	4.9	9.2	1.8	11.0
Tete	8.4	0.8	9.3	14.3	8.4	22.6
Manica	5.2	0.4	5.6	7.9	0.9	8.8
Sofala	2.0	0.1	2.1	7.5	10.9	18.4
Inhambane	6.0	0.6	6.7	11.3	1.2	12.4
Gaza	1.8	0.0	1.8	14.4	0.7	15.2
Maputo Province	13.1	0.6	13.8	30.2	2.1	32.3
Maputo City	28.5	1.8	30.3	39.2	10.6	49.7
Total	**5.1**	**0.1**	**5.6**	**11.7**	**4.7**	**16.5**

Source: Gaspar, Cossa, Santos *et al* 1998, Instituto Nacional de Estatística and Ministério de Saúde 2005

2.4.3 Preceding birth intervals in Mozambique

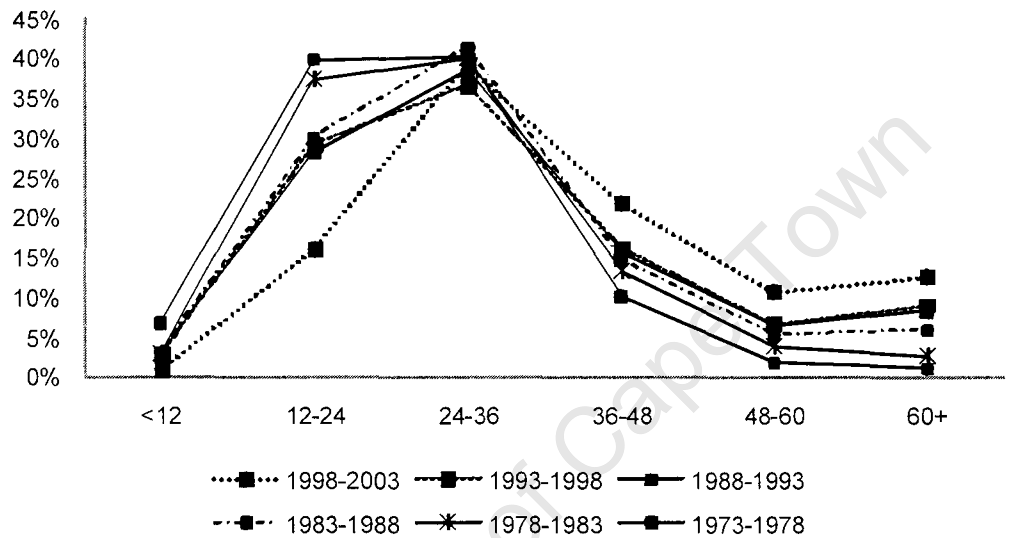
Preceding birth intervals are calculated as the period (in months) between two subsequent live births. First births do not have a preceding birth and consequently by definition are not included. The per cent distribution of preceding birth intervals in Mozambique was calculated in quinquennial periods for the 1997 and 2003 DHS (Figure 2.5 and Figure 2.6). In general, the proportion of short preceding birth intervals has been declining in Mozambique. A higher proportion of short preceding birth intervals occurred in the period 1967 to 1978, corresponding to the liberation war decade of 1964 to 1974. Short preceding birth intervals during this period contributed to alarming rates of child and maternal mortality (Kaplan 1984, Raisler 1984, Cliff 1991).

Figure 2.5 Weighted per cent distribution of preceding birth interval categorizes (in months) for quinquennial birth periods, 1997 DHS



The difference between the quinquennial periods from 1983 to 1998 and the most recent period from 1998 to 2003 might reflect the deterrence of progress in family planning provision due to direct and indirect effects of the civil war (Figure 2.6). The same gap is evident in the 1997 DHS between the 10 year period 1982 to 1992 and the most recent period 1992 to 1997 (Figure 2.5). The reduced prevalence of short preceding birth intervals in the post war period coupled with increased reported use of traditional birth spacing methods may lend support to the social control theory, although the increased uptake of modern contraceptives in Mozambique definitely contributed to reducing short preceding birth intervals. Notwithstanding, the significant decline in the proportion of short birth intervals for the period 1998 to 2003 in the 2003 DHS might be a result of omission of dead children born following short preceding birth intervals. However the fact that the same pattern is observed in the 1997 DHS (that did not exhibit possible omission of dead children in the analysis of child mortality rates) invokes other possibilities including imputing effects.

Figure 2.6 Weighted per cent distribution of preceding birth interval categorizes (in months) for quinquennial birth periods, 2003 DHS



The proportion of short preceding birth intervals is however also sensitive to various other factors including the mother's age at birth, birth order and survival of the previous birth. Thus for instance, reduced child mortality rates due to factors of improved vaccination or improved health services may reduce the frequency of child replacement; a motive for short birth spacing.

This chapter has provided a review of the literature of birth spacing and child mortality, discussed some contestations of the association and the hypothesized mechanisms. A statement of the Mosley and Chen (1984) framework was provided as the theoretical base for the modelling of child mortality. Trends in child mortality rates in Mozambique were shown using the census data and the 1997 and 2003 DHS data. The last section discussed birth spacing in Mozambique ending with a discussion on the occurrence of preceding birth intervals. The methodology to be applied in the modelling of short preceding birth intervals and child mortality is discussed in the following chapter.

3 METHODOLOGY

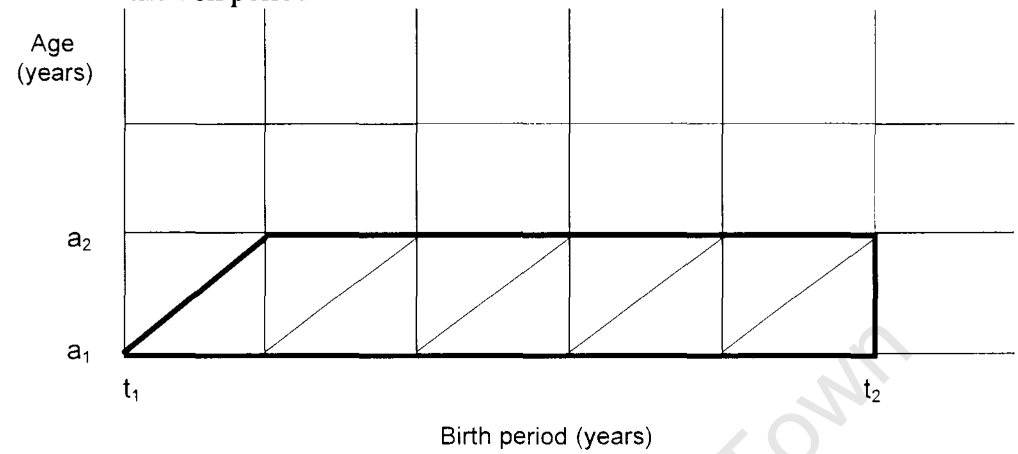
The association between short preceding birth intervals and child mortality will be determined by analyzing the "time to death" associated with varying lengths of the preceding birth interval. The analysis of time to death is referred to as analysis of "time to an event" (with death as the event) which when defined within time limits becomes "event history analysis" (Yamaguchi 1991). Event history analysis is discussed in the first section including a discussion of hazard rates which are modelled in event history analysis and the choice of the hazard rate model to be employed in data analysis. Section 3.2 elaborates on log rate models for piecewise constant rates with a discussion on the Poisson model and the Negative Binomial model. The final section discusses limitations of applying the log rate model for piecewise constant rates in data analysis.

3.1 Event history analysis

Event history analysis is commonly known as survival analysis, although the term 'survival analysis' literally refers to an outcome of death; the event of interest can refer to any outcome. In event history analysis, a survival period precedes the event and the occurrence of an event at a particular point assumes a (preceding) "duration of non-occurrence" (Yamaguchi 1991:1). This duration of non-occurrence is characterized by two distinct periods: a risk period and a non-risk period. The risk period is the duration where an individual is at risk of having the event of interest and the non-risk period is the period where the risk of the event occurring is absent (Yamaguchi 1991). The period of interest in event history analysis is the risk period thus event history analysis is defined as "...the analysis of rates of the occurrence of the event during the risk period" Yamaguchi (1991:3).

The risk period is defined by the design and objectives of a study. A two dimensional risk period delineated by the period of birth and age at death is defined in this research. The analysis of child mortality is stratified into quinquennial periods between 1978 and 1998 (discussed in chapter 5) with the hazard of child mortality computed at age at death categories of 0 months (neonatal mortality), 1 to 11 months (post neonatal mortality), 0 to 11 months (infant mortality), 12 to 59 months (child mortality) and 0 to 59 months (under five mortality). Figure 3.1 illustrates the two dimensional risk periods using a Lexis diagram.

Figure 3.1 Lexis diagram showing the time dimensions (age and period of birth) of the risk period



The risk period is enclosed in bold lines; within the upper and lower limits of each quinquennial period of birth (between t_1 and t_2) and age at death category (between the ages of a_1 and a_2). A child born in the period between t_1 and t_2 is at risk of death occurring between the ages of a_1 and a_2 in the area enclosed by bold lines (Figure 3.1). Each birth period (between t_1 and t_2) is composed of five single year cohorts.

When defined for a particular period and a particular group, the rate of occurrence of events in event history analysis is referred to as a hazard rate (Yamaguchi 1991). The hazard rate or hazard function is defined as the "…instantaneous risk of having the event at time *t*, *given that the event did not occur before time t*" (Yamaguchi 1991:9). The hazard rate is also referred to as the "force of mortality at time *t*" if the decrement is death (Laird and Olivier 1981: 233). If *T* denotes a random variable representing the length of survival time, the hazard rate $h(t)$ can be represented as (Yamaguchi 1991: 10):

$$h(t) = \lim_{\Delta t \to 0} \frac{P(t + \Delta t > T \geq t \mid T \geq t)}{\Delta t} = \frac{f(t)}{S(t)}$$

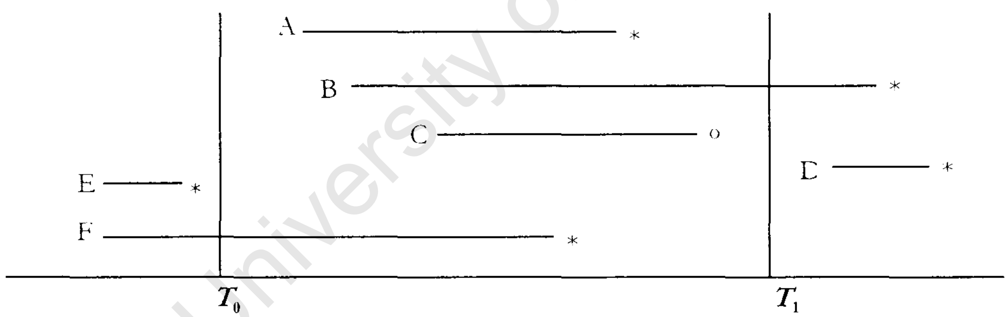
The numerator $P(t + \Delta t > T \geq t \mid T \geq t)$ represents the probability that the event will occur within the interval $(t, t + \Delta t)$ given that the event did not occur prior to time t (Yamaguchi 1991). In other words, the numerator depicts the probability of the event occurring within a short interval $(t, t + \Delta t)$ conditional upon survival to the beginning of the short interval at time t (Hougaard 2000). The short interval is depicted by taking the limit of Δt as it tends towards zero ($\lim_{\Delta t \to 0}$) applied to the hazard in the denominator. The hazard rate can also be defined as the ratio of the probability density function of having the event $f(t)$ (instantaneous and unconditional) with the survivor function $S(t)$ depicting survival up to time t (Laird and Olivier 1981, Yamaguchi 1991).

The main advantage of hazard rate models (or survival data analysis in general) over other types of models (such as linear regression) is the ability of hazard rate models to deal with censored observations. Censored observations are observations with partial information on the duration of the risk period (Yamaguchi 1991). There are several types of censoring of observations that can occur and these are explored in the subsequent section.

3.1.1 Censoring

Given a fixed period of study, between two distinct time points T_0 and T_1, observations can be censored as illustrated in Figure 3.2 below:

Figure 3.2 Right and left censored observations



where: $*$ =occurrence of event of interest

o =occurrence of event other than the event of interest

Adapted from Yamaguchi (1991:4)

Subject A is not a censored observation as the event of interest occurs within the risk period. Subject B is right truncated or right censored since observation is stopped or truncated at the end of study period (T_1). In retrospective birth histories, right truncation (Subject B) is the predominant type of censoring (Yamaguchi 1991). Observation of child survival is truncated at survey date.

An important assumption however needs to be made on the nature of right truncation if survival analysis models are to be adequately applied to the data. The determination of T_1 must be independent of the risk of the event occurring or independent of the survival time (Yamaguchi 1991, Hougaard 2000). The 1997 and 2003 Mozambique DHS survey dates were determined during survey design before data collection and are thus independent of the risk of child mortality associated with the length of preceding birth intervals. The hazard rate model can therefore be adequately and accurately applied to the Mozambique DHS data.

Subject C experiences an event that is of non interest to the study. For example, in the analysis of death as a result of a particular disease, if death occurs from a cause not linked to the disease under study then this type of censoring is referred to as independent censoring and is treated in the same way as a right-censored observation such as Subject B. The cause of the event must be unrelated to the event under study otherwise the type of censoring is non-independent and the analysis becomes an analysis of competing events (Yamaguchi 1991). Data on the cause of death is not available in the 1997 and 2003 Mozambique DHS data. However in order to isolate child mortality resulting from a short preceding birth interval, other determinants of child mortality will be controlled in the multivariate modelling. Data limitations in the DHS data sets may prevent an adequate control of other determinants of child mortality.

Subject D is completely right truncated with no partial observation within the period of study. Hence data of Subject D is absent in the data set. The most important issue raised by the presence of complete right censoring is that of selection bias (Yamaguchi 1991). Selection bias emanates from early timing of certain observations that qualifies entry into the analysis and disqualifies other late entries into the analysis. Hence in the current analysis, 'fast breeders' will have a higher number of children and thus contribute more births to the analysis, whilst the 'slow breeders' contribute fewer births. Selection bias, like any other bias, affects the accuracy of the model and hence the reliability of the results. Selection bias can be removed or reduced to reasonable levels by controlling for factors which introduce selection bias (Yamaguchi 1991). In the analysis of child mortality and preceding birth intervals the mother's age at birth and parity will be modelled to control for selection bias.

Subject E is a completely left censored observation as the event of interest occurs before the start of the study period. Subject E introduces selection bias into the analysis that is much harder to correct (Yamaguchi 1991). Children exposed to the risk of mortality and who die in periods more distant in time than the lower limit of the study period are completely left censored. Subject F is partially left censored or left truncated as the risk period commences before the start of the study period. Partial censoring of Subject F is only problematic in the absence of information on the commencement of the risk period. In this analysis, observation is initiated at birth based on reported birth histories thus avoiding left truncation.

The hazard rate model has been determined in the discussion above as the model to be applied in data analysis. The following section discusses the choice of the hazard rate model.

3.1.2 Choice of hazard rate model

The log rate model for piecewise constant rates is the hazard rate model to be applied in the modelling of child mortality with the length of the preceding birth interval. The log rate model for piecewise constant rates (also referred to as a piecewise constant log rate model) assumes that the risk period can be categorized into mutually exclusive and exhaustive segments with a constant hazard rate in each segment (Laird and Olivier 1981, Yamaguchi 1991).

A piecewise constant log rate model has a fundamental difference from the commonly applied Cox proportional hazard rate model. A proportional hazard rate model assumes that the ratio of the hazard rate among different groups is independent of time and thus constant over time (Cox 1972, Yamaguchi 1991). A proportional hazard assumption is not necessary for piecewise constant log rate models which model time dependent covariates. Although time dependent covariates can be modelled in the Cox proportional hazard model, the process is not as analytically simple as the piecewise constant log rate model (Moultrie 2002). Thus interactions of time dependent covariates with other variables can be easily incorporated and interpreted with the piecewise constant log rate model (Yamaguchi 1991).

In addition using the Poisson model as the log rate model allows data from two different surveys to easily be aggregated by calculating the deaths and person years lived and aggregating them. (Moultrie 2002). The 1997 and 2003 Mozambique DHS data can thus be aggregated to have a larger data set which allows narrower preceding birth intervals to be modelled for the Mozambique data; an advantage over past studies which generally analyze longer preceding birth intervals for country specific studies (due to scanty data). Modelling longer preceding birth intervals potentially masks mechanisms of short preceding birth intervals. Log rate models for piecewise constant rates are discussed in the next section.

3.2 Log rate models for piecewise constant rates

3.2.1 Piecewise constant hazard rate

Holford (1976) introduced piecewise constant rates by dividing the period of follow-up into non-overlapping intervals and assuming a constant hazard rate within each time interval. Piecewise constant rates are derived by assuming that the "…probability density function of duration is piecewise exponential" (Yamaguchi 1991:71). The piecewise constant hazard is thus "…piecewise the hazard of exponential distributions" (Hougaard 2000:56). The resulting hazard function is a step, or piecewise, function, calculated to approximate the continuous exponential distribution function, with an assumption of a constant hazard rate in each interval (Friedman 1982, Yamaguchi 1991, Hougaard 2000).

Laird and Olivier (1981:234) define the piecewise exponential distribution or the piecewise hazard rate model in the following:

$$h(t,\mathbf{X}) = h_i e^{\mathbf{X}^T\boldsymbol{\beta}} \quad \text{for } t \ \varepsilon \ \Omega_i$$

where $h(t,\mathbf{X})$ denotes the hazard function with a vector $\mathbf{X}$ of known covariates,
h_i denotes the constant hazard in each interval denoted by Ω_i with $i = 1,\ldots,I$
$\boldsymbol{\beta}$ is a column vector of unknown covariate parameters

There are four underlying assumptions of piecewise constant hazard rate models. First the hazard rate must exist continuously over time, although varying across time intervals. As a force of mortality the hazard function exists continuously, although it can be approximated by a piecewise function (Friedman 1982, Yamaguchi 1991). Second, the nature of the hazard rate must be piecewise constant. It is important for the true nature of the underlying hazard function to be piecewise or to be reasonably assumed as piecewise for instance by modelling narrow time segments otherwise inconsistent parameters are obtained (Holford 1976, Friedman 1982). Narrow time segments of 6 months (to be discussed in chapter 5) are modelled in this research resulting in a hazard function that can be reasonably assumed to be piecewise. Furthermore, the literature review (chapter 2) provides evidence that the hazard is piecewise since child mortality risks decline as the length of the preceding birth interval increases until an optimal interval length after which mortality risks are observed to increase (Hobcraft, McDonald and Rutstein 1985, Pebley and Millman 1986, Koenig, Phillips, Campbell *et al* 1990, Boerma and Bicego 1992, Madise and Diamond 1995, Kuate Defo 1997, Whitworth and Stephenson 2002).

The third assumption is that the hazard rate is different among heterogeneous groups and these differences can be characterized by modelling time independent categorical explanatory variables. The same studies that support the piecewise nature of the hazard also confirmed significant independent categorical explanatory variables. The last assumption is that the "…logarithm of hazard rates is a linear function of parameters for time and other explanatory variables" (Yamaguchi 1991:71). The fourth assumption refers to the link function of the log rate model and this relationship is proven in the following discussion of the Poisson model as the log rate model of choice.

3.2.2 Log rate model

The Poisson regression model is applied as the log rate model in computing piecewise constant rates. The application of the Poisson model in the estimation of piecewise constant rates stems from the fact that the maximum likelihood function for exponential regression is equal to the maximum likelihood function for Poisson regression (Holford 1976, Laird and Olivier 1981, Friedman 1982). The advantage of applying the Poisson model is that it computes the hazard rate using logarithms for maximum likelihood estimators that are easily available and easy to compute (Holford 1976, Laird and Olivier 1981, Friedman 1982).

The Poisson model is considered a fundamental method for the modelling of count data (Hilbe 2007). If Y is defined as the number of occurrences or events, the probability distribution function (PDF) of the Poisson distribution can be expressed as (Dobson 2001, Hilbe 2007):

$$f(y) = \frac{e^{-t\mu}(t\mu)^{y}}{y!}$$

where μ = average number of occurrences of events per unit of exposure t.
t = the length of time or exposure during which events occur

Defining $Y_1,\ldots,Y_N$ as independent random variables, the generalized linear model for Poisson regression can be represented as (Dobson 2001):

$$E(Y_i) = \mu_i = n_i e^{X_i^T \beta} \text{ ; } Y_i \sim \text{Poisson } (\mu_i)$$

where Y_i = the number of events observed from exposure n_i for the ith covariate pattern

μ_i = expected value of Y_i

X = covariate pattern

β = covariate parameters

The natural link function of the Poisson regression model in logarithmic form is expressed as (Dobson 2001):

$$\log \mu_i = \log n_i + \mathbf{x}_i^T \boldsymbol{\beta}$$

The term $\log n_i$ representing the log of the exposure n_i, is a constant term in the model referred to as the offset. This log link function of the Poisson model is applied in modelling piecewise constant hazard rates where the "μ" terms are replaced to model the hazard function (Laird and Olivier 1981). The log rate model for piecewise constant rates becomes (Laird and Olivier 1981: 234):

$$\ln h(t, \mathbf{X}) = \ln h_i + \mathbf{X}^T \boldsymbol{\beta},\ t\ \varepsilon\ \Omega_i$$

where $h(t, \mathbf{X})$ denotes the hazard function with a vector $\mathbf{X}$ of known covariates

$\ln h_i$ denotes the offset or constant hazard in each interval denoted by Ω_i with $i = 1, \ldots, I$

$\boldsymbol{\beta}$ is a column vector of unknown covariate parameters

The main characteristic of the Poisson model is equi-dispersion of the response variable, where the mean μ (average number of occurrences) is equal to the variance σ^2 of the number of occurrences ($\mu = \sigma^2$) (Dobson 2001, Hilbe 2007). When equi-dispersion is not present, the model is either under-dispersed (where the variance is less than the mean) or over-dispersed (where the variance is greater than the mean) (Hilbe 2007). Overdispersion is the most common violation of equi-dispersion (Hilbe 2007). According to Hilbe (2007:51), there are three possible causes of overdispersion: positive correlation between responses, excess variation between response probabilities or counts and violations in the distributional assumptions of the data. The fact that a single mother can contribute to multiple births and hence multiple deaths, resulting in a clustering of child deaths around the mother can lead to a positive correlation of responses and consequently in overdispersion. Overdispersion leads to non-significant explanatory variables becoming significant due to an underestimation of standard errors (Hilbe 2007).

Hilbe (2007) however cautions against apparent versus real overdispersion. Apparent overdispersion results from the following scenarios: (1) if the model omits important explanatory variables (2) if the data is fraught with outliers (3) if the model fails to include a sufficient number of interaction terms (4) the apparent overdispersion may be indicative of the need to transform the predictor variable and (5) in the event that the link function is mis-specified. Real overdispersion is determined by excluding these possible causes of apparent overdispersion through (1) re-checking the model to ensure that important explanatory variables are not omitted (2) inspect the data for outliers and adjust for outliers (3) include appropriate interaction terms in the model (4) transform the predictor variable and (5) apply the correct link function to the data Hilbe (2007).

Three model testing parameters are applied to Poisson models to test for real overdispersion namely; the Pearson chi-square dispersion value, Lagrange multiplier and Z tests (Hilbe 2007). The model testing parameters are used to test the hypothesis of overdispersion:

H_0: there is no overdispersion in the Poisson model

H_1: the Poisson model is overdispersed

The Z test is a *post-hoc* test used to determine which model is appropriate between the Poisson model and the negative binomial model whilst the Pearson chi-square dispersion value reflects the underlying variability in the data. The Lagrange multiplier is also a *post-hoc* test testing the hypothesis of overdispersion of the Poisson model (Hilbe 2007).

The Z test (Hilbe 2007:47): $Z_i = \dfrac{(y_i - \mu_i)^2 - y_i}{\mu_i \,\mathrm{sqrt}(2)}$

where: y_i =the observed number of events for the *i*th covariate pattern

μ_i =expected number of counts of y_i

Pearson chi-square dispersion value (Hilbe 2007:73): $\frac{\text{Pearson } \chi^2}{\text{Residual df}}$

$$\text{Pearson } \chi^2 = \sum_{i=1}^{n} \frac{(y_i - \mu_i)^2}{V(\mu_i)}$$

where: y_i =the observed count

μ_i =expected count of y_i

n = number of possible outcomes

V =variance function

The Lagrange Multiplier (Hilbe 2007:48): $\chi^2 = \frac{(\sum_i \mu_i^2 - ny)^2}{2\sum_i \mu_i^2}$ with 1 dof

where: y_i = observed number of events for the *i*th covariate pattern

μ_i =expected number of counts of y_i

n = the number of observations

In the presence of real overdispersion in the data (the null hypothesis is rejected), the negative binomial variant of the Poisson model is modelled with the response variable characterized by a Poisson process with overdispersion (Hilbe 2007). The variance function of the negative binomial model has an overdispersion parameter which accounts for the overdispersion of the response variable (Hilbe 2007). The variance function for the negative binomial model (referred to by Hilbe as NB-2) is expressed as $\mu + \alpha\mu^2$ where μ is the Poisson regression variance (since $\mu = \sigma^2$) and α is the overdispersion parameter (Hilbe 2007:78). If α is equal to zero the variance function is equal to the Poisson regression variance.

Goodness-of-fit tests of the fitted negative binomial models are essential to determine the statistical significance of the model in adequately modelling the overdispersed Poisson data. The likelihood ratio chi-square test for the null hypothesis that the overdispersion parameter α is equal to zero (in which case the model is equivalent to a Poisson model) is one of the commonly used goodness-of-fit tests and will be used to test model fit. A dispersion parameter that is significantly greater than zero indicates the negative binomial model as a better model fit relative to the Poisson model.

To recap on the methodology, event history analysis is adopted in this research mainly due to its ability in dealing with censored observations (characteristic of survival data). Furthermore hazard rate models can be employed without specifying the distributional form of survival times (Yamaguchi 1991). Thus modelling of hazard rates is more flexible and not compromised by specifying a parametric distribution which may not be entirely appropriate for the survival data. The log rate model for piecewise constant rates is the hazard rate model to be applied to the data. The underlying assumption of the piecewise log rate model of a stepwise hazard rate constant within each interval allows narrow categories of the length of the preceding birth interval to be modelled the results of which are beneficial to understanding their association of child mortality risks. Furthermore, modelling the Poisson regression model as a log rate model facilitates the easy aggregation of data from two surveys. The negative binomial model will be modelled in the event of significant real overdispersion in the Poisson model.

The model type adopted however has several limitations discussed in the following section.

3.3 Limitations of the log rate model for piecewise constant rates

The specification of the number of intervals in log rate piecewise models is a subjective matter as there are no guidelines provided (Friedman 1982). The two limiting cases of interval selection are when there is one interval and when the number of intervals tends to infinity: (I=1, $I \rightarrow \infty$) using Laird and Olivier's (1981:234) notation. When there is one interval the model is an exponential hazard function (Holford 1976, Laird and Olivier 1981). When the number of intervals tends to infinity the hazard model becomes a nonparametric model (Laird and Olivier 1981).

Applying the Poisson model assumes that the occurrence of events (child deaths) follow a Poisson distribution. One of the conditions for the occurrence of child deaths to follow a Poisson distribution is that the occurrence of events in two non-overlapping time intervals must be independent (Moultrie 2002). The condition of independent events in the log rate model is however violated by the fact that a single mother can contribute to multiple births and hence multiple deaths, resulting in a clustering of child deaths around the mother. The violation of independence can result in reduced standard errors and an overstatement of significant covariates (Madise and Diamond 1995, Whitworth and Stephenson 2002).

The inability of Poisson regression to take into account increased variability in DHS data due to cluster sampling implies that statistical tests will be less significant than they appear which may also result in an overstatement of significant covariates.

Use of aggregated data introduces three sources of error (Moultrie 2002). The 1997 and 2003 DHS data are weighted before the data is aggregated to ensure the data are nationally representative. This aggregation of weighted data leads to narrower standard deviations of estimated coefficients. Second, use of aggregated data does not allow clustering effects (referred to above) to be investigated and does not account for the fact that a single mother can contribute to multiple births and hence multiple deaths. Third, some variables modelled as individual characteristics are better represented as community variables; however weighted aggregation does not allow multilevel modelling (Moultrie 2002). These errors however affect the standard deviations of coefficients and not the coefficients themselves thus maintaining the integrity of model results. However as Moultrie (2002) notes, marginally significant results may be best taken as statistically insignificant in light of the errors present. Thus the interpretation of model results must be done within the context of the limitations of log rate models for piecewise constant rates.

This chapter provided a description of log rate models for piecewise constant rates as the hazard rate model adopted for this event history analysis. The Poisson model is the log rate model to be applied and in the event that the model is overdispersed the negative binomial will be modelled. Chapter 4 briefly describes the data sources to be used in the analysis and provides a quality assessment of the data sources.

4 DATA SOURCES AND DATA QUALITY

The first section of this chapter contains a discussion of Demographic and Health Surveys in general and more specifically the 1997 and 2003 Mozambique DHS. An assessment of data quality of the 1997 and 2003 DHS data is provided in section 4.2 by checking for age misreporting errors, birth omissions and birth misplacements. The final section discusses data quality effects.

4.1 Data sources

Data from the Mozambique Demographic and Health Surveys (*Inquérito Demográfico e de Saúde*) conducted in 1997 and 2003 will be used to estimate the risks of child mortality associated with the length of preceding birth intervals. The Demographic and Health Survey (DHS) program was initiated in 1984 by the United States Agency for International Development (USAID) as a follow up to the World Fertility Survey and Contraceptive Prevalence Survey (Rutstein and Rojas 2003).

The first DHS in Mozambique 1997 was carried out between March and July 1997. The subsequent 2003 DHS was conducted between August 2003 and December 2003. Both surveys were co-ordinated by the National Institute of Statistics (*Instituto Nacional de Estatística*) together with the Ministry of Health (*Ministério de Saúde*). Technical support was provided by Macro International Inc.

The DHS is primarily targeted to interview women of reproductive age, aged 15 to 49 years, with at least two questionnaires being used in the survey: a women's questionnaire and a household questionnaire (Rutstein and Rojas 2003). The 1997 and 2003 Mozambique Demographic and Health Surveys utilised three questionnaires: a household questionnaire, a women's questionnaire and a men's questionnaire. Questionnaires used for the 1997 and 2003 DHS were model questionnaires for the third and fourth phase of the DHS program respectively.

The women's questionnaire collects background characteristics of the mother and partner, birth history, contraception knowledge and use, maternal health, child health, feeding practices of children under the age of 5 years and knowledge on sexually transmitted infections (STIs) and HIV/AIDS.

A total of 8779 women were interviewed in the 1997 DHS out of 9590 eligible women, translating into a 91.5 per cent national response rate. The 2003 DHS had a bigger sample of 12418 women interviewed out of an eligible 13657, with a national response rate of 90.9, slightly lower than the 1997 rate. Selected background characteristics of women interviewed in the 1997 and 2003 DHS are discussed in the following section.

4.2 Data quality

A data quality assessment of retrospective DHS data is essential as retrospective data generally contains age misreporting errors, birth omissions and birth displacements (Potter 1977, Hobcraft, Goldman and Chidambaram 1982). Furthermore, errors can be introduced through data imputation, where missing or incomplete dates are imputed based on known information (Croft 1991).

Age misreporting affects interpretation of age outputs and variables derived from age data. Age variables relevant to the current research include the current age of the mother, the age of surviving children, the age at death of dead children, the length of the preceding birth interval and the length of the subsequent birth interval. The DHS collects data on the month and year of birth to calculate age and birth interval variables.

Omission of births artificially lengthens the preceding or subsequent birth interval, potentially reducing the strength of the association of birth intervals with child mortality. If omitted births are dead children, child mortality rates will be under estimated and vice versa. It is of importance to note that the selective omission of events by age and period will determine the effect of omissions on results as Potter (1977: 337) argues, "…consequences of omitted events in birth histories collected during a survey depend greatly on how the omissions are distribution by period and cohort."

Birth displacement distorts the period analysis of births. Brass (1971) and Potter (1977) describe tendencies of displacing births in what are generally referred to as Brass and Potter effects respectively. The Brass effect postulates that women exaggerate the starting interval of older births to an interval closer to the date of survey. As a result, births in the period closest to the survey date are shifted and displaced beyond the survey cut-off date. Brass effects result in a false fertility decline for recent birth cohorts due to the displacement.

Potter effects are based on two propositions: first, that the further back in time an event occurred, the less accurate the recall and second, that if live births are asked in the order in which they occurred, excluding information on the first birth, dates of birth of subsequent births are dependent on information provided on previous births (Potter 1977). Consequently the most recent births are accurately dated; whilst subsequent birth intervals are exaggerated back in time resulting in fewer births than actual being reported in the last interval. Potter effects result in inaccurately lower fertility for periods furthest from the survey with an apparent fertility rise in subsequent periods, with fertility declining to correct levels as current births are dated correctly. Misreporting errors, omission of births and displacement of births will be investigated in the DHS data sets.

4.2.1 Misreporting errors

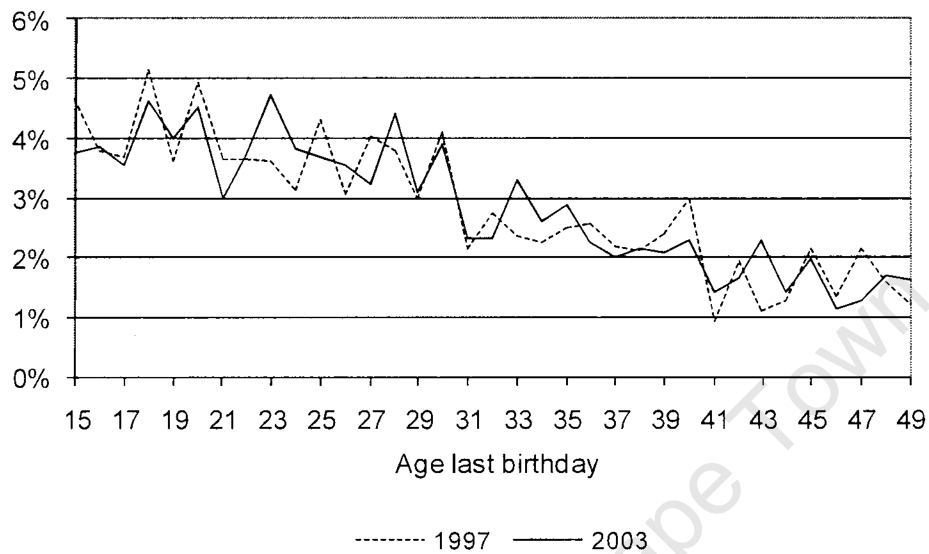
Per cent distribution and age ratio outputs of the age at last birthday of women 15 to 49 years, the age of surviving children and the age at death of dead children are provided to diagnose misreporting errors in the DHS data. As previously stated, the DHS collects age data by asking respondents the year and month of birth. Peaked age distributions or age ratios, coupled with relatively lower percentage distributions of preceding ages, indicate age misreporting.

Age at last birthday of women 15 to 49 years

The per cent distribution of the age at last birthday of women 15 to 49 years shows evidence of preference for the digit 0 in the year of birth in both the 1997 and 2003 DHS (Figure 4.1). There is evidence of heaping at ages of 23, 33 and 43 years in the 2003 DHS corresponding to the year of birth 1980, 1970 and 1960 respectively. Similarly there is evidence of age heaping at ages of 27 and 47 years in the 1997 DHS, which corresponds to the year of birth 1970 and 1950 respectively. Preference for the digit 5 in the year of birth is present in the 2003 DHS with heaping at age 28 years which corresponds to the year of birth 1975.

There are instances during data collection where a respondent reports an actual age which is then converted to the DHS date of birth format (Croft 1991). Preference for the digit 0 is evidenced by heaping at ages of 20, 30 and 40 years for both the 1997 and 2003 DHS (Figure 4.1). Preference for the digit 5 is evident at ages 25 and 45 years in the 1997 DHS and at age 45 in the 2003 DHS. Heaping at age 18 is evident in both data sets related to voting rights since 18 years is the minimum voting age in Mozambique.

Figure 4.1 Per cent distribution of the age at last birthday of women 15 to 49 years, 1997 and 2003 DHS



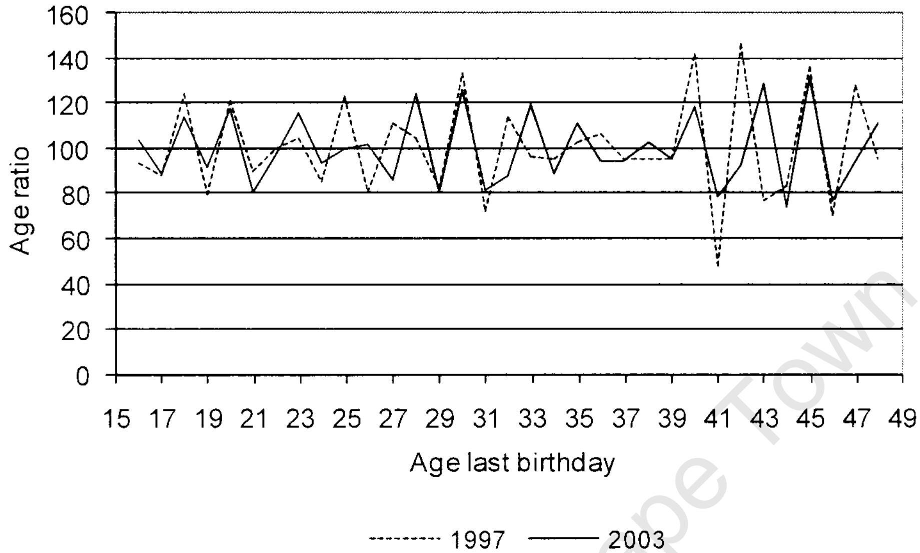
Age ratios were computed assuming a rectangular distribution over 3 adjacent ages (Shryock and Siegel 1976). An age ratio of greater than 100 reflects age heaping; a ratio less than 100 reflects avoidance whilst a ratio of 100 is the expected norm (Figure 4.2). Similar heaping patterns already identified in the per cent distribution (Figure 4.1) are also exhibited in the age ratio plot. Further evidence of preference for the digit 5 is illustrated in the age ratio output from heaping at ages of 32 and 42 years in the 1997 DHS corresponding to women born in 1965 and 1955 respectively (Figure 4.1).

Large fluctuations can be noted in the age ratios of older women 40 years and older stemming from the smaller frequencies at older subsequent ages (Table 4.1).

The ages of surviving children

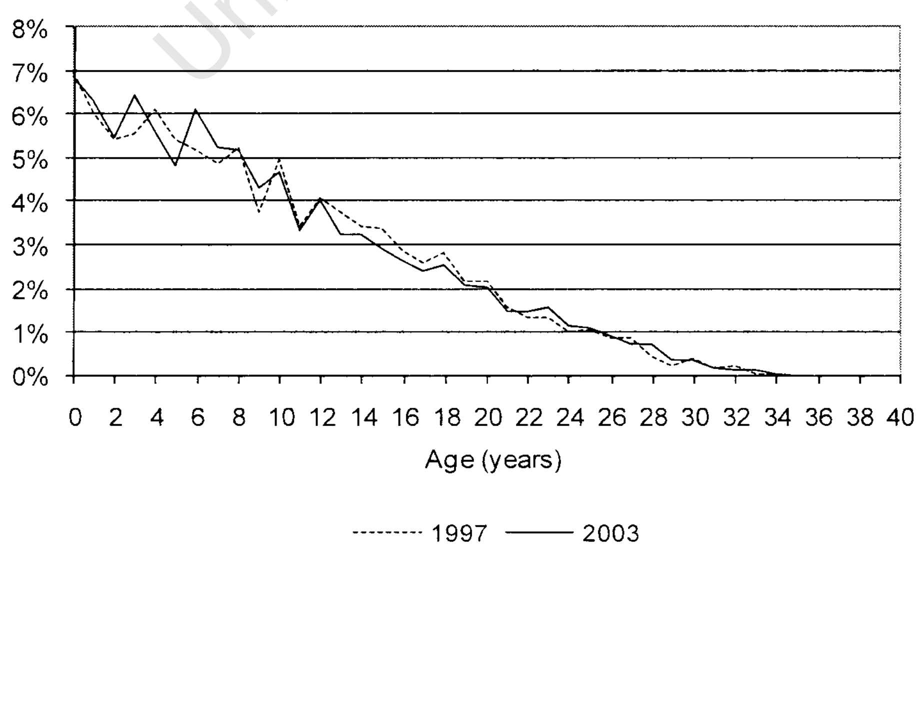
The per cent distribution of the ages of surviving children declines with increasing age from the increased exposure to the risk of death with age (Figure 4.3). The fluctuating trend in the early ages up to age 12 is a result of age heaping patterns.

Figure 4.2 Age ratios of the age at last birthday of women 15 to 49 years, 1997 and 2003 DHS



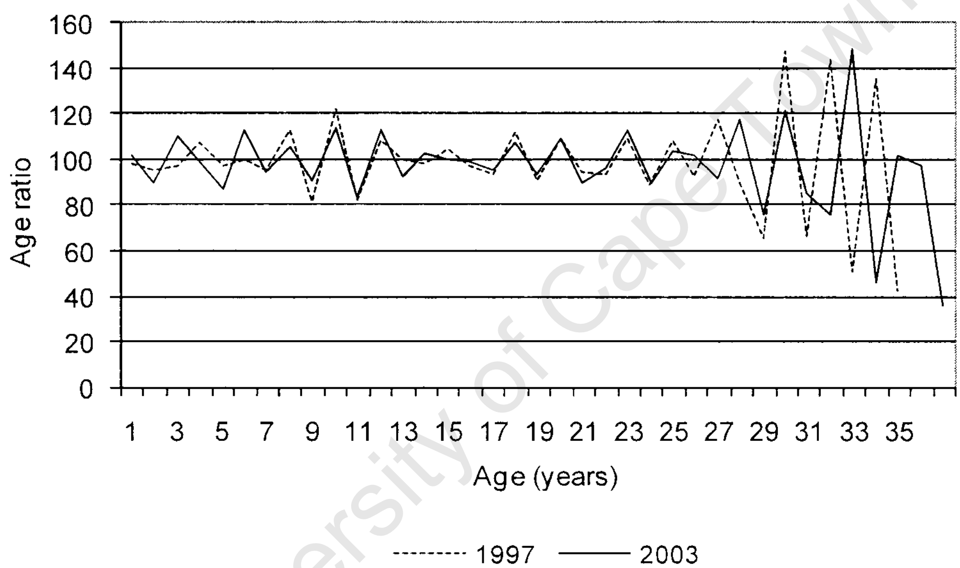
Age misreporting by enumerators to avoid the section on child health and immunization is evident from age heaping at the age of 4 years in the 1997 DHS and at the age of 6 years in the 2003 DHS in both the per cent distribution plot and the age ratio plot (Figure 4.3 and Figure 4.4).

Figure 4.3 Percent distribution of ages of children alive at survey date, 1997 and 2003 DHS



The 1997 DHS used a cut off age of 3 years for inclusion in the child health and immunization section whilst the 2003 DHS used a cut off age of 5 years. Digit preference for the digit 0 is present in the 2003 DHS with heaping at age 3 years which corresponds to the year of birth 2000 and at the ages of 10 years and 20 years in both the 1997 and 2003 DHS (Figures 4.3 and 4.4). Since the age ratios were calculated assuming a rectangular distribution over 3 adjacent ages, there is no age ratio calculated at age 0.

Figure 4.4 Age ratios of children alive at survey date, 1997 and 2003 DHS



The huge fluctuations in the age ratio plot (Figure 4.4) among older surviving children aged 30 years and older are a consequence of fewer cases as the number of cases becomes select due to the mother's age at birth (Table 4.1). There are much lower numbers of surviving children in the age groups 30 to 34 years and 35 to 37 years (Table 4.1).

Table 4.1 Frequencies of surviving children by age, 1997 and 2003 DHS

Age group	1997	2003
0-4	6 219	9 400
5-9	5 062	7 864
10-14	4 066	5 680
15-19	2 874	3 853
20-24	1 542	2 375
25-29	727	1 187
30-34	194	270
35-37	9	10

Age at death for dead children

The imputed variable for the age at death (b7) is used to assess the extent of age misreporting among dead children. The age at death analysis will be limited to deaths up to 60 months, although the percentages discussed are based on all reported child deaths.

The markedly high neonatal rates are illustrated in the steep decline from deaths at age 0 to age at death of 1 month. A quarter of deaths in both the 1997 and 2003 DHS were reported at age 0 (Figure 4.5). Age heaping in the age at death per cent distribution is evident at multiples of 6 months; 6 months, 12 months, 24 months, 36 months, 48 months and 60 months for both the 1997 and 2003 DHS, and to a lesser extent at age 18 months (Figure 4.5). The DHS collects information on the reported age at death. The frequencies of deaths reported under the age of 60 months are presented in Table 4.2.

Figure 4.5 Age at death at 60 months or younger, 1997 and 2003 DHS

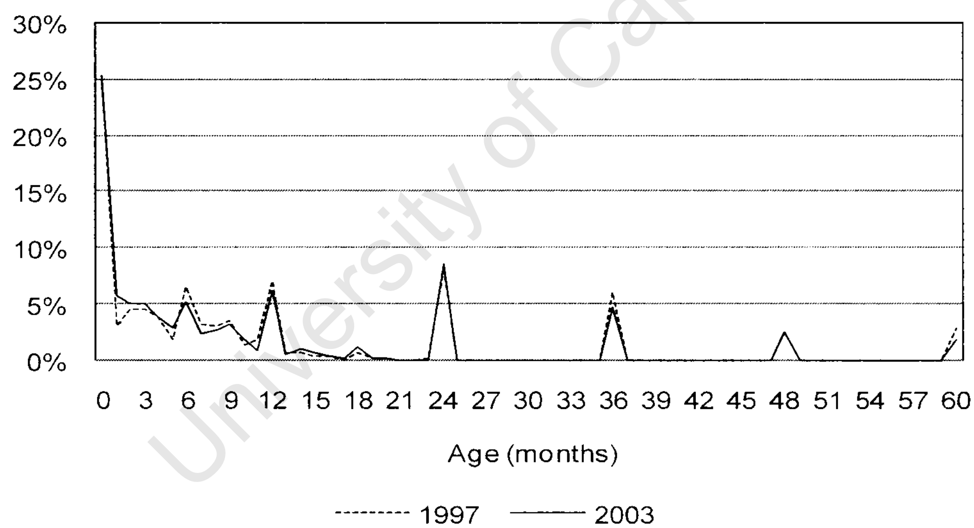


Table 4.2 Frequencies for age at death (in months), 1997 and 2003 DHS

Age at death	1997	2003
0	1 549	2 107
1-11	2 305	3 203
12-23	626	877
24-35	507	711
36-47	377	397
48-59	157	205

4.2.2 Omission errors and displacement of births

Comparing lifetime fertility with current fertility provides a diagnostic measure of birth omission and birth displacement (Hobcraft, Goldman and Chidambaram 1982). Lifetime fertility is denoted by P and current fertility is denoted by F with the ratio of current and lifetime fertility referred to as the P/F ratio. Hobcraft, Goldman and Chidambaram (1982) provide a direct method of calculating P/F ratios from cohort period fertility rates for periods prior to the survey date (Tables 4.3 and 4.4).

Panel A shows the weighted number of women in each 5 year age group at the date of survey and the corresponding weighted number of births in 5 year periods starting from the date of survey up to 40 years before the survey.

Annual cohort period fertility rates in Panel B are derived by dividing total births in each age cohort for each period, with the total number of women in each age cohort at the date of survey, then dividing the result by 5 which represents the average number of years a woman spends in each birth cohort.

Panel B rates are rotated to give cohort period fertility rates in Panel C. Columns are period comparisons, rows enable age comparisons by period and diagonals are cohort rates. Panel D shows cumulative fertility rates of cohorts (lifetime fertility) at the end of each period (P) calculated as sum of annual cohort rates at the end of each period (sum of diagonals in Panel C) multiplied by 5. Panel D is used to diagnose the presence of birth omissions or displacement of births by comparing adjacent diagonals.

Panel E shows cumulative fertility within each period (period fertility) (F) computed as the cumulative total of annual rates within each period multiplied by 5 (cumulating columns in Panel C). The value obtained for the 45-49 age group 5 to 9 years before the survey is equal to the period total fertility for the period 0-4 years before the survey on the assumption that old age fertility is more or less constant between periods.

Panel F shows values of P/F ratios obtained by dividing the cumulative fertility rates of cohorts at the end of the period (P) by cumulative fertility within each period (F). Diagonals reflect cohort P/F ratios.

If data were perfect and fertility constant, lifetime fertility would equal cumulative period fertility and hence P/F ratios would be equal to 1 (notwithstanding P/F ratios for the age group 15 to 19 years that are equal to 1 due to a common cell problem in the computation of the ratios since the value of lifetime fertility (P) is always equal to current fertility (F)). P/F ratios of less than one highlight errors in lifetime fertility. Hence initial diagnosis involves identifying P/F ratio less than 1 in Panel F followed by an analysis of Panel D rates to determine whether the source of the error is a result of birth omission or birth displacement. The analysis of P/F ratios is however sensitive to age misreporting, with age exaggeration by older women having a similar effect to understating parity with age (Hobcraft, Goldman and Chidambaram 1982).

The 1997 DHS results show the expected pattern in P/F ratios, with the oldest age groups indicating data errors (Panel F in Table 4.3). The cohort of women 45 to 49 years has P/F ratios of less than one except in the latest period (diagonal). The cohort 40 to 44 years also has P/F ratios less than one in the periods 15-19 years and 20-24 years before the survey. Women in the 30-34 years cohort have a P/F ratio below one 10-14 years prior to the survey. Potter effects are evident for the cohort of women 40 to 44 years with cumulative fertility for the cohort consistently lower than fertility for the cohort 35 to 39 years during the period extending 10 years and 24 years before the survey (Panel D in Table 4.3). Thus women in the age group 40 to 44 years displaced births to more recent periods in the 1997 DHS.

The period 5 to 9 years before the survey has P/F ratios less that one for three cohorts of women aged 30 to 34, 35 to 39 and 40 to 44 years (Figure 4.4). Panel D does not indicate Brass or Potter birth displacement effects, signifying that the observed error might be a result of non severe recall bias in the 2003 birth history data in the age group 35 to 39 years in the period 5 to 9 years before the survey.

4.3 Effects of data quality on analysis

Age misreporting (of children's ages) distorts the length of preceding birth interval, distorts age specific mortality rates and affects period analysis by shifting the period of birth due to misstatement of the year of birth. Misstatement of the age at death of children present in both the 1997 and 2003 DHS affects age specific mortality rates, especially for age at death categories which have the preferred age as an age limit (child mortality from age 12 months to 59 months). Misreporting the current age of the mother affects the age of the mother at birth. However younger women generally report their ages more accurately than older women who have been found to be strongly associated with longer preceding birth intervals (Potter 1977, Winikoff 1983).

Table 4.3 Cohort period fertility rates and P/F ratios, 1997 DHS

			Years prior to survey							
			0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39
	AGE									
A		NUMBER OF WOMEN	NUMBER OF BIRTHS							
	15-19	1836	655	17	0	0	0	0	0	0
	20-24	1663	1914	680	57	0	0	0	0	0
	25-29	1591	2046	1862	760	32	0	0	0	0
	30-34	1197	1215	1667	1408	546	31	0	0	0
	35-39	1028	893	1327	1444	1233	550	30	0	0
	40-44	724	407	750	949	1028	845	343	18	0
	45-49	739	211	488	722	875	823	678	323	45
B	COHORT PERIOD FERTILITY RATES									
	15-19		0.071	0.002						
	20-24		0.230	0.082	0.007					
	25-29		0.257	0.234	0.096	0.004				
	30-34		0.203	0.279	0.235	0.091	0.005			
	35-39		0.174	0.258	0.281	0.240	0.107	0.006		
	40-44		0.112	0.207	0.262	0.284	0.233	0.095	0.005	
	45-49		0.057	0.132	0.195	0.237	0.223	0.183	0.087	0.012
C	COHORT PERIOD FERTILITY RATES									
	15-19		0.071	0.082	0.096	0.091	0.107	0.095	0.087	
	20-24		0.230	0.234	0.235	0.240	0.233	0.183		
	25-29		0.257	0.279	0.281	0.284	0.223			
	30-34		0.203	0.258	0.262	0.237				
	35-39		0.174	0.207	0.195					
	40-44		0.112	0.132						
	45-49		0.057	0.057						
D	CUMULATIVE FERTILITY OF COHORTS AT THE END OF THE PERIOD (P)									
	15-19		0.357	0.409	0.478	0.456	0.535	0.474	0.437	
	20-24		1.559	1.648	1.633	1.734	1.640	1.354		
	25-29		2.934	3.026	3.138	3.060	2.467			
	30-34		4.041	4.429	4.370	3.651				
	35-39		5.297	5.405	4.629					
	40-44		5.967	5.289						
	45-49		5.574							
E	CUMULATIVE FERTILITY WITHIN PERIODS (F)									
	15-19		0.357	0.409	0.478	0.456	0.535	0.474	0.437	
	20-24		1.507	1.579	1.654	1.656	1.701	1.391		
	25-29		2.793	2.971	3.058	3.075	2.815			
	30-34		3.808	4.261	4.369	4.260				
	35-39		4.676	5.297	5.346					
	40-44		5.238	5.956						
	45-49		5.523	6.242						
F	P/F RATIOS									
	15-19		1.000	1.000	1.000	1.000	1.000	1.000	1.000	
	20-24		1.034	1.044	0.987	1.047	0.964	0.974		
	25-29		1.050	1.018	1.026	0.995	0.876			
	30-34		1.061	1.039	1.000	0.857				
	35-39		1.133	1.021	0.866					
	40-44		1.139	0.888						
	45-49		1.009							

Table 4.4 Cohort period fertility rates and P/F ratios, 2003 DHS

			Years prior to survey							
			0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39
	AGE									
A		NUMBER OF WOMEN	NUMBER OF BIRTHS							
	15-19	2454	1021	44	0	0	0	0	0	0
	20-24	2456	2880	1140	73	0	0	0	0	0
	25-29	2224	2737	2806	1051	60	0	0	0	0
	30-34	1792	1953	2425	1993	875	73	0	0	0
	35-39	1411	1183	1712	1900	1583	678	65	0	0
	40-44	1126	581	1096	1356	1514	1289	592	51	0
	45-49	954	265	720	1021	1257	1381	1107	453	17
B	COHORT PERIOD FERTILITY RATES									
	15-19		0.083	0.004						
	20-24		0.235	0.093	0.006					
	25-29		0.246	0.252	0.095	0.005				
	30-34		0.218	0.271	0.222	0.098	0.008			
	35-39		0.168	0.243	0.269	0.224	0.096	0.009		
	40-44		0.103	0.195	0.241	0.269	0.229	0.105	0.009	
	45-49		0.055	0.151	0.214	0.263	0.289	0.232	0.095	0.004
C	COHORT PERIOD FERTILITY RATES									
	15-19		0.083	0.093	0.095	0.098	0.096	0.105	0.095	
	20-24		0.235	0.252	0.222	0.224	0.229	0.232		
	25-29		0.246	0.271	0.269	0.269	0.289			
	30-34		0.218	0.243	0.241	0.263				
	35-39		0.168	0.195	0.214					
	40-44		0.103	0.151						
	45-49		0.055	0.055						
D	CUMULATIVE FERTILITY OF COHORTS AT THE END OF THE PERIOD (P)									
	15-19		0.416	0.464	0.473	0.488	0.480	0.526	0.475	
	20-24		1.637	1.734	1.600	1.602	1.670	1.635		
	25-29		2.965	2.953	2.948	3.014	3.082			
	30-34		4.043	4.161	4.219	4.400				
	35-39		4.999	5.192	5.469					
	40-44		5.708	6.224						
	45-49		6.501							
E	CUMULATIVE FERTILITY WITHIN PERIODS (F)									
	15-19		0.416	0.464	0.473	0.488	0.480	0.526	0.475	
	20-24		1.589	1.726	1.585	1.609	1.625	1.686		
	25-29		2.819	3.079	2.931	2.953	3.072			
	30-34		3.909	4.292	4.135	4.271				
	35-39		4.747	5.265	5.205					
	40-44		5.263	6.019						
	45-49		5.541	6.297						
F	P/F RATIOS									
	15-19		1.000	1.000	1.000	1.000	1.000	1.000	1.000	
	20-24		1.030	1.005	1.010	0.995	1.028	0.970		
	25-29		1.052	0.959	1.006	1.021	1.003			
	30-34		1.034	0.969	1.020	1.030				
	35-39		1.053	0.986	1.051					
	40-44		1.084	1.034						
	45-49		1.173							

Birth displacement into periods closer to the survey date (Potter effects) was detected in the 1997 DHS. The misplacement of births closer to the survey date has the effect of shortening the preceding birth interval and depending on the survival status of the child, effects of the preceding birth interval are strengthened if the child died or alternatively diminished if the child survived. In addition, birth displacement affects period analysis of child mortality by distorting the period of birth.

The exercise of establishing errors in the data is important to establish the extent to which results obtained are influenced by data errors. The assessment of data quality provided in this chapter shows that although data errors prone to retrospective data are present in the 1997 and 2003 DHS datasets to be utilised in the current analysis the extent of age misreporting and birth displacement is not severe as to preclude genuine model results.

In addition, identifying data errors allows appropriate action to be taken which minimizes the influence of those errors on results. Thus to minimize heaping effects, age at death categories (except for child mortality: 12 to 59 months) and preceding birth intervals categories will be split into categories that incorporate the preferred digit and both adjacent digits.

It is important to mention that although the omission of dead children is not identified from methods employed in this chapter, the sharp decline in child mortality for the period 1998 to 2003 raises the possibility of women omitting to report dead children.

The following chapter discusses the determination of categories for the length of the preceding birth interval with a constant hazard rate, the data aggregation process and covariates to be modelled.

5 DESCRIPTIVE STATISTICS AND DATA ANALYSIS

This chapter provides a description of the steps taken in preparation for data analysis. The determination of categories of the length of the preceding birth interval is discussed in the first section. Section 5.2 contains a discussion on the aggregation of the 1997 and 2003 Mozambique DHS data sets. Covariates to be included in the multivariate modelling of child mortality with preceding birth intervals are presented in the subsequent section with descriptive statistics of model variables. The final section contains a discussion of the modelling procedure.

5.1 The length of the preceding birth interval

5.1.1 Descriptive statistics for the length of the preceding birth interval

The length of the preceding birth interval is characterised by a right skewed distribution for both the 2003 and 1997 DHS data. Heaping is evident at interval lengths of 24 months (4.8 per cent) and 36 months (3 per cent) in the 1997 DHS and lengths of 22 months (3.9 per cent) and 26 months (4.5 per cent) in the 2003 DHS (Figure 5.1).

Figure 5.1 Percent distribution of monthly preceding birth intervals, 1997 and 2003 DHS

The 1997 and 2003 DHS collected birth history data starting with the oldest child. After reporting the date of birth of their oldest child, it is most likely that women estimated the date of birth of subsequent children in intervals of 24 months and 36 months. The heaping patterns in the 2003 DHS most likely resulted from enumerator's attempts to avoid observed heaping patterns in the 1997 DHS by questioning the reported interval of 24 months, with the end result being heaping at ± 2 months of that interval. It is important to highlight that some of the observed trends in the length of the preceding birth interval variable may be a result of imputing of date of births. According to Croft (1991:20), "...short birth intervals may be a result of the imputation process and not necessarily the real situation."

The median length of preceding birth intervals increased by a month from 1997 to 2003 (Table 5.1). The mean length of preceding birth intervals is included for completeness although the median value is a more robust measure of central tendency as the preceding birth interval variable is highly skewed. A minimum length of the preceding birth interval of 9 months and a maximum of 290 months was reported in the 1997 DHS. The 2003 DHS reported lower values of the minimum and maximum interval of 6 months and 238 months respectively (Table 5.1).

Table 5.1 Descriptive statistics of the length of preceding birth intervals (weighted), 1997 and 2003 DHS

DHS Year	Median	Mean	Standard deviation	Minimum	Maximum	Weighted N
1997	28	33.9	21.8	9	290	19920
2003	29	34.4	20	6	238	28905

5.1.2 Categories for the length of the preceding birth interval

The premise that the hazard rate is assumed constant in each time segment is used as the basis in determining categories for the preceding birth interval. Whilst narrow categories allow more accurate modelling and precise determination of the mechanisms of short preceding birth intervals on child mortality, the categories must have sufficient cases to avoid fragmentary data which affects the stability and reliability of model estimates (Holford 1976, Moultrie 2002). Friedman (1982) recommends a starting point of between 5 to 7 intervals in a piecewise hazard model.

A lower limit of 9 months was set for the length of the preceding birth interval for two reasons. First, the 1997 DHS data did not report children with a preceding birth interval of less than 9 months. Second, by assuming a normal gestation period of 9 months, premature births with a preceding birth interval of less than 9 months are excluded from the analysis due to their high risk of child mortality which might confound the analysis (Rutstein 2005). 0.8 per cent of children in the 2003 DHS had a preceding birth interval of less than 9 months.

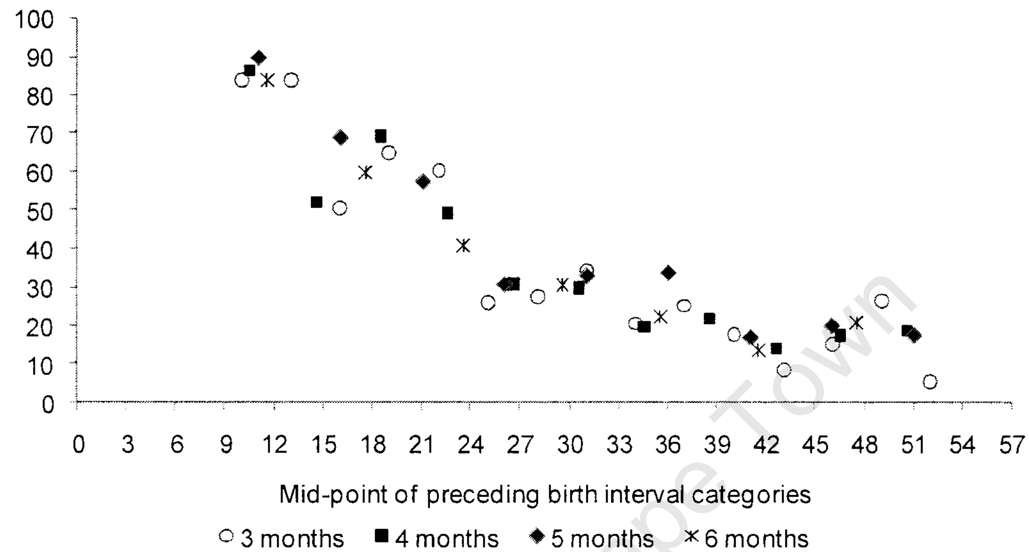
An upper limit (open ended interval) for the length of the preceding birth interval of 60 months or longer was initially selected. Less than a per cent (0.5 per cent) of children had a preceding birth interval of 60 months or longer.

According to Moultrie (2002:178), "Events should be distributed approximately uniformly over the time segment, and not heaped excessively at either the beginning or the end of each segment." Therefore the interval lengths where heaping was identified should ideally be placed in mid-range of the categories of the length of preceding birth interval.

Neonatal mortality rates in the 2003 DHS for the most recent period (1998-2003) were used to determine categories of the length of preceding birth interval. Several studies found effects of a short preceding birth interval to be strongest in the neonatal period (Koenig, Phillips, Campbell *et al* 1990, Mturi and Curtis 1995, Kuate Defo 1997). Furthermore, the influence of the civil war (which can potentially mask the association of child mortality with the length of the preceding birth interval) can be assumed to be minimal in the 5 years preceding the 2003 DHS.

Neonatal mortality rates were calculated for preceding birth interval categories of 3 months, 4 months, 5 months and 6 months in length to determine the category that can be assumed to have constant rates (Figure 5.2). 3 month and 4 month long categories display erratic neonatal mortality rates, with less erratic rates for the 5 month category. Neonatal mortality rates for the 6 month category are more stable with a clearly declining trend (Figure 5.2). Thus based on the inspection of the trend and stability of neonatal mortality rates, it can be reasonably assumed that the hazard rate is constant in each 6 month category.

Figure 5.2 Neonatal mortality rates (per 1000) by preceding birth interval categories of 3 months, 4 months and 6 months, for the five years preceding the 2003 DHS



Categories of preceding birth intervals which are 6 month in length will hence be employed in modelling the risk of child mortality associated with the length of the preceding birth interval in Mozambique. The minimum category was set at 9 months and the open interval was changed from 60 months or longer to an open interval of preceding birth intervals 57 months or longer to adapt the modelling of 6 month categories. Except for the preceding birth interval length of 26 months, the 6 month categories incorporate the heaping patterns noted in the preceding birth interval variable in both the 1997 and 2003 DHS.

5.2 Aggregation of the 1997 and 2003 DHS datasets

The 1997 and 2003 DHS individual data files containing birth histories of women 15 to 49 years formed the base of analysis. A maximum parity of 15 was set to minimize data errors in birth history data introduced by very distant events. The index child or child under study is defined as a single live birth of second birth order or higher. First order births are excluded from the analysis as they have no preceding birth. All multiple births are excluded due to the excess mortality associated with multiple births. Furthermore definitional problems of a birth interval between multiple births normally born within moments of each other leads to their exclusion as index births (Hobcraft, McDonald and Rutstein 1983).

Just over a quarter (25.6%) of total births in both the 1997 and 2003 DHS data were first births. Multiple births accounted for 2.9% and 3% of total births in the 1997 and 2003 DHS data. Non-live birth outcomes from induced abortions, miscarriages and stillbirths are excluded since the mechanisms of a preceding birth interval cannot be investigated on a non-live birth outcome.

This research adopted an approach of running separate models for the risk of child mortality at each age at death and birth period. Instead of creating a dummy variable for the birth period (the usually adopted approach), a separate model was run for each birth period at each age at death. Therefore four models corresponding to quinquennial birth periods (between 1978 and 1998) were run at each age at death (neonatal, postneonatal, infant, child and under five), totalling 20 models. This approach was taken to allow significant variables of child mortality to be determined for each birth period to offer insight into period determinants of child mortality in Mozambique and consequently the influence of environmental factors. The creation of a dummy variable for the period of birth would have resulted in a single model at each age at death.

The aggregation of the 1997 and 2003 DHS data was based on an index child's date of birth (month and year). Cut off points for inclusion in the aggregated database (lower and upper limits) were based on exactly overlapping birth periods in the 1997 and 2003 DHS. Birth periods were derived using the furthest date of birth reported in the 2003 DHS birth histories (September 1968) as the lower limit for the date of birth of the ultimate birth period. Thereafter, lower limits for subsequent birth periods were derived by adding multiples of 60 months. The upper limit (most recent date of birth) of each birth period was calculated by adding 60 months to the lower limit derived for that respective birth period. The lower limit is inclusive of each birth period whereas the upper limit is exclusive. The birth period September 1993 to September 1998 was set as the most recent birth period. In accordance with the calculation of child mortality rates in the DHS, births in the month of the survey were excluded from the analysis. Data were weighted before aggregation.

The two ultimate birth periods; 1968 to 1973 and 1973 to 1978 were excluded from data analysis due to sparse events. The final aggregated data set used in data analysis extends over the 20 year period September 1978 to September 1998.

The application of log rate models for piecewise constant rates requires total number of events and total exposure for each combination of covariates as input data for the model

(Yamaguchi 1991). The total number of deaths and total exposure (calculated in person months lived) were computed at each age at death, birth period and preceding birth interval category (Table 5.2).

According to Yamaguchi (1991), a sparse distribution of events may lead to zero marginal frequencies and result in a less accurate chi-square statistic. The input data presented in Table 5.2 does not contain zero frequencies although the ultimate birth period (1978 to 1983) has single frequency events for longer preceding birth interval categories (51 months and longer) for neonatal and child mortality. Since the categories of interest are short preceding birth intervals, the sparse events will not affect results of the analysis. There are also relatively sparse events at ages of between 12 months and 59 months (child mortality) (Table 5.2).

The previous two sections have established that data analysis will be conducted for quinquennial birth periods over the period September 1978 to September 1998 for 6 month categories of the length of the preceding birth interval. Life table survival curves are presented in the following section.

Life table survival curves

Life table survival curves at each age at death and quinquennial period were calculated for 6 month categories of the length of the preceding birth interval for the 1997 and 2003 DHS data. The survival curves are used to confirm the choice of 6 month preceding birth interval categories and provide descriptive statistics in the modelling of child mortality with the length of the preceding birth interval. At the same time, the survival curves allow a comparison of plots from two different surveys referring to the same birth period and age at death.

In general, the shorter the length of the preceding birth interval, the less the proportion of children surviving. Some notable differences however exist across birth periods and for overlapping periods in the 1997 and 2003 DHS.

Table 5.2 **Deaths and person-months lived at each age at death, for each quinquennial birth period and length of preceding birth interval, aggregated 1997 and 2003 DHS data**

	Neonatal		Postneonatal		Infant		Child		Underfive	
	Deaths	P/Months	Deaths	P/Months	Deaths	P/Months	Deaths	P/Months	Deaths	P/Months
1993-1998										
PBI groups										
9-14	82	468	68	4088	150	4651	14	5875	163	10692
15-20	76	1106	121	10274	197	11525	46	15681	243	27759
21-26	121	2064	196	19580	318	21878	77	29683	394	52482
27-32	84	1982	143	18572	227	20720	40	25196	267	46393
33-38	68	1399	91	12731	159	14245	26	18232	186	32793
39-44	22	894	40	8261	62	9201	18	12280	80	21699
45-50	13	624	17	5784	30	6430	5	9007	36	15502
51-56	9	387	19	3630	28	4039	5	5460	33	9559
57+	29	1197	29	11137	58	12372	9	17690	67	30167
1988-1993										
PBI groups										
9-14	98	709	109	6448	207	7302	22	10853	229	18419
15-20	114	1240	172	11488	285	12934	99	18553	384	32652
21-26	139	2423	220	22377	357	25059	134	39109	491	65716
27-32	82	1724	165	15920	247	17836	85	27109	332	45967
33-38	50	1343	78	12190	127	13629	27	19762	154	33718
39-44	41	788	55	7109	96	7957	46	12981	141	21487
45-50	9	524	38	5103	47	5668	26	8451	73	14430
51-56	13	320	17	2807	30	3149	7	4213	37	7446
57+	16	1162	26	11105	42	12297	10	20450	52	32870
1983-1988										
PBI groups										
9-14	33	462	62	4062	95	4597	19	6851	114	11676
15-20	88	903	103	8007	191	9037	42	13059	234	22604
21-26	142	1923	192	18492	334	20647	90	30972	423	52682
27-32	71	1350	121	12780	192	14270	59	21886	251	36865
33-38	24	1052	52	10019	76	11134	48	16942	124	28654
39-44	15	511	50	4865	65	5429	17	8277	82	13910
45-50	4	336	11	3181	15	3528	12	5131	26	8799
51-56	4	180	9	1670	12	1861	3	2599	15	4495
57+	9	543	6	5252	15	5805	20	9062	35	15103
1978-1983										
PBI groups										
9-14	37	359	63	3214	100	3647	16	5337	116	9178
15-20	41	695	89	6594	128	7390	42	11275	170	19168
21-26	63	1483	103	13906	166	15512	59	23570	225	39722
27-32	38	875	97	7968	135	8951	31	12226	166	21553
33-38	26	553	24	5130	50	5717	12	8094	62	13949
39-44	13	327	9	3027	22	3366	11	5472	33	8970
45-50	3	168	5	1367	8	1541	2	2274	10	3839
51-56	1	94	5	873	6	971	1	1318	7	2306
57+	1	246	2	2268	4	2517	1	3783	5	6316

P/Months=Amount of exposure to risk in Person Months

PBI groups=Categories of the length of the preceding birth interval

Neonatal mortality

Differences in the proportion of children surviving are clearly visible for 6 months categories of preceding birth intervals for the 1997 DHS except during the period 1993 to 1998 where the survival curves are grouped with the exception of the two shortest categories (Figure 5.3). In contract, survival plots for the 2003 DHS show clear differences across categories for other birth periods except the period 1978 to 1983 with grouped survival curves. Differences in the proportion of children surviving in the 2003 DHS plots can be seen for shorter categories of less than 32 months, whilst plots of longer categories are grouped (Figure 5.4). Since short preceding birth intervals are of interest in this research, it is suffice that differences in survival plots are exhibited for categories of shorter preceding birth intervals.

Neonatal survival for the shortest category is relatively worse in the two most recent birth periods, 1988 to 1993 and 1993 to 1998 (Figure 5.3 and Figure 5.4). A common trend of a steep decline in the proportion of children surviving from birth to about 9 days after birth can be noted for survival curves of both surveys, indicating the high perinatal mortality in Mozambique also found in the Burden of Disease study in Maputo (Dgedge, Novoa, Macassa *et al* 2001).

Postneonatal mortality

Life table survival curves for the 1997 and 2003 DHS show similar patterns in overlapping birth periods with differences in the proportion of children surviving across categories more pronounced in the 2003 DHS compared to the 1997 DHS (Figure 5.5 and Figure 5.6). Children in category of shortest preceding intervals (9 to 14 months) experience worse survival in the 2003 DHS relative to the 1997 DHS.

No common trend can be noted in the proportion of children surviving in the postneonatal period, although some plots indicate a steeper decline between the first and the second month after birth (birth period 1983 to 1988 in both surveys and the two latest periods in the 2003 DHS) (Figure 5.5 and Figure 5.6).

Figure 5.3 Life table survival curves for neonatal mortality for 6 month categories of the length of the preceding birth interval, 1997 DHS

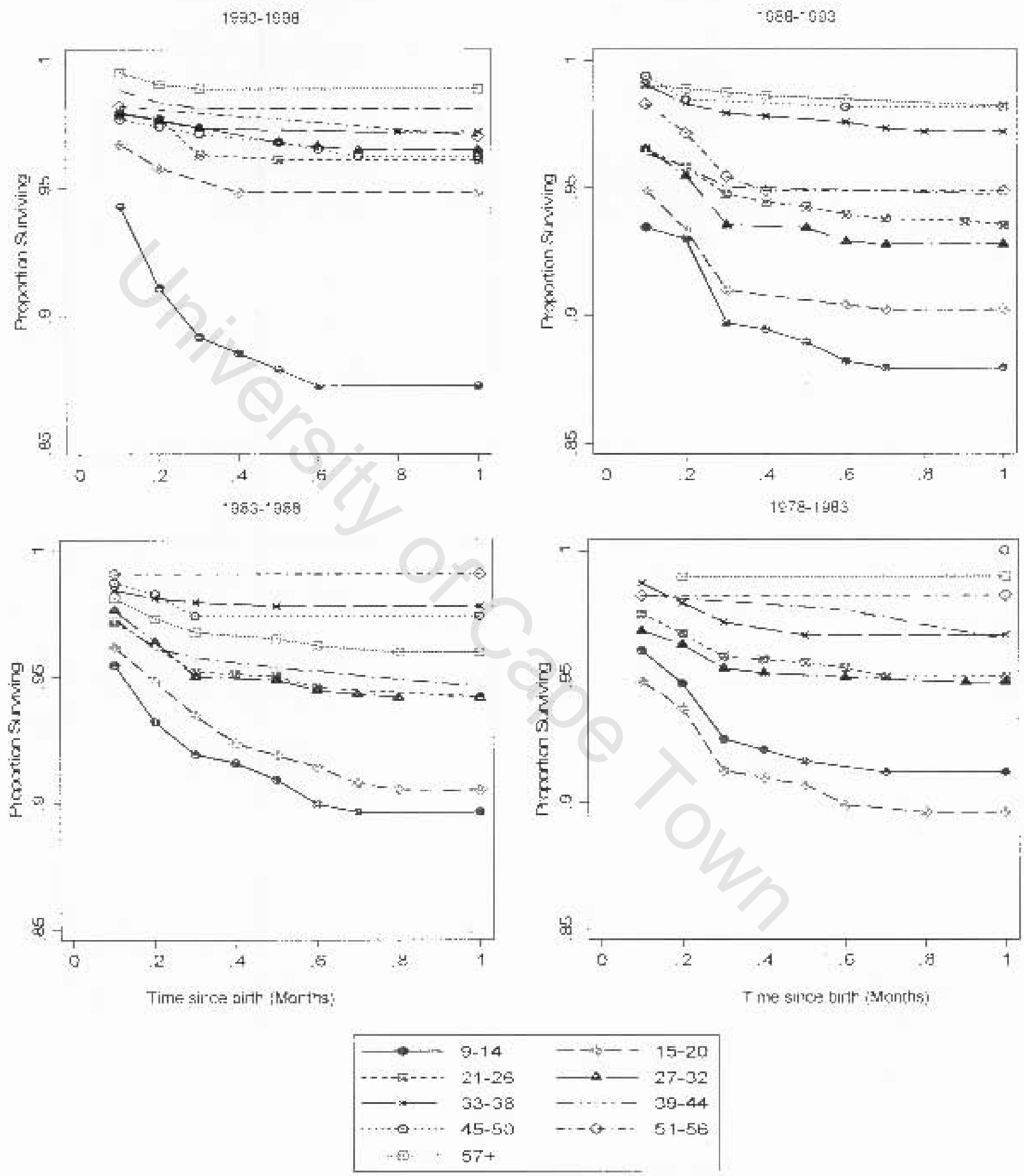


Figure 5.4 Life table survival curves for neonatal mortality for 6 month categories of the length of the preceding birth interval, 2003 DHS

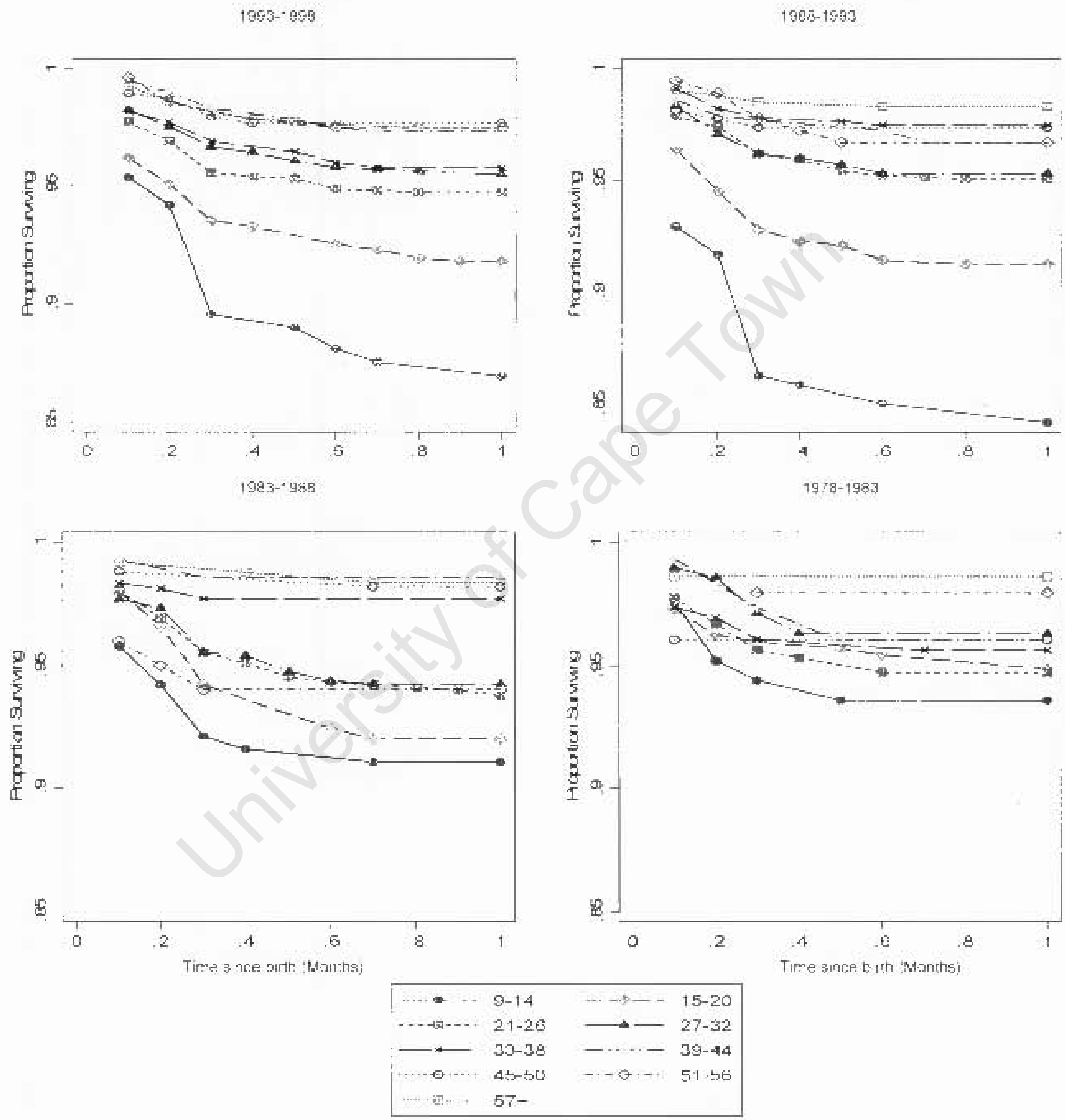


Figure 5.5 Life table survival curves for postneonatal mortality for 6 month categories of the length of the preceding birth interval, 1997 DHS

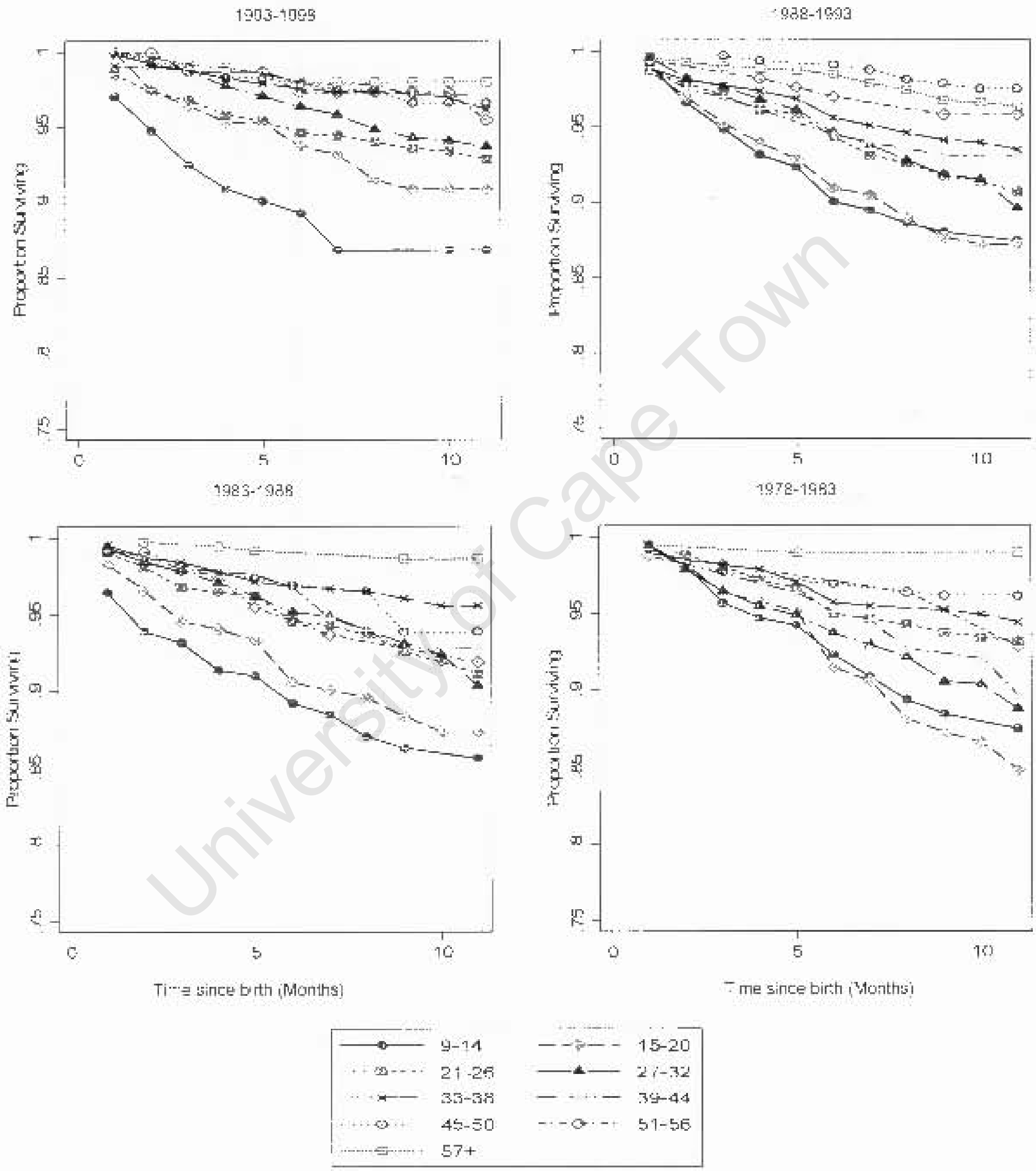
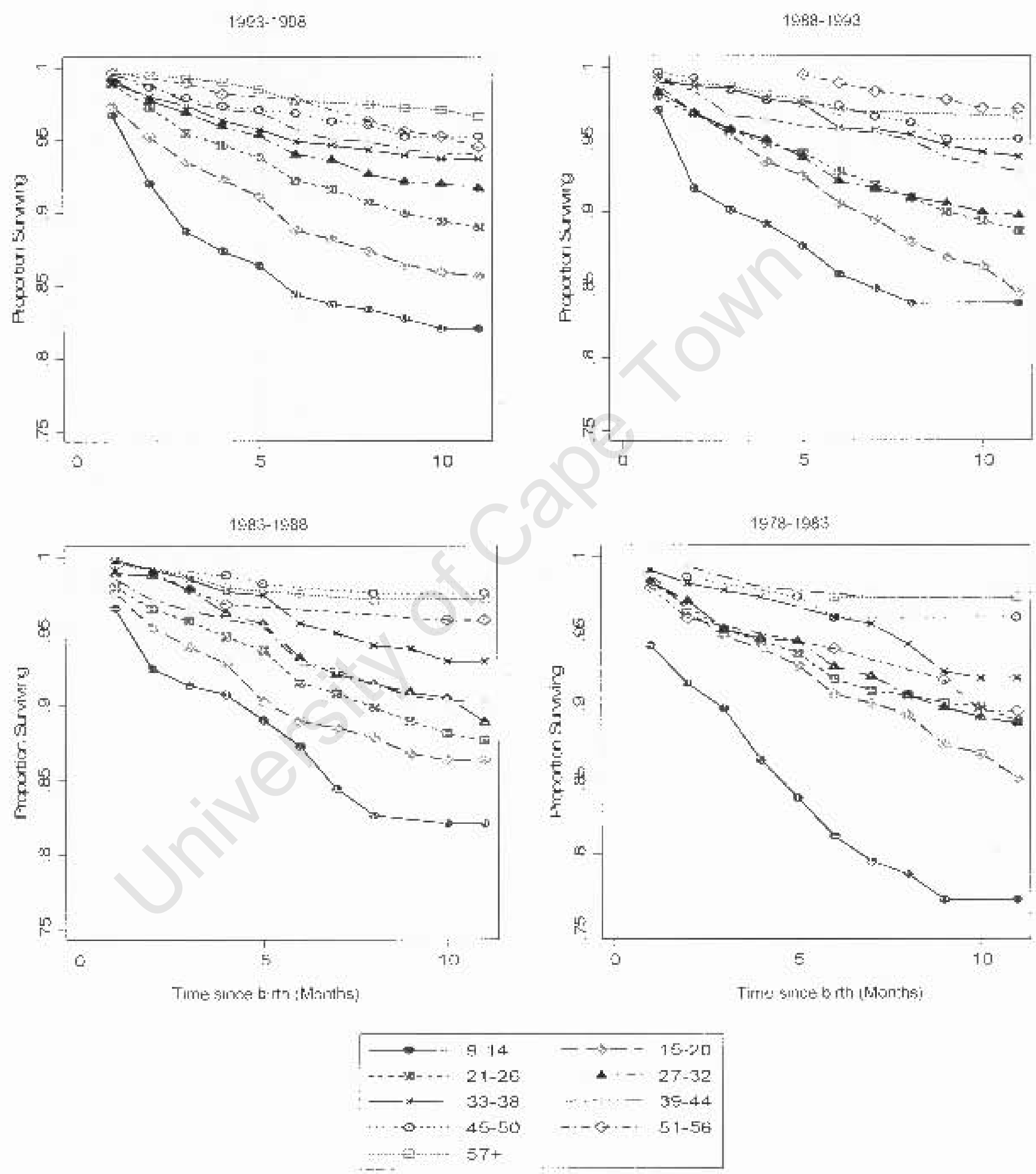


Figure 5.6 Life table survival curves for postneonatal mortality for 6 month categories of the length of the preceding birth interval, 2003 DHS



Infant mortality

Infant mortality plots for both the 1997 and 2003 DHS show similar trends in the proportion of children surviving across categories, with categories of shorter preceding birth intervals exhibiting the worst survival (Figure 5.7 and Figure 5.8). The 2003 DHS survival plots show the worst survival for the category with the shortest preceding birth intervals (9 to 14 months) compared to the 1997 DHS across all birth periods.

The worst survival for children is as expected at age 0 (or in the first month of life) as shown in the discussion of annual mortality rates in chapter 2. Trends in survival curves indicate a reduced gradient in survival after the eighth or ninth month for children born following short preceding birth intervals of 9 to 14 months and 15 to 20 months (Figure 5.7 and Figure 5.8).

Child mortality

Sparse events for child mortality (Table 5.2) are evident in the plots of survival curves (Figure 5.9 and Figure 5.10). The worst survival experience is interchangeable between categories of short preceding birth intervals less than 26 months for the 2003 DHS and less than 32 months for the 1997 DHS. Effects of short birth spacing appear minimal between the age of 12 months and 59 months due to relatively smaller variation in survival experience of children born following short and long preceding birth intervals (Figure 5.9 and Figure 5.10).

Underfive mortality

Survival curves for children under the age of 5 years summarize the discussion at other ages at death. The 6 month categories of the length of the preceding birth interval exhibit varying survival experience with categories of short preceding birth intervals exhibiting the worst survival particularly for the 2003 DHS (Figure 5.12). The category 15 to 20 months shows worst survival than the shortest category of intervals 9 to 14 months in the period 1978 to 1983 for the 1997 DHS with closely similar survival experience for the two shortest categories for birth periods extending from 1983 to 1993 (Figure 5.11).

The trend in survival curves of children under the age of five exhibits the steepest decline in the proportion of children surviving during the first year of life. The proportion remains almost stable in the period 20 to 59 months after birth (Figure 5.11 and Figure 5.12).

Figure 5.7 Life table survival curves for infant mortality for 6 month categories of the length of the preceding birth interval, 1997 DHS

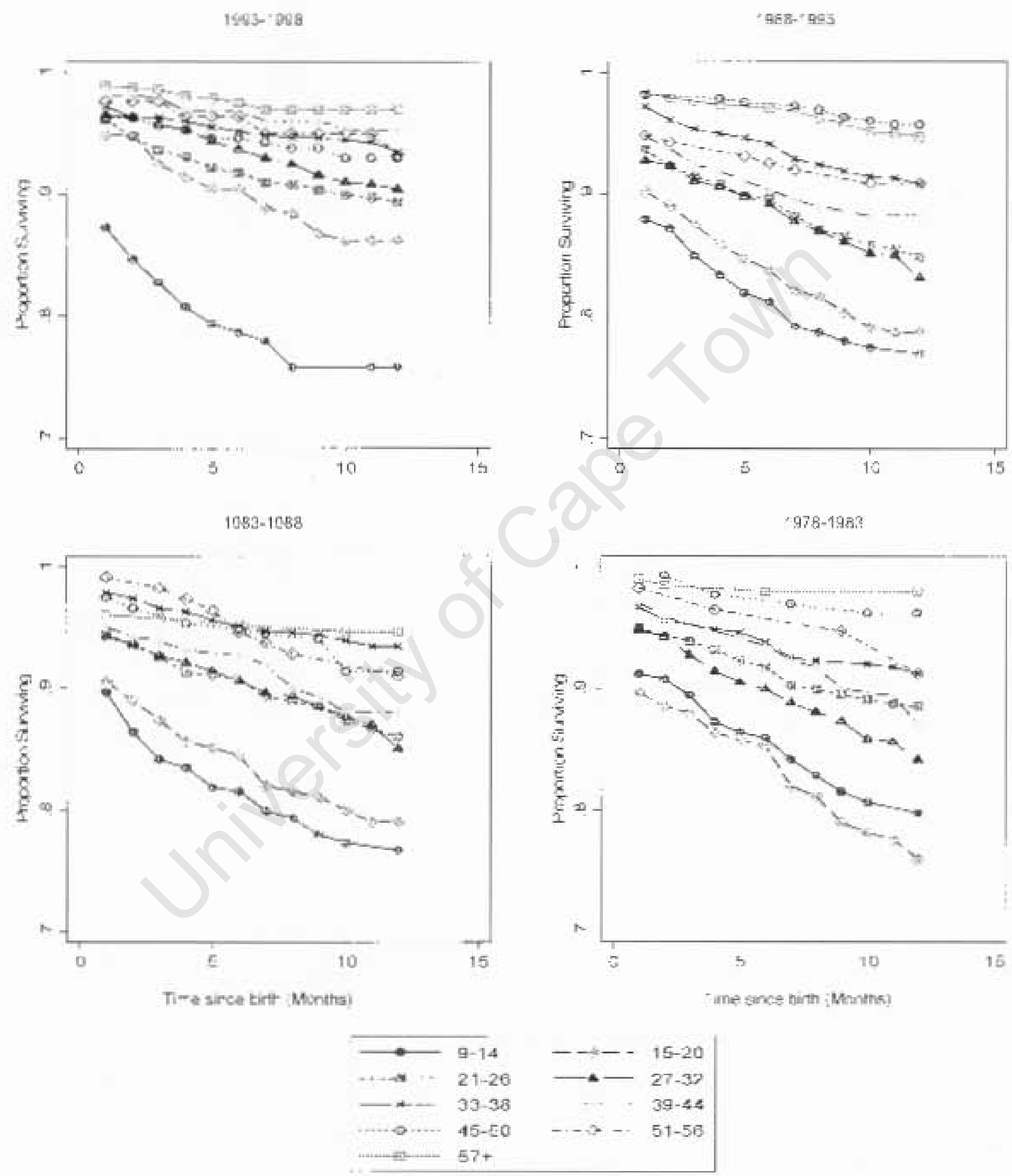


Figure 5.8 Life table survival curves for infant mortality for 6 month categories of the length of the preceding birth interval, 2003 DHS

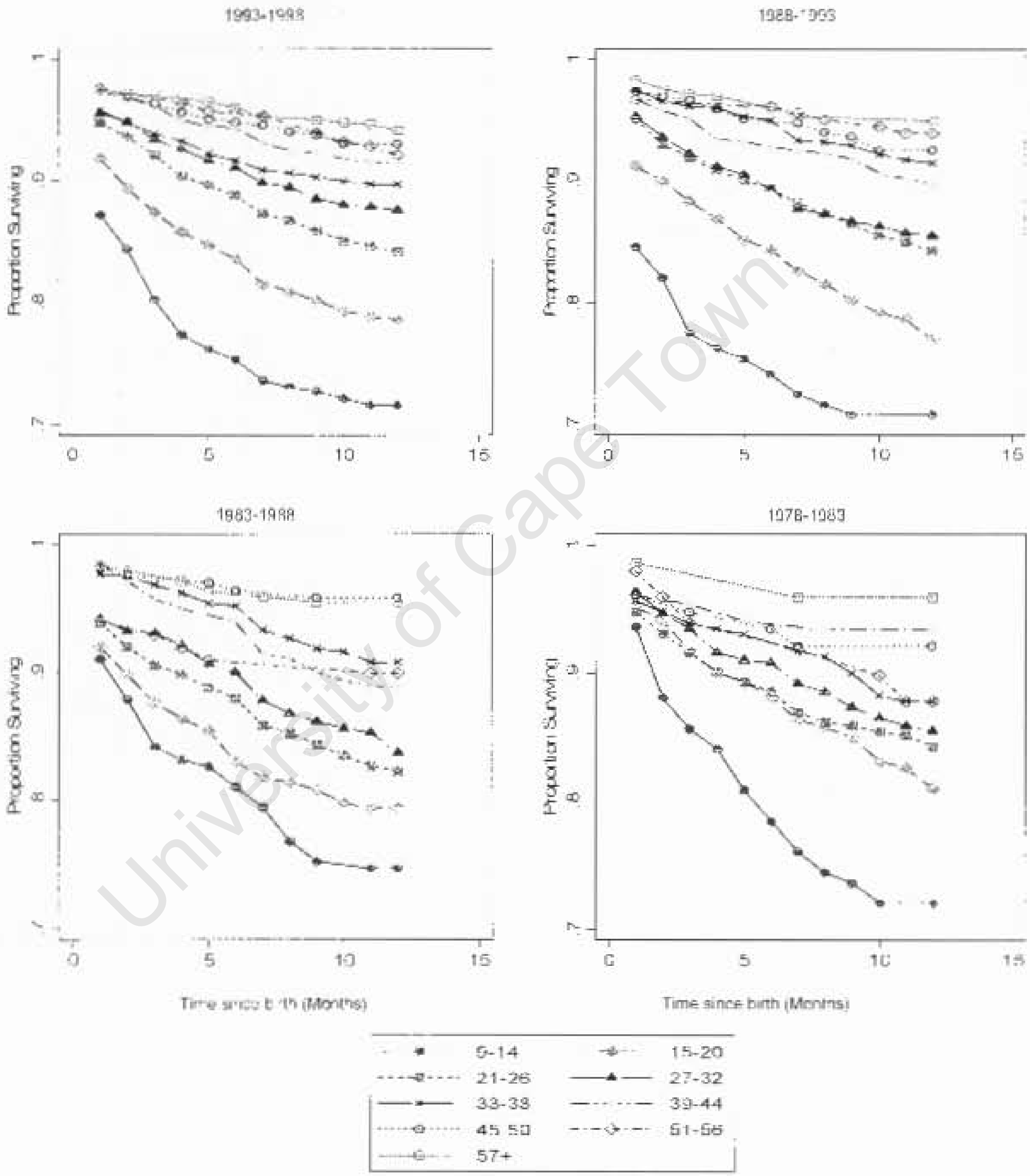


Figure 5.9 Life table survival curves for child mortality for 6 month categories of the length of the preceding birth interval, 1997 DHS.

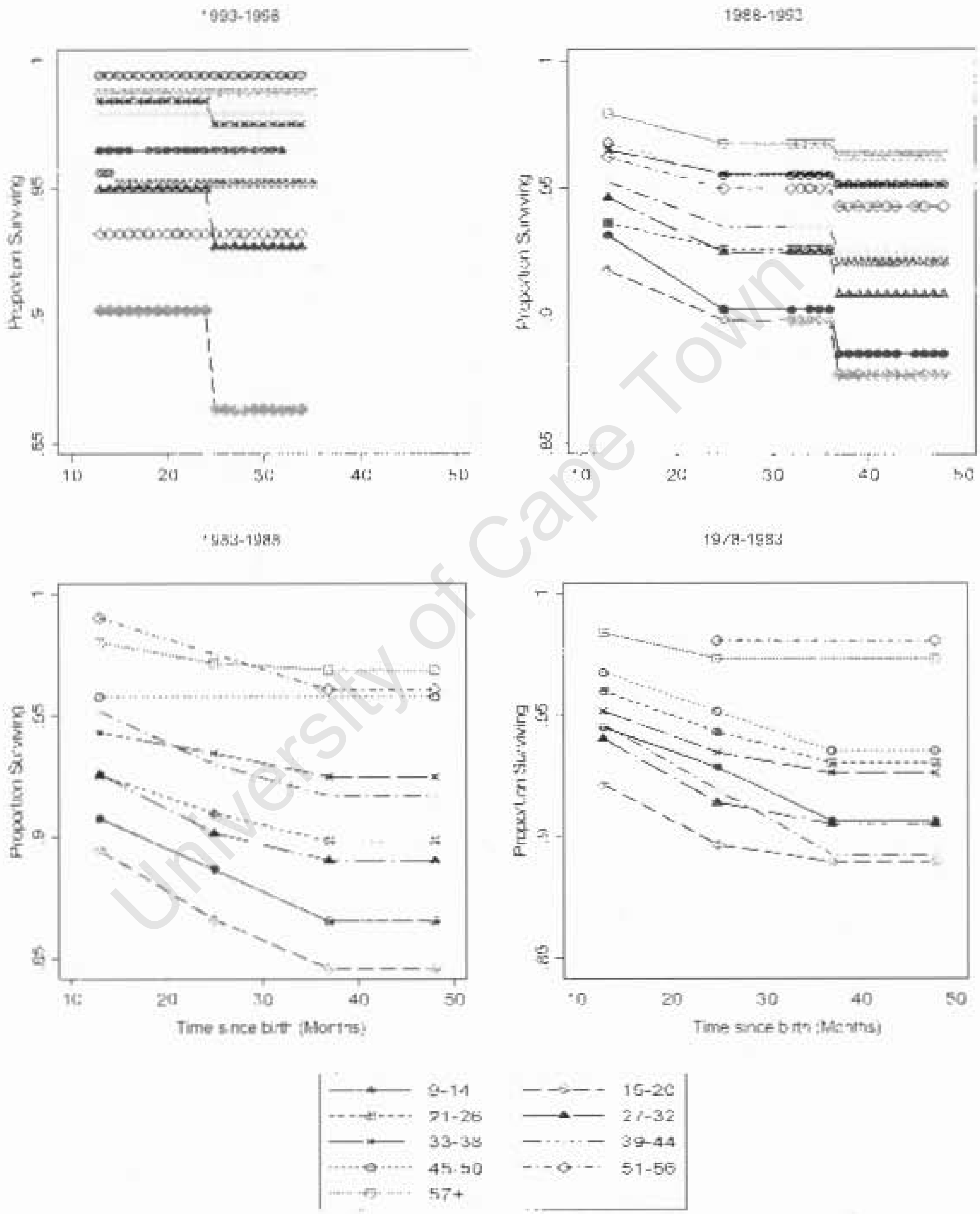


Figure 5.10 Life table survival curves for child mortality for 6 month categories of the length of the preceding birth interval, 2003 DHS

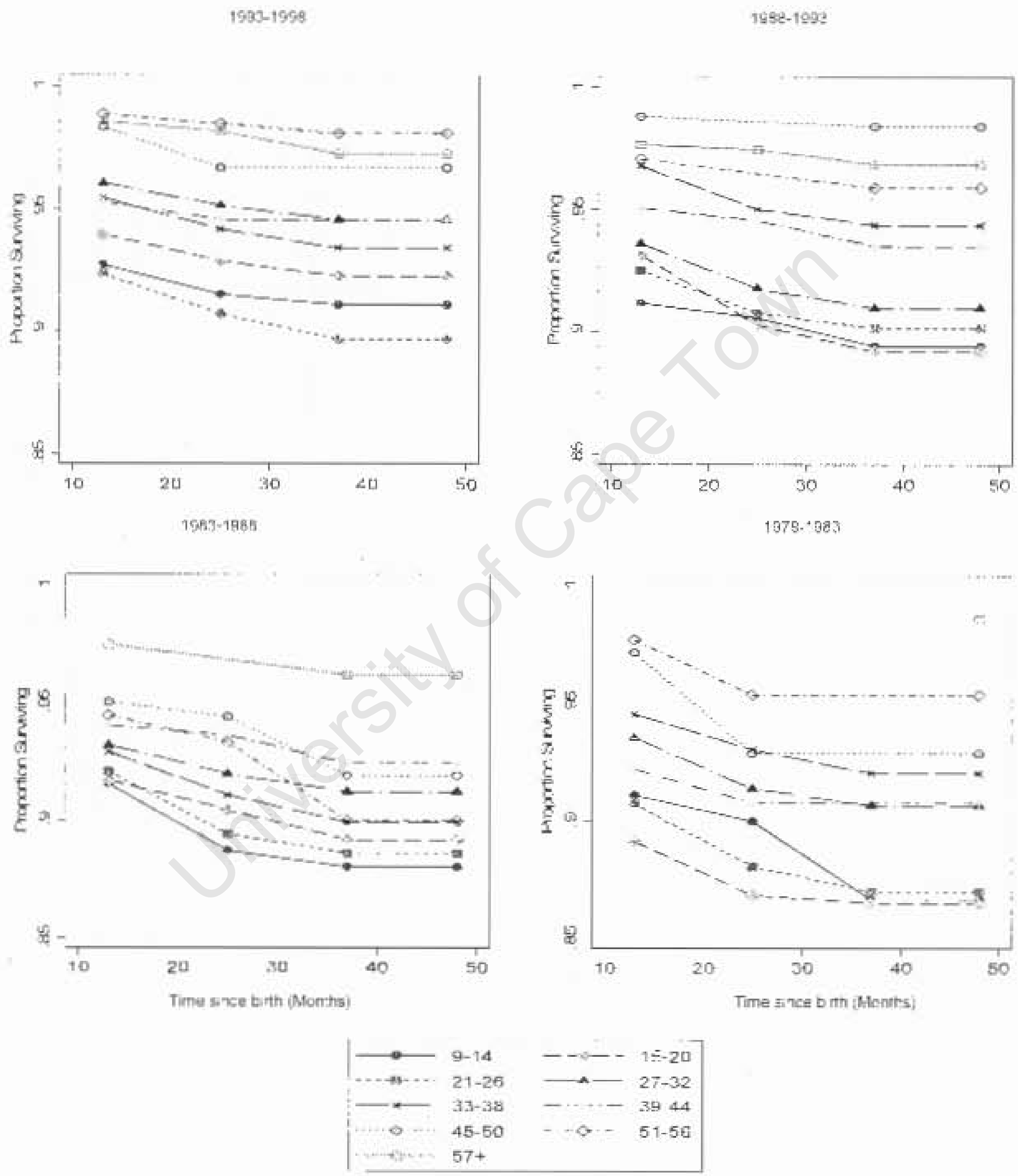


Figure 5.11 Life table survival curves for children under the age of 5 years for 6 month categories of the length of the preceding birth interval, 1997 DHS

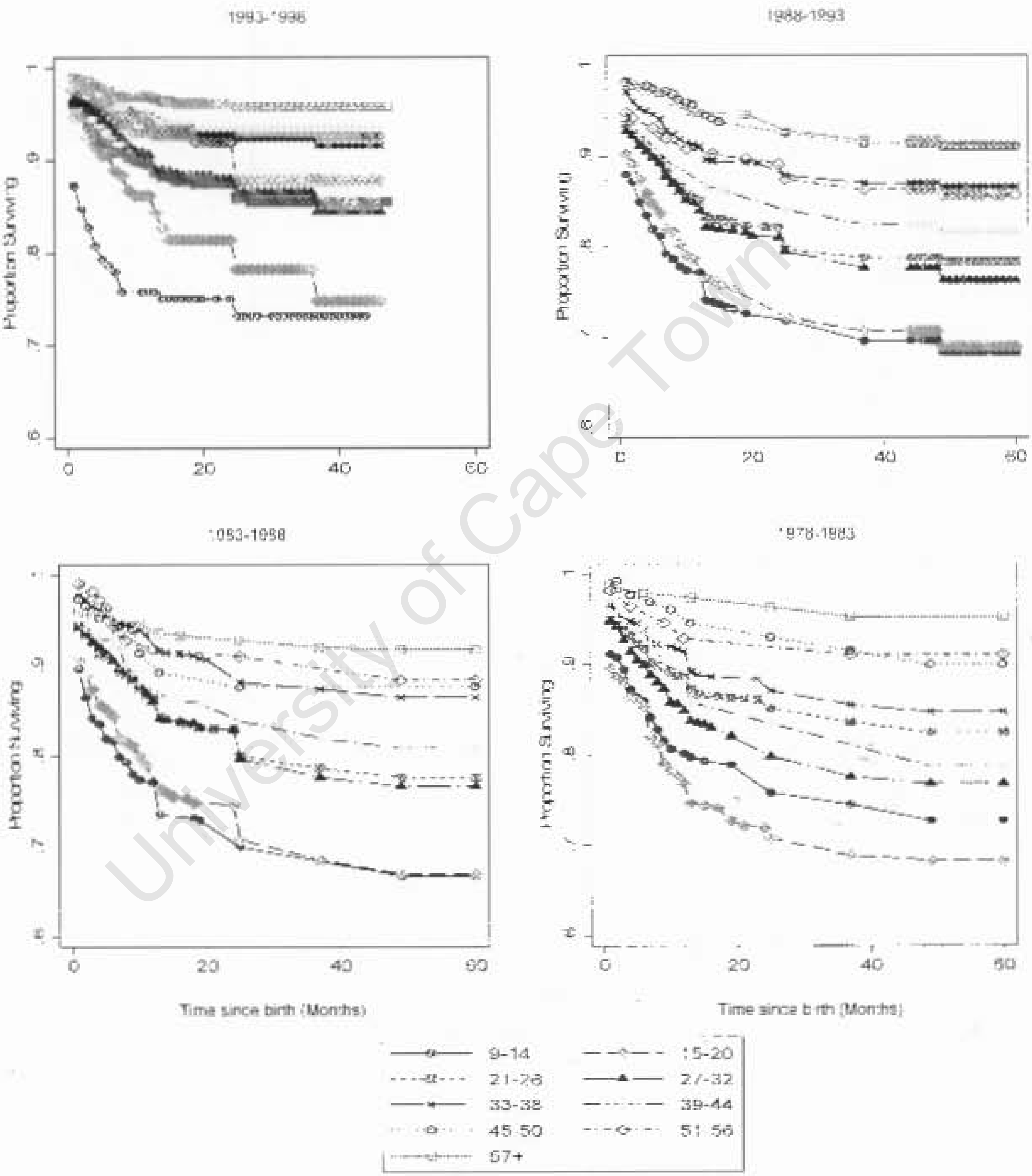
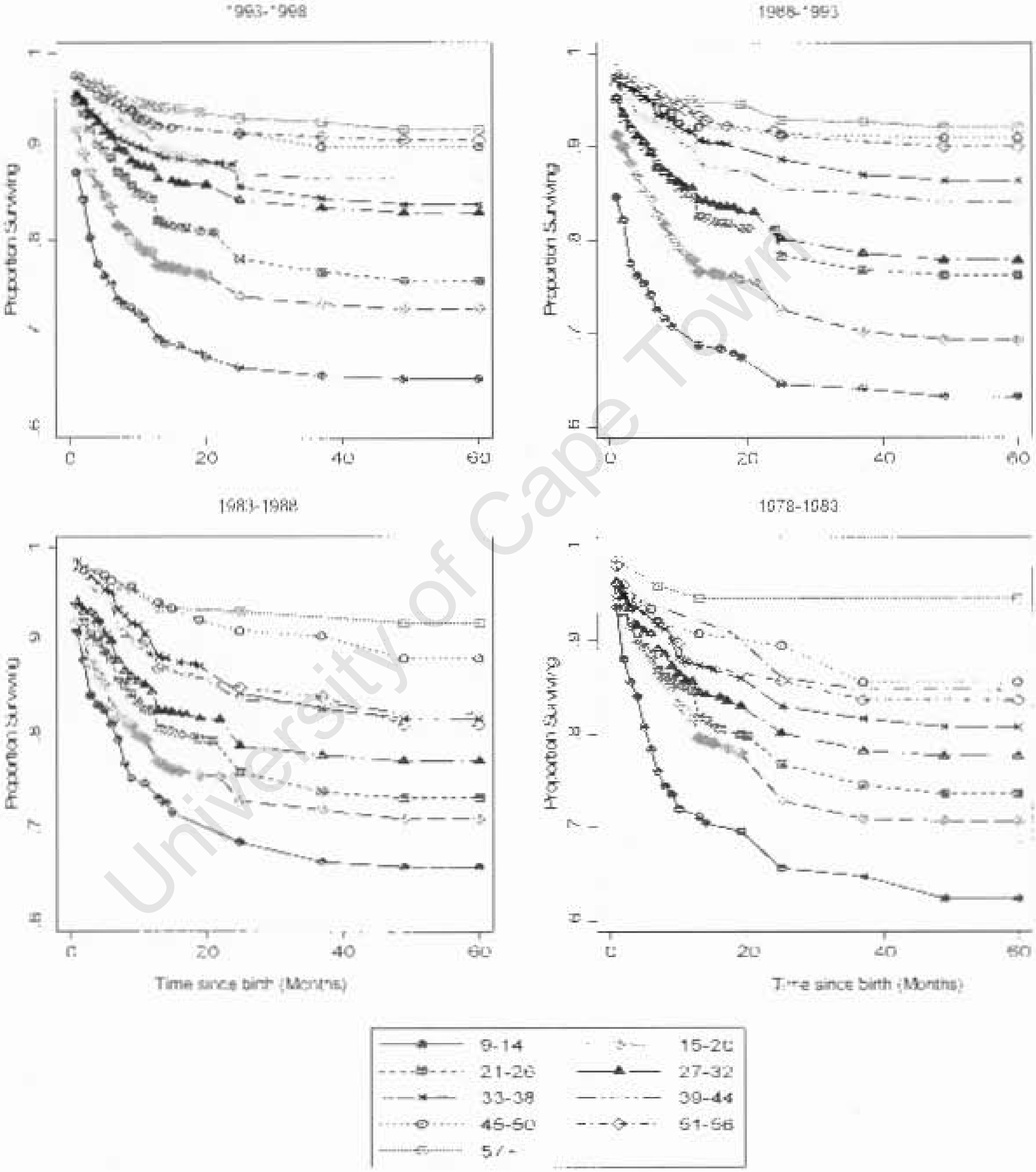


Figure 5.12 Life table survival curves for children under the age of 5 years for 6 month categories of the length of the preceding birth interval, 2003 DHS



Interpretation of the description of survival curves

Children born following a short preceding birth interval of 9 to 14 months exhibited the worst survival during the birth periods 1988 to 1993 and 1993 to 1998 for neonatal, postneonatal and infant mortality. It is possible that effects of the civil war which intensified in the late 1980s (Baden 1997), resulted in the devastation of health care access and delivery and shortages of basic survival commodities (UNICEF 1989), which in turn worsened survival chances of children already at risk from intrauterine mechanisms of short preceding birth intervals. However another hypothesis especially for the period 1993 to 1998 is that of reduced competing risks of mortality previously masking the effects of a short preceding birth interval during the civil war years.

The comparison of survival curves for overlapping periods in the 1997 and 2003 DHS indicated differences in the proportion of children surviving at the various ages at death. Whilst the different surveys have different survey designs, the application of sample weights makes the data representative at national level and thus comparable. Some of the differences in the proportion of children surviving may be influenced by data quality differentials. The differences observed may pose a methodological limitation to the extent of their statistical significance. However the observed differences do not appear to be markedly different and the data can be aggregated with a reasonable assumption of similarity in overlapping periods.

The covariates included in the modelling of child mortality with the length of the preceding birth interval are presented in the following section.

5.3 Covariates

Covariates of child mortality were outlined in the Mosley and Chen (1984) framework of proximate and socio-economic determinants of child mortality in developing countries (Chapter 2). The inclusion of variables in the model is subject to their availability in the 1997 and 2003 DHS data. Furthermore, variables with less chances of being affected by the problem of current status data will be modelled. Variables with current status data reflect the prevailing situation at the DHS survey date, and not the situation that prevailed at the time of birth of the index child (which is of interest). For instance the inclusion of rural/urban place of residence is highly compromised stemming from rural to urban migration during the civil war during which an estimated three quarters of the rural population was displaced internally and internationally (Baden 1997). The bias from current status data increases as the date of birth of the index child moves further back in time. Thus variables that can be reasonably assumed to have remained constant between the time of birth of the index child and the survey date are modelled.

Although not discussed in the Mosley and Chen framework of child mortality determinants, the survival status of the immediately preceding child was also included as a covariate of child mortality. The survival status of the immediately preceding child is modelled to capture intra-familial mortality risks, which is a risk factor for the index child. Two covariates of intra-familial risk were modelled: survival status of the previous child by age 5 and the survival status of the previous child at conception of the index child. Zenger (1993) showed that neonatal deaths among immediate siblings had a stronger association relative to siblings further apart, indicating similarity in conditions experienced by immediate siblings relative to siblings further apart.

For the survival status of the previous child at conception of the index child, the death of an immediately prior child shortens postpartum infecundity induced by breastfeeding (assuming the prior child was being breastfed) and in the absence of contraceptive use, increases chances of an early conception which results in a short preceding birth interval for the index child (Winikoff 1983, Rutstein 2005). Furthermore, the replacement of a dead prior child can also result in a short preceding birth interval for the index child (Winikoff 1983).

A total of thirteen covariates where initially contemplated for the model (excluding the preceding birth interval variable). The thirteen covariates were composed of seven biological covariates (sex of the index child, sex of previous child, length of the subsequent conception interval, survival status of the previous child by age 5, survival status of the previous child at index child's, mother's age at birth and birth order) and six socio-economic covariates (mother's education attainment, father's education attainment, region of residence, mother's religion, mother's linguistic group and the mother's childhood place of residence).

Pairwise correlation coefficients of model covariates were computed and analyzed to avoid multi-collinearity among model variables. As expected the intra-familial covariates: survival status of previous child at index child's conception and survival status of previous child by age 5 were strongly correlated (correlation coefficient of 0.8303) (Table 5.3). The survival status of the previous child by age 5 was more strongly correlated with the response variable (deaths) compared to the survival status of the previous child at conception of the index child and was kept in the model.

The birth order variable was strongly correlated with the mother's age at birth variable with a correlation coefficient of 0.646 (Table 5.3). The mother's age at birth was more strongly correlated with the response variable relative to the birth order variable and was kept in the model. The mother's education was also correlated with the father's education (correlation coefficient of 0.441). According to Mosley and Chen (1984) both variables have an effect on child survival, however the effect of a father's education, "...is likely to be most significant for child survival when more educated fathers are married to less educated mothers" (Mosley and Chen 1984: 34). Father's education is thus modelled relative to the mother's education [father's education attainment minus mother's education attainment] to establish its effect over the mother's education using three categories: (1) father's education attainment less than the mother's education attainment (2) father's education attainment equal to the mother's education attainment (3) father's education attainment higher than the mother's education attainment (Table 5.4).

Thus eleven of the thirteen initially contemplated variables were modelled. A summary of model covariates with respective categories and frequency distributions for the period 1978 to 1998 for the 1997 and 2003 DHS is presented in Table 5.4.

The length of the subsequent conception interval variable was computed by assuming a 9 month gestation period. Since child mortality is analyzed to age 5, a subsequent conception five years after the birth of an index child and not having a subsequent conception was considered to have similar effects for purposes of this analysis and grouped into a single category. In order to capture effects of a subsequent conception on breastfeeding the categories were divided into a subsequent conception in the first year, second year and between the third and fifth year (Table 5.4).

The mother's age at birth variable was grouped into four categories (10 to 19 years, 20 to 24 years, 25 to 29 years and 30 to 49 years) to ensure roughly distributed categories and also avoid sparsely distributed categories. The same reasoning was also applied in the education attainment categories by combining secondary education and higher since the proportion of parents with tertiary education is low in Mozambique.

Table 5.3 Pairwise correlation coefficients of model covariates

	Deaths	PBI	Age at birth	Birth order	Subsequent conception	Survival of previous birth to age 5	Sex of previous child	Survival of previous birth at index conception	Sex of index child	Region	Religion	Father's education	Mother's education	Linguistic group	Mother's childhood place of residence
Deaths	1														
PBI	-0.090	1													
Age at birth	-0.042	0.232	1												
Birth order	0.005	-0.008	**0.646**	1											
Subsequent conception	-0.026	-0.088	-0.121	-0.099	1										
Survival of previous birth to age 5	-0.127	0.193	0.114	0.001	-0.005	1									
Sex of previous child	-0.003	0.013	0.010	0.012	0.002	0.029	1								
Survival of previous birth at index conception	-0.114	0.097	0.090	0.001	0.013	**0.830**	0.024	1							
Sex of index child	-0.013	-0.003	0.000	0.003	-0.003	0.001	0.017	0.003	1						
Region	-0.092	0.100	0.069	-0.045	-0.009	0.104	0.000	0.098	0.000	1					
Religion	-0.040	0.037	0.002	-0.022	0.021	0.033	0.003	0.028	0.003	0.270	1				
Father's education	-0.049	0.044	-0.064	-0.096	0.003	0.076	-0.002	0.064	0.001	0.166	0.103	1			
Mother's education	-0.044	0.049	-0.075	-0.124	-0.022	0.060	-0.007	0.051	0.000	0.137	0.101	**0.441**	1		
Linguistic group	-0.011	-0.012	-0.012	-0.040	-0.020	0.030	-0.007	0.028	-0.003	0.002	-0.005	0.037	0.014	1	
Mother's childhood place of residence	0.054	-0.043	0.042	0.059	0.022	-0.081	-0.002	-0.074	-0.007	-0.190	-0.107	-0.286	-0.283	0.025	1

PBI =Categories of the length of the preceding birth interval

Table 5.4 Descriptive statistics for the period 1978 to 1998 of covariates of child mortality to be modelled, 1997 and 2003 DHS

Variable	Categories	1997 DHS		2003 DHS	
		%	n	%	n
Sex of index child	Male®	52.4	1604	51.5	1933
	Female	47.7	1460	48.5	1819
Sex of previous child	Male®	50.8	1557	51.4	1927
	Female	49.2	1508	48.6	1825
Length of the subsequent conception interval	No subsequent conception or subsequent conception in the period 60 months and longer	21.4	656	10.6	396
	Subsequent conception in the period 0-12 months	32.0	981	33.5	1258
	Subsequent conception in the period 13-24 months®	28.6	875	36.8	1379
	Subsequent conception in the period 25-59 months	18.0	553	19.2	718
Survival status of the previous child	Previous birth dead by age 5	42.6	1293	42.6	1576
	Previous birth alive at age 5®	57.4	1743	57.4	2126
Mother's age at birth	10-19 years	17.6	539	22.0	825
	20-24 years®	33.8	1036	33.5	1257
	25-29 years	21.7	665	24.5	920
	30-49 years	26.9	826	20.0	751
Mother's education attainment	No education®	55.1	1690	59.2	2219
	Primary education	44.1	1353	39.9	1498
	Secondary or higher	0.7	22	0.9	35
Father's relative education attainment	Less than mother's education	8.7	203	7.1	251
	Equal to mother's education®	59.6	1394	59.1	2087
	Higher than mother's education	31.7	741	33.8	1196
Region of residence	North	40.6	1240	47.2	1771
	Centre®	40.1	1224	38.1	1431
	South	19.4	592	14.7	551
Mother's religion	No religion	22.7	691	17.0	637
	Catholic®	31.6	964	30.3	1136
	Muslim	20.9	636	24.0	899
	Zionist	6.5	197	6.1	227
	Protestant/Evangelic	10.8	329	22.5	845
	Other religion	7.5	229	0.2	7
Mother's linguistic group	Xitsonga and similar	12.6	375	8.1	302
	Emakua and similar	41.2	1228	45.7	1715
	Cisena and similar®	28.0	835	27.6	1036
	Elomwe and Emarenjo	8.4	249	6.3	236
	Xitswa and similar	6.5	194	6.9	260
	Portuguese	0.7	20	0.7	27
	Other	2.7	82	4.7	174
Mother's childhood place of residence	City	8.0	243	7.4	278
	Town	4.8	148	6.8	255
	Countryside®	87.2	2668	85.75	3206

®=Reference group

Categories used in the 2003 DHS for the mother's religion were applied to the 1997 DHS and the 1997 DHS categories for the mother's linguistic group were applied to the 2003 DHS to have equal categories (Table 5.4). The discussion of the covariates follows the order in which the covariates are presented in Table 5.4.

The proportion of male index children born in the period 1978 to 1998 is slightly higher than female index children (51% male vs. 49% female). The 1997 and 2003 DHS have identical proportions of the sex of the index child and the sex of the previous child.

The majority of subsequent conceptions occurred within two years of a prior birth (60.6% in the 1997 DHS and 70.3% in the 2003 DHS) in roughly identical proportions in the first and second year. The category of no subsequent conceptions or a subsequent conception after 60 months or longer has different per cent distributions for the 1997 DHS (21.4%) and 2003 DHS (10.6%). The other difference is observed in the category of a subsequent interval 13 to 24 months 28.6 per cent in the 1997 DHS and 36.8 per cent in the 2003 DHS over the same period (Table 5.4).

Just over four in ten women (42.6%) for both the 1997 and 2003 DHS reported that a previous child had died over the period. On average a fifth of the women interviewed for the 1997 and 2003 DHS gave birth in their teenage years. The 2003 DHS has a slightly higher proportion of teenage mothers (22%) compared to the 1997 DHS (17.6%). The 1997 DHS shows a higher proportion of mothers giving birth in the older age group 30 to 49 years (26.9%) compared to the 2003 DHS (20%) (Table 5.4).

Women in Mozambique are characterised by low education attainment, with over half of women (55% in the 1997 DHS and 59% in the 2003 DHS) reporting no education attainment. Less than one per cent of women attained secondary education or higher. The majority of fathers have equal education attainment when compared to mother's education attainment (59%), with just over thirty per cent of fathers having higher education attainment relative to the mother' education for both the 1997 and 2003 DHS (Table 5.4).

A large part of the women interviewed in the 2003 DHS are resident in the North of the country (47.2%), whereas for the 1997 DHS very similar proportions of women resident in the North and Centre were interviewed (roughly 40%). The 1997 DHS has a slightly larger per cent of women from the South of Mozambique (19.4% vs. 14.7% in the 2003 DHS).

Women in Mozambique have remained predominantly Catholic, although the percentage of women reporting to be affiliated with Protestant or Evangelic religious denominations increased from 10.8 per cent in 1997 to 22.5 per cent in 2003. The per cent of women professing Other religious affiliations decreased noticeably from between 1997 and 2003 from 7.5 per cent to 0.2 per cent in 2003. Just over a fifth of women are Muslim (Table 5.4).

The distribution of women by linguistic groups is roughly similar between the 1997 and 2003 DHS showing a much higher proportion of women in the Emakua and similar linguistic group. The observed per cent distributions are influenced by the reported regions. Linguistic groups from the North (Emakua and similar and Elomwe and Emarenjo) have higher distributions of 49.6 per cent in the 1997 DHS and 52 per cent in the 2003 DHS. Cisena and similar from the Centre has an exact per cent distribution in 1997 and 2003 of 28 per cent. Xitsonga and similar and Xitswa and similar predominantly found in the South have the least per cent distributions of 19.1 per cent in 1997 and 15 per cent in the 2003 DHS (Table 5.4).

As expected the large part of women interviewed in both the 1997 and 2003 DHS grew up in the countryside or rural areas since the population is largely rural based. Differences in the per cent distributions are very slight (Table 5.4). The city/town distinction was maintained in the analysis in spite of the relatively small numbers since in Mozambique cities are relatively much more urbanized with more socio-economic development, access to health care and higher education compared to towns.

Socio-economic model covariates were selected based on the assumption that they are less affected by the current status problem. The assumption was tested for by comparing the per cent distributions of categories of model covariates. Differences were noted in the per cent distribution of women with no education for the mother's education attainment variable, in the per cent distribution of the region of residence, in the Protestant/Evangelic and the Other religious denomination categories for the religion variable (and also no religion), and the linguistic groups Emakua and similar and Xitsonga and similar. These differences question the validity of the assumption of not being affected by the current status problem. However no wide differences were noted in most of the covariates (with the exception of religion) implying that the assumption of variables less affected by the current status problem is still upheld.

The comparison of per cent distributions of covariate categories in the 1997 and 2003 DHS also allowed the modelling procedure of combining overlapping data from two surveys. From the minimal differences, data from the 1997 and 2003 DHS for the period 1978 to 1998 can be aggregated and analyzed with reasonable accuracy. The modelling procedure adopted is discussed in the following section.

5.4 Modelling procedure

Model fitting commenced with the null model of child mortality and preceding birth interval categories. Covariates were introduced in the model and successively nested models (where one model contains all the terms in the previous model plus an extra variable) were compared using a likelihood ratio test to determine a statistically significant improvement in model fit from the addition of the extra variable. The Akaike's Information Criterion (AIC) was used to determine statistical significance from adding an extra variable between nested models (Collett 2002). The model containing the lowest AIC was considered the best model, to be included in the subsequent likelihood ratio test of nested models (Collett 2002, Hilbe 2007). Insignificant variables were excluded from the model. The most frequently occurring category or mode of each variable in the aggregated data set, was selected as the reference category avoid the number of cases influencing the significance of model estimates.

Data were initially modelled using the Poisson regression model as the log rate model. Values of the mean and variance of the response variable (deaths) were calculated in the initial modelling phase to verify the Poisson model assumption of equi-dispersion (Table 5.5). A visual analysis of Table 5.5 indicates preliminary evidence of overdispersion as the variance is generally greater than the mean across the various ages at death and birth periods.

Table 5.5 Mean and variance of the response variable for each quinquennial birth period and age at death

	Birth period							
	1978-1983		1983-1988		1988-1993		1993-1998	
Age at death	Mean	Variance	Mean	Variance	Mean	Variance	Mean	Variance
Neonatal	0.05	0.12	0.05	0.18	0.06	0.19	0.05	0.14
Postneonatal	0.08	0.21	0.08	0.25	0.09	0.35	0.07	0.18
Infant	0.13	0.32	0.13	0.43	0.15	0.53	0.12	0.32
Child	0.04	0.08	0.04	0.12	0.05	0.20	0.02	0.03
Under 5	0.16	0.39	0.18	0.53	0.19	0.71	0.15	0.35

Three overdispersion testing parameters; the Pearson chi-square dispersion value, Lagrange multiplier and the Z test were applied to the Poisson model to determine the statistical significance of the overdispersion (Hilbe 2007). The tests were conducted for the period 1993 to 1998 (Table 5.6). A value of the Pearson chi-square dispersion statistic of greater than one indicates overdispersion. However the dispersion statistic must be interpreted with the total observations modelled. The t-probability value of the Z test and the p value of the Lagrange multiplier determine whether the null hypothesis of no overdispersion is rejected or not rejected.

The Pearson overdispersion statistic indicates the presence of overdispersion across all ages at death. The t-probability for the Z test is significant at all ages except for under five mortality. The null hypothesis of no overdispersion is not rejected, indicating the Poisson model as an appropriate model for underfive mortality. P values of the Lagrange multiplier (with one degree of freedom) are significant across all ages at death meaning that the hypothesis of no overdispersion is also rejected (Table 5.6).

Table 5.6 Overdispersion test results of the Pearson chi-square dispersion value, Lagrange multiplier and the Z test at each age at death for the period 1993 to 1998

Age at death	Pearson Dispersion	Observations	Z test score	t prob.	Lagrange Multiplier	p value
Neonatal	15.92	8895	0.73	0.00	4674.73	0.00
Postneonatal	4.55	7668	0.73	0.00	4625.67	0.00
Infant	8.96	8895	0.77	0.00	11079.14	0.00
Child	11.05	6908	0.69	0.00	3562.40	0.00
Underfive	17.71	8895	21.21	0.30	3.286e^10	0.00

Except for under five mortality, all three testing parameters concluded that the Poisson model is overdispersed across the ages at death. However as discussed in chapter 3, checks of apparent overdispersion need to be conducted to determine that the observed overdispersion is real (Hilbe 2007). Apparent overdispersion is present in the following situations: (1) if the model omits important explanatory variables (2) if the data is fraught with outliers (3) if the model fails to include a sufficient number of interaction terms (4) the apparent overdispersion may be indicative of the need to transform the predictor variable and (5) in the event that the link function is mis-specified (Hilbe 2007).

A theoretical assessment of apparent overdispersion checks found the overdispersion in the Poisson model to be real. The thorough review of literature on child mortality (chapter 2) means that it can be reasonably assumed that no important explanatory variables have been omitted. In cases where variable information is absent (for example information on breastfeeding) proxy variables were modelled and in the case of breastfeeding, the length of the subsequent conception captures most breastfeeding effects. Plots of the variables concluded that data was not fraught with outliers. Interaction terms (discussed in more detail below) were modelled and tested for significance. No variable transformations of the predictor variable were deemed appropriate (theoretical basis) and furthermore the link function is considered to not be mis-specified as other studies have modelled similar data with the same link function (Trussel and Hammerslough 1983, Lantz, Partin and Palloni 1992).

Hence based on the tests of overdispersion, and the check of apparent overdispersion, real overdispersed was found in the Poisson model and the negative binomial regression model was applied instead. Model fitting was conducted in the same steps described above of fitting the base model and successively adding a variable and testing nested models for a statistically significant improvement from adding the extra variable using the Akaike's Information Criterion (AIC).

Interactions

Once the main effects model was determined, variable interactions were tested to determine the presence of effect modifiers based on theoretical evidence. An effect modifier modifies the effect of the exposure variable on the outcome variable (Collett 2002). In this research an effect modifier modifies the effect of the length of the preceding on child mortality. A mother's education attainment and the region of residence were identified as variables potentially modifying the effect of the length of the preceding birth interval on child mortality.

More educated mothers are hypothesized to be in a better socio-economic position with better access to health care service and resources including hired child help (Setty-Venugopal and Upadhyay 2002). These factors are hypothesized to impede the pathways of short preceding birth intervals on child mortality, thus negating the hazardous effects of a short preceding birth interval.

Inter-regional differentials in health service delivery and quality is hypothesized to influence the impact of preceding birth intervals on child mortality. Well resourced regions with better health service delivery and of better quality are hypothesized to contribute to reducing the negative effects of a short preceding birth interval on child mortality (Rawlings, Rawlings and Read 1995). In Mozambique the more urbanized Southern region (Arnaldo 2003) is hypothesized to have better health service delivery compared to the Central region and the North which is the least urbanized.

Two way interactions between the mother's education or region of residence with the length of the preceding birth interval categories or between the mother's education with the region of residence were tested only if the main effects were significant. Three way interactions were also tested if two way interactions were found significant.

Model outputs showing significant variables and incidence rate ratios at each age at death and birth period are presented in the Appendix (Table A.1 to Table A.10).

Goodness-of-fit tests

The likelihood ratio chi-square test for the null hypothesis that the overdispersion parameter α is equal to zero was used as a goodness-of-fit test to verify the application of the negative binomial model. Table 5.7 shows the likelihood ratio chi-square for each model with the level of statistical significance of each test.

Table 5.7 Likelihood ratio chi-square statistics and significance level

Age at death	Birth period			
	1978-1983	1983-1988	1988-1993	1993-1998
Neonatal	527.07 ****	1021.86 ****	1328.78 ****	1423.76 ****
Postneonatal	100.46 ****	312.77 ****	636.51 ****	613.80 ****
Infant	331.11 ****	1018.06 ****	1595.85 ****	1462.45 ****
Child	59.80 ****	116.78 ****	434.50 ****	35.20 ****
Under 5	604.99 ****	1669.27 ****	2360.34 ****	2221.84 ****

*$p \leq 0.1$, **$p \leq 0.05$, ***$p \leq 0.01$, ****$p \leq 0.001$

All chi-square test statistics have a p-value significant at the 0.1% level which indicates that the overdispersion parameter α is not equal to zero hence proving that the negative binomial model is a better fit than the Poisson model (Table 5.7).

Having confirmed the negative binomial as the best suited model, predicted incidence rates were computed for each category of the length of preceding birth interval using the "predict...if e(sample)" option in STATA. The predicted rates are expected incidence rates of child mortality (at each age at death) given the length of the preceding birth interval.

Chapter 5 presented a discussion on the determination of categories for the length of the preceding birth interval and the aggregation of the 1997 and 2003 DHS. Section 5.3 presented covariates of child mortality to be included in the model with a discussion of descriptive statistics of the covariates. The final section presented the modelling procedure which led to the use of the negative binomial model over the Poisson model. The next chapter presents model results and discusses the elevated risk that a Mozambican child is faced with following a short preceding birth interval.

6 RESULTS AND DISCUSSION

This chapter presents results of the modelling of child mortality with preceding birth intervals in the form of predicted incidence rates and relative risks. Significant variables of child mortality are discussed in section 6.2 with the final section providing a discussion of model results.

6.1 Results

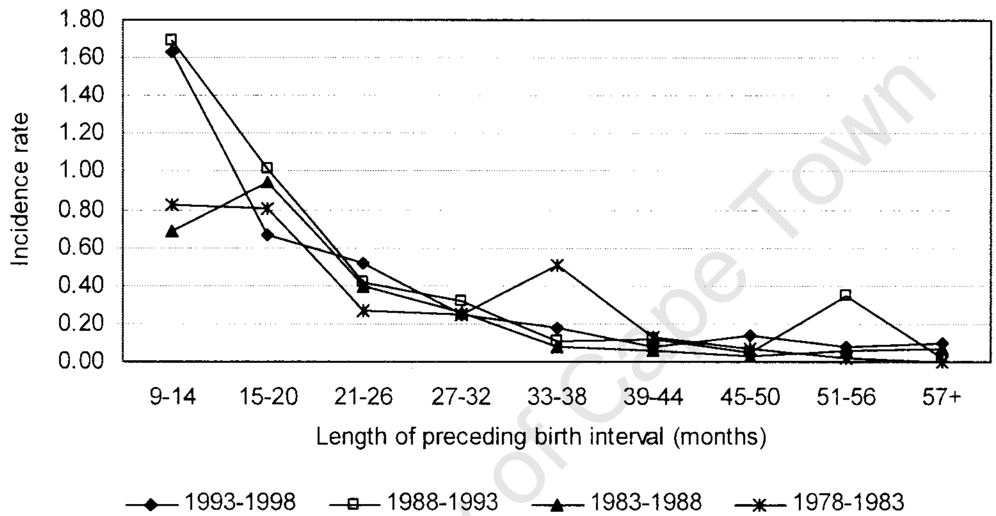
Model results are presented in the form of predicted incidence rates. Model outputs are provided in the Appendix (Table A.1 to Table A.10). Predicted incidence rates are presented for each age at death; neonatal mortality (less than 1 month), postneonatal mortality (1 to 11 months), infant mortality (0 to 11 months), child mortality (12 to 59 months) and under five mortality (0 to 59 months).

Neonatal mortality (less than 1 month)

The trend in predicted incidence rates of neonatal mortality indicates two general patterns (Figure 6.1). The two most recent birth periods 1988 to 1993 and 1993 to 1998 display a declining trend in predicted incidence rate of neonatal mortality as the length of the preceding birth interval increases, with slight fluctuations for longer preceding birth interval categories. The two furtherest birth periods, 1978 to 1983 and 1983 to 1988 display a trend that initially increases (1983 to 1988) or stays constant (1978 to 1983) from the shortest preceding birth interval category of 9 to 14 months to the subsequent period of length 15 to 20 months (Figure 6.1). A generally declining trend is noted thereafter with slight fluctuations for categories of longer intervals in the trend for the period 1978 to 1983 (Figure 6.1). The observed fluctuations result from scanty data for categories of longer preceding birth intervals.

The observed pattern for the periods 1978 to 1988 is most likely a result of competing environmental risks of neonatal mortality from the civil war which masked the hazardous influence of short preceding birth intervals on child mortality. Similar masking of the influence of short preceding birth intervals was suggested in Bangladesh for postneonatal mortality as a result of a famine (Koenig, Phillips, Campbell *et al* 1990). The higher incidence rates of neonatal mortality associated with the shortest preceding birth interval category (9 to 14 months), corresponding to the periods capturing the end of the civil war (1988 to 1993) and the post war era (1993 to 1998) is most likely due to the absence of major competing environmental risks.

Figure 6.1 Predicted incidence rates for neonatal mortality for each length of preceding birth interval category and quinquennial birth period

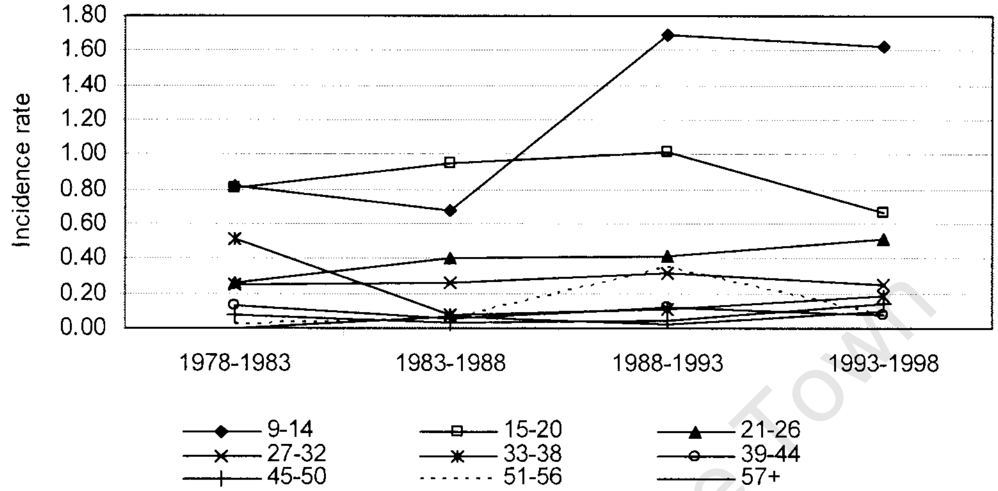


In the absence of masking effects attributable to the civil war, a short preceding birth interval of 9 to 14 months amplifies the incidence rate of neonatal mortality almost two and a half times (for the period 1993 to 1998) and just over one and a half times (for the period 1988 to 1993) compared to the subsequent preceding birth interval category of 15 to 20 months.

A visual inspection of the plot of predicted rates shows that rates level off in the preceding birth interval category of 39 to 44 months (Figure 6.1). This levelling off (ignoring fluctuations for categories of longer intervals resulting from scanty data), suggests an optimal birth spacing period for neonatal mortality of approximately 42 months or three and a half years. The optimal birth spacing interval corresponds to the last interval at which the per cent change in predicted incidence of neonatal mortality drastically reduces; the point at which there is minimal or no gain from additional spacing.

The relative risk of neonatal mortality was computed for each birth period assuming that children born following a preceding birth interval less than the suggested optimal birth spacing period of 42 months are exposed to short birth spacing (Table 6.1).

Figure 6.2 Trend in predicted incidence rates for neonatal mortality for each length of preceding birth interval category over time



The estimated optimal spacing period is used to calculate the relative risk of neonatal mortality. The relative risk was computed as the ratio of the predicted incidence rate for each preceding birth interval length category to the predicted incidence of the category 39 to 44 months (Collett 2002). A relative risk of greater than one indicates that the predicted incidence of neonatal mortality for that category is higher than the predicted incidence of children born following the estimated optimal birth period (category 39 to 44 months), whilst a value of less than one indicates that the category has lower incidence than the optimal period (Table 6.1).

Table 6.1 Relative risk of neonatal mortality for each length of preceding birth interval category (in months) and quinquennial birth period

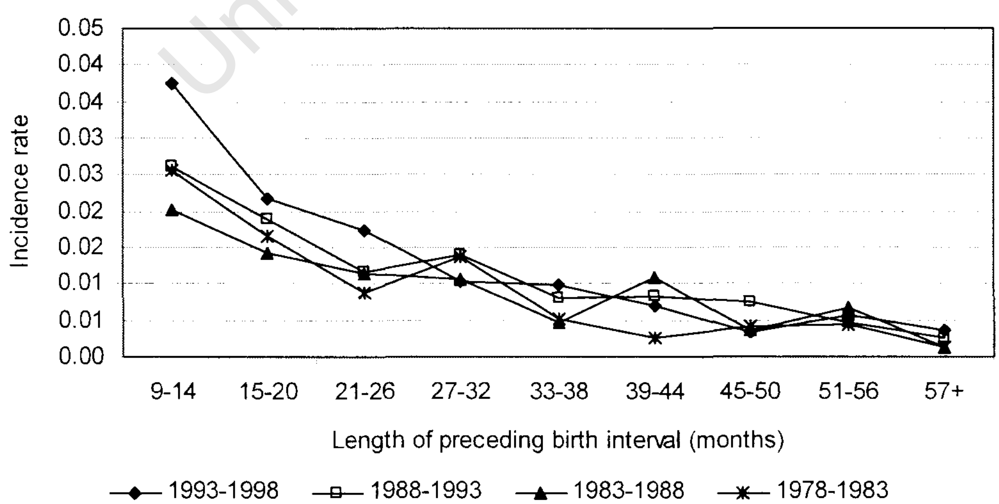
Length of preceding birth interval	Birth periods			
	1978-1983	1983-1988	1988-1993	1993-1998
9-14	6.51	12.20	13.68	20.44
15-20	6.40	16.90	8.25	8.39
21-26	2.11	7.15	3.40	6.49
27-32	1.95	4.60	2.54	3.18
33-38	4.02	1.45	0.85	2.28
39-44	1.00	1.00	1.00	1.00
45-50	0.59	0.55	0.39	1.74
51-56	0.19	1.05	2.81	1.02
57+	0.01	1.17	0.15	1.30

Children born during 1993 and 1998 with a preceding birth interval of between 9 to 14 months have a relative risk of neonatal mortality twenty fold that of children born following an optimal spacing of between 39 to 44 months (Table 6.1). Except for the period 1983 to 1988, the relative risk of neonatal mortality for the category containing the shortest preceding birth intervals is the highest with risk declining up to the optimal spacing period. Civil war effects which intensified during the period 1983 to 1988 most likely explain the fluctuation in relative risk for the 9 to 14 months category with the category 15 to 20 months exhibiting higher risk compared to the shortest category of 9 to 14 months.

Postneonatal mortality (1 to 11 months)

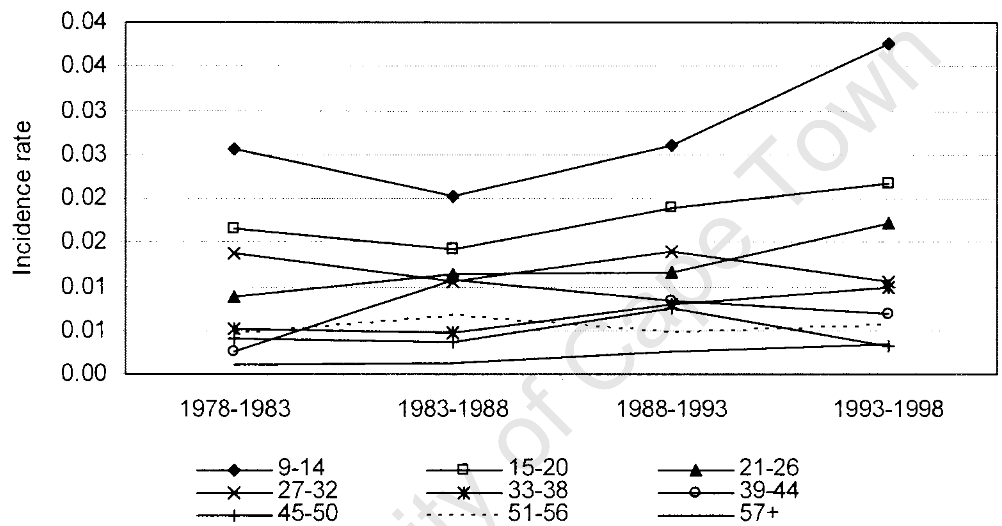
A generally declining trend in incidence rates of postneonatal mortality can be noted as the length of the preceding birth interval increases, although less concave compared to the trend in neonatal mortality incidence rates (Figure 6.3). The trend in postneonatal incidence rates is however highly erratic for preceding birth interval categories of 27 months and longer, making it difficult to establish an optimal birth spacing period for postneonatal mortality (Figure 6.3). Relative risks were not calculated since no optimal birth spacing category was established for postneonatal mortality.

Figure 6.3 Predicted incidence rates for postneonatal mortality for each length of preceding birth interval category and quinquennial birth period



Periodic predicted incidence rates for shorter categories (9 to 14 months and 15 to 20 months) increase with time, most probably from reduced competing environmental risks during the period when the civil war ended (1988 to 1993) and the post war period (1993 to 1998) (Figure 6.4).

Figure 6.4 Relative risk of postneonatal mortality for each length of preceding birth interval category over time

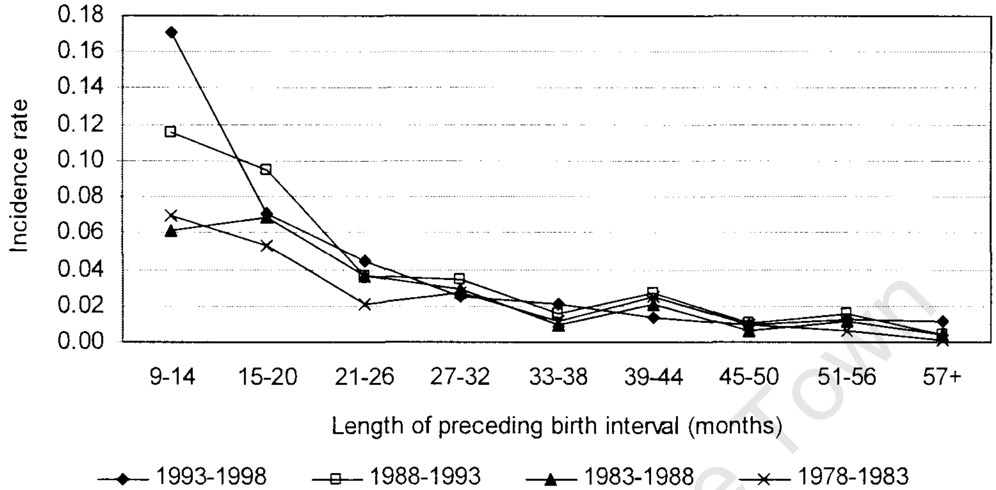


Infant mortality (0 to 11 months)

With the exception of the birth period 1983 to 1988, predicted incidence rates of infant mortality decline as the length of the preceding birth interval increases (Figure 6.5). Incidence rates for the period 1983 to 1988 increase from the shortest category of 9 to 14 months to the subsequent category of 15 to 20 months, most likely due to intensified civil war action during that period (Baden 1997).

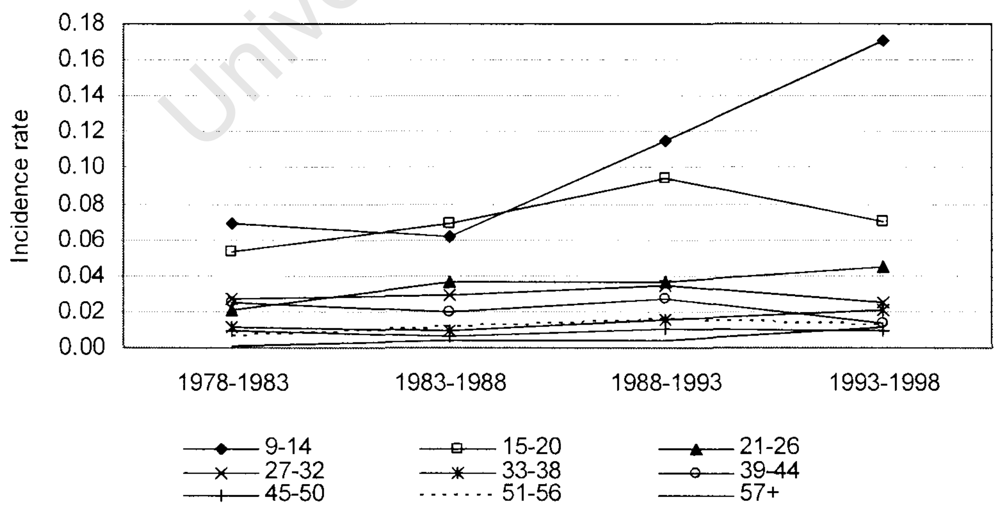
Incidence rates appear to level off in the category 33 to 38 months, although fluctuating in subsequent categories (Figure 6.5). It is important to bear in mind that this optimal spacing does not correspond to the category with the lowest incidence rates, but to the category at which the per cent decline in incidence rates is significantly reduced. The category of preceding birth intervals 33 to 38 months in length coincides to a mid point of approximately 36 months. Thus an optimal birth spacing period of 36 months is implied for infant mortality in Mozambique.

Figure 6.5 Predicted incidence rates for infant mortality for each length of preceding birth interval category and quinquennial birth period



The trend in incidence rates for the shortest preceding birth interval category of 9 to 14 months increase sharply from the period 1983 to 1988 to the period 1993 to 1998. Once again the rationale of reduced environmental mortality risks from the civil war explains the trend (Figure 6.6).

Figure 6.6 Trend in predicted incidence rates for infant mortality for each length of preceding birth interval category over time



Assuming an optimal spacing of 36 months, the predicted incidence rate for the category 9 to 14 months is just over ten times the incidence rate of the category 33 to 38 months during the period 1993 to 1998 (Table 6.2). Preceding birth intervals 15 to 20 months in length also exhibit markedly higher incidence rates compared to the estimated optimal spacing period except for the latest period 1993 to 1998 which has a relative risk of 3.84 (Table 6.2).

Table 6.2 Relative risk of infant mortality for each length of preceding birth interval category (in months) and quinquennial birth period

Length of preceding birth interval	Birth periods			
	1978-1983	1983-1988	1988-1993	1993-1998
9-14	7.57	7.07	9.29	10.02
15-20	6.35	8.03	7.46	3.84
21-26	2.09	3.99	2.81	2.53
27-32	2.71	3.22	2.37	1.24
33-38	1.00	1.00	1.00	1.00
39-44	3.04	2.22	1.64	0.78
45-50	3.59	0.78	0.65	0.47
51-56	0.46	1.12	0.92	0.50
57+	0.14	0.50	0.26	0.48

Child mortality (12 to 59 months)

A highly fluctuating trend of predicted incidence rates is shown for child mortality (Figure 6.7). The preceding birth interval category of 15 to 20 months exhibits higher predicted incidence rates compared to the shortest category of 9 to 14 months in the last two birth periods (Figure 6.7 and Figure 6.8). A probable explanation for the highly fluctuating trend is the scant number of deaths in the age range 12 to 59 months. Relative risks were not calculated for the highly fluctuating trend, as no optimal birth spacing category was established for child mortality.

Figure 6.7 Predicted incidence rates for child mortality for each length of preceding birth interval category and quinquennial birth period

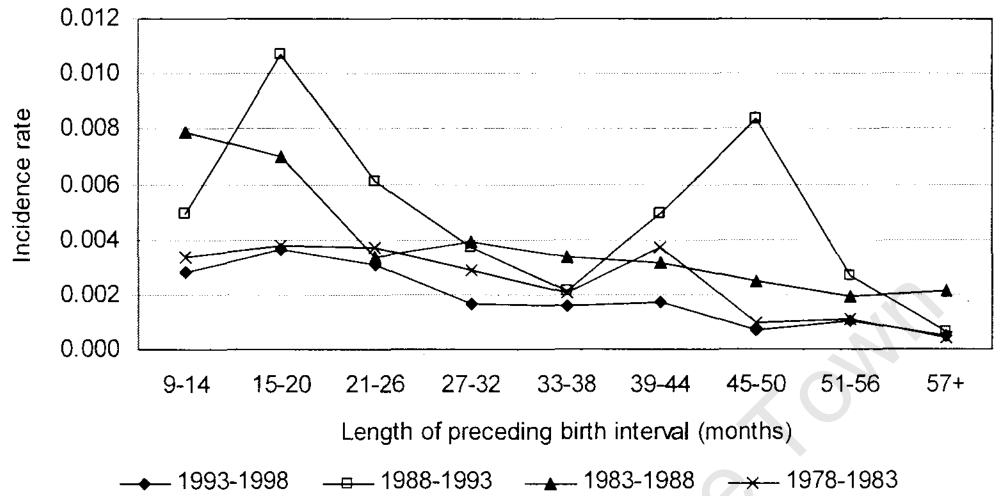
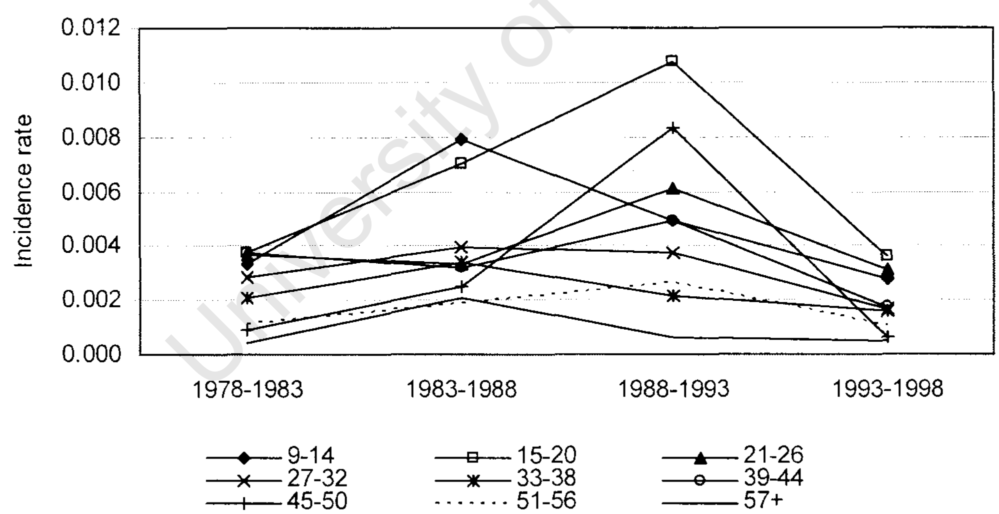


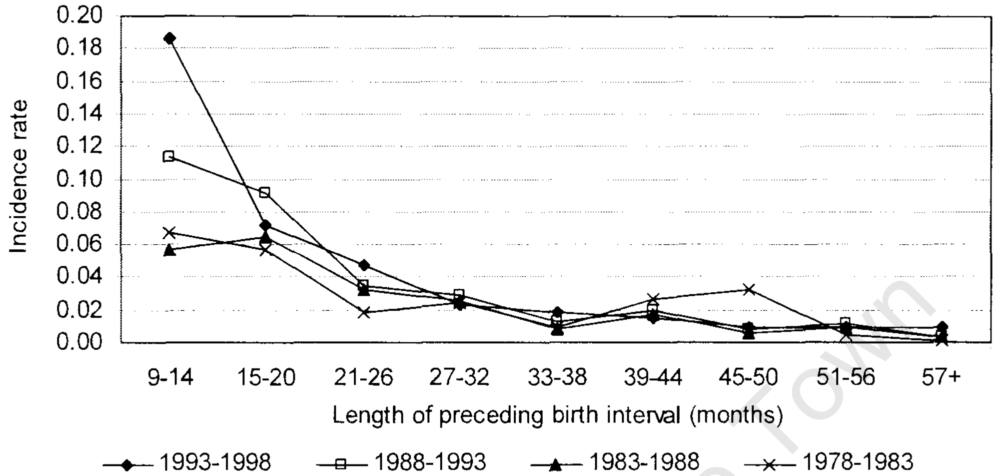
Figure 6.8 Trend in predicted incidence rates for child mortality for each length of preceding birth interval category over time



Underfive mortality (0 to 59 months)

Predicted incidence rates for mortality of children under the age of five show a generally declining trend as the length of the preceding birth interval increases (Figure 6.9). A dual pattern in incidence rates can be observed for the shorter preceding birth interval categories (similar to the trend in incidence rates of neonatal mortality).

Figure 6.9 Predicted incidence rates for underfive mortality for each length of preceding birth interval category and quinquennial birth period



Birth periods coinciding with the civil war (1978 to 1983 and 1983 to 1988) display lower incidence rates for shorter preceding birth intervals most likely a result of the civil war masking mechanisms of a short preceding birth interval (Figure 6.9). Incidence rates for the periods coinciding with the end of the civil war (1988 to 1993) and the post war era (1993 to 1998) are less affected by competing environmental risks especially the post war period.

The trend in predicted incidence rates levels off in the preceding birth interval category of 33 to 38 months (with fluctuations for longer categories particularly for the period 1978 to 1983) (Figure 6.9). This levelling off, suggests an optimal birth spacing period for mortality of children under the age of five years of approximately 36 months or 3 years.

Table 6.3 presents relative risks of underfive mortality, with an optimal birth spacing period in the category 33 to 38 months. Children born in the shortest preceding birth interval category (9 to 14 months) have an incidence rate of underfive mortality ten times the predicted incidence rate of children born following an optimal spacing interval of 33 to 38 months (Table 6.3).

Figure 6.10 Trend in predicted incidence rates for underfive mortality for each length of preceding birth interval category over time

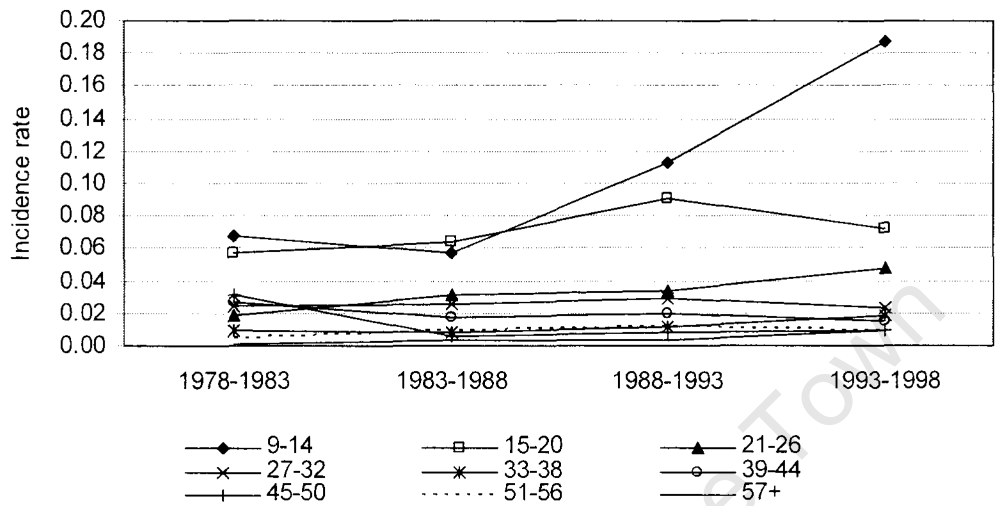


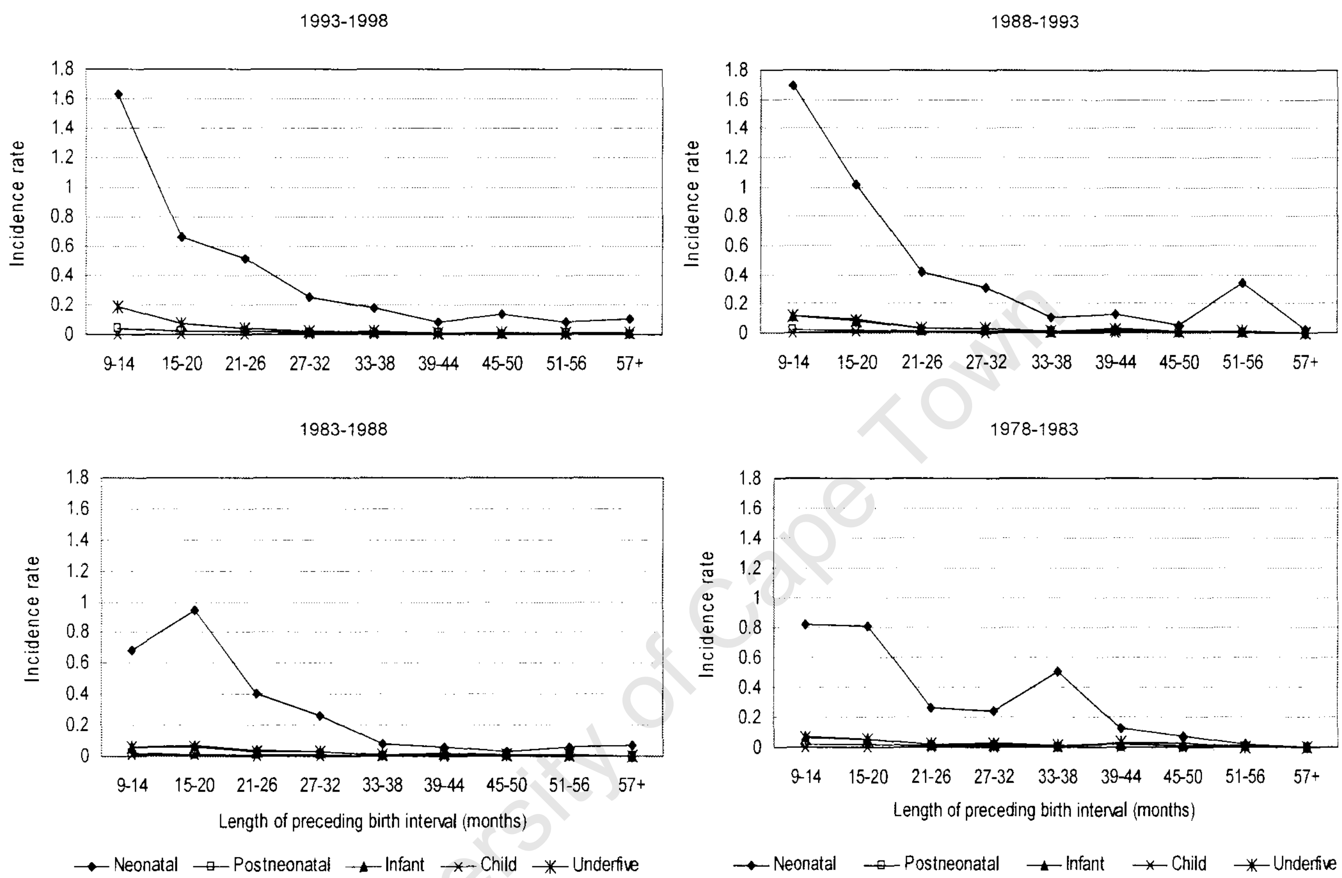
Table 6.3 Relative risk of underfive mortality for each length of preceding birth interval category (in months) and quinquennial birth period

Length of preceding birth interval	Birth periods			
	1978-1983	1983-1988	1988-1993	1993-1998
9-14	7.47	7.07	9.74	10.00
15-20	6.48	8.03	7.59	3.88
21-26	2.11	3.99	2.89	2.53
27-32	2.74	3.22	2.42	1.25
33-38	1.00	1.00	1.00	1.00
39-44	3.08	2.22	1.66	0.78
45-50	3.61	0.78	0.69	0.47
51-56	0.48	1.12	1.02	0.50
57+	0.14	0.50	0.28	0.48

Incidence rates in each quinquennial birth period

Predicted incidence rates at the various ages at death were plotted for each birth period (Figure 6.11). Incidence rates of neonatal mortality associated with categories of shorter preceding birth intervals are markedly higher compared to other ages at death for birth periods 1993 to 1998 and 1988 to 1993 (Figure 6.11). Hence the effect of short preceding birth intervals is strongest in the first month of life.

Figure 6.11 Predicted incidence rates for each birth period, across the various ages at death and preceding birth interval categories



As further evidence, incidence rates for infant mortality and underfive mortality (incorporating the first month of life) are slightly higher for categories of shorter preceding birth intervals compared to postneonatal mortality and child mortality, which do not include the hazardous first month of life. Using incidence rates for the latest period 1993 to 1998 with minimal masking effects; the magnitude of predicted incidence rates of neonatal mortality for the shortest preceding birth interval category (9 to 14 months) are ten fold and nine fold predicted incidence rates of infant mortality and underfive mortality respectively, forty-three fold predicted incidence rates for postneonatal mortality and a massive five hundred and eighty five fold predicted incidence rates for child mortality.

The masking effect of the civil war on the effects of a short preceding birth interval is illustrated in the birth periods 1978 to 1983 and 1983 to 1988, displaying much reduced predicted incidence rates of neonatal mortality for categories of shorter preceding birth intervals (less than 21 months).

6.2 Other significant factors of child mortality

Significant variables of child mortality were analyzed at each age at death and birth period. Predicted incidence rates were calculated for each category of the significant variable. The discussion of significant variables at each age at death and birth period offers insight into the variables affecting child mortality and the influence of period effects on each variable.

Neonatal mortality

Table 6.4 indicates three consistent variables of neonatal mortality over the 20 year period of study: the length of the subsequent conception interval, the survival status of the previous child by age five and the region of residence (Table 6.4). Children with a subsequent conception within the first year after birth have a significantly magnified risk of neonatal mortality across all birth periods. The death of a previous sibling by age five is a risk factor for neonatal mortality with higher predicted incidence due to intra-familial risk. Predicted incidence of neonatal mortality is higher in the North, followed by the Centre, with the Southern region predicted to have the lowest incidence of neonatal mortality except during the period 1988 to 1993 when incidence was higher in the South compared to the Centre (Table 6.4).

The mother's education attainment is significant across all birth periods except the period 1988 to 1993 which may be a result of the devastation of the civil war affecting health service delivery (at the macro level), thus affecting all mothers educated and non educated alike. Predicted incidence rates decline with increasing education attainment (expected direction) (Table 6.4).

The father's relative education is significant during the period 1988 to 1993 in which maternal education is not significant. The father's relative education models the impact of a father's education above that of the mother's, thus its significance in a period when mother's education is not significant may signify that paternal education is only important for neonatal mortality if maternal education is not significant. A child whose father has less education attainment than the mother is exposed to higher neonatal mortality with the advantage of higher relative paternal education evident from lower incidence (Table 6.4). Macassa, Ghilagaber, Bernhardt *et al* (2003a) found parental education to not be significant for neonatal mortality for births between 1987 and 1997. It is possible that modelling over a longer 10 year period diluted the significant effects of education evident in this analysis for the period 1993 to 1998.

Table 6.4 Predicted incidence rates of neonatal mortality for significant variables

Significant Variables	Categories	Birth periods			
		1978-1983	1983-1988	1988-1993	1993-1998
Sex of index child	Male	0.493	-	-	-
	Female	0.257	-	-	-
Sex of previous child	Male	0.494	-	-	-
	Female	0.250	-	-	-
Length of the subsequent conception interval	0-12 months	1.169	1.064	1.568	2.105
	13-24 months	0.214	0.205	0.241	0.188
	25-59 months	0.117	0.092	0.110	0.069
	No subsequent conception/ 60+ months	0.195	0.278	0.169	0.115
Survival status of the previous child	Previous birth dead by age 5	1.195	1.062	1.342	0.913
	Previous birth alive at age 5	0.124	0.122	0.146	0.205
Mother's age at birth	10-19 years	-	0.964	0.886	-
	20-24 years	-	0.215	0.619	-
	25-29 years	-	0.223	0.204	-
	30-49 years	-	0.214	0.196	-
Mother's education attainment	No education	0.434	0.401	-	0.529
	Primary education	0.304	0.272	-	0.211
	Secondary or higher	0.072	0.018	-	0.062
Father's relative education attainment	Less than mother's education	-	-	0.977	-
	Equal to mother's education	-	-	0.365	-
	education	-	-	0.331	-
Region of residence	North	0.863	0.794	0.882	0.723
	Centre	0.315	0.184	0.172	0.243
	South	0.102	0.128	0.240	0.125
Mother's religion	No religion	-	-	0.262	0.284
	Catholic	-	-	0.612	0.449
	Muslim	-	-	0.601	0.706
	Zionist	-	-	0.187	0.190
	Protestant/Evangelic	-	-	0.185	0.142
	Other religion	-	-	0.505	0.127
Mother's childhood place of residence	City	-	0.331	0.163	-
	Town	-	0.334	0.118	-
	Countryside	-	0.331	0.480	-

Interactions between the mother's education and the length of the preceding birth interval were significant in the latest period 1993 to 1998 indicating the influence of a mother's education in mediating effects of a short preceding birth interval.

Children born to adolescent mothers were at a higher risk of dying in the first month during the period 1983 to 1993, which corresponds to the period of civil war intensity (1983 to 1988) (Baden 1997) and aftermath of the destruction (1988 to 1993). The significance of this variable might be reflecting complications of teenage child birth not adequately attended due to the destruction of the health delivery system.

Religion is significant in the last two birth periods. Muslim women who are predominantly from Northern Mozambique and Catholic women have the highest predicted incidence rate of neonatal mortality.

Postneonatal mortality

Three variables of postneonatal mortality were significant for the entire period of study; length of the subsequent conception interval, the survival status of the previous child by age 5 and the region of residence (Table 6.5). Children with a subsequent conception within the first year after birth and those with an immediately prior sibling that died by age 5 are at an increased risk of postneonatal mortality. Children whose mothers are resident in the North are exposed to a higher risk of postneonatal mortality, followed by those resident in the Centre, whilst the South has an advantage of lower incidence (Table 6.5). Differences between the hazardous categories and other categories are however markedly reduced for postneonatal mortality compared to neonatal mortality.

Predicted incidence of postneonatal mortality of fathers whose education attainment is less than the mother's education is consistently higher than the other categories of equal/higher education attainment. The significance of a father's relative education attainment for postneonatal mortality (except for the period 1983 to 1988), not observed for neonatal mortality may reflect the importance of household resources beyond the first month of life where biological mechanisms are stronger. Small differences however exist in predicted incidence between fathers with equal or higher education relative to the mother. Contrary to Macassa, Ghilagaber, Bernhardt *et al* (2003a), mother's education was found significant in explaining postneonatal mortality over the period 1983 to 1998. Interactions of the mother's education with the length of the preceding birth interval were significant during the period 1988 to 1993.

Religion is significant in the latest two birth periods (1988 to 1998) although no marked differences are evident in incidence except for children whose mothers profess Zion and Other religions with lower incidence of postneonatal mortality.

Table 6.5 Predicted incidence rates of postneonatal mortality for significant variables

Significant Variables	Categories	Birth periods			
		1978-1983	1983-1988	1988-1993	1993-1998
Sex of index child	Male	0.012	-	0.013	-
	Female	0.009	-	0.009	-
Length of the subsequent conception interval	0-12 months	0.024	0.024	0.030	0.047
	13-24 months	0.008	0.009	0.011	0.011
	25-59 months	0.006	0.005	0.006	0.006
	No subsequent conception/ 60+ months	0.006	0.006	0.005	0.006
Survival status of the previous child	Previous birth dead by age 5	0.027	0.025	0.027	0.033
	Previous birth alive at age 5	0.006	0.006	0.007	0.007
Mother's age at birth	10-19 years	0.019	-	0.022	0.023
	20-24 years	0.009	-	0.010	0.016
	25-29 years	0.009	-	0.009	0.010
	30-49 years	0.005	-	0.011	0.008
Mother's education attainment	No education	-	0.011	0.014	0.015
	Primary education	-	0.009	0.009	0.011
	Secondary or higher	-	0.001	0.006	0.001
Father's relative education attainment	Less than mother's education	0.022	-	0.019	0.015
	Equal to mother's education	0.010	-	0.009	0.012
	education	0.009	-	0.013	0.012
Region of residence	North	0.018	0.014	0.017	0.017
	Centre	0.013	0.011	0.010	0.014
	South	0.004	0.004	0.007	0.006
Mother's religion	No religion	-	-	0.012	0.012
	Catholic	-	-	0.012	0.013
	Muslim	-	-	0.012	0.012
	Zionist	-	-	0.007	0.008
	Protestant/Evangelic	-	-	0.011	0.014
	Other religion	-	-	0.007	0.005
Mother's linguistic group	Xitsonga and similar	-	0.004	0.006	-
	Emakua and similar	-	0.014	0.017	-
	Cisena and similar	-	0.013	0.012	-
	Elomwe and Emarenjo	-	0.016	0.012	-
	Xitswa and similar	-	0.006	0.009	-
	Portuguese	-	0.000	0.002	-
	Other	-	0.006	0.005	-
Mother's childhood place of residence	City	0.003	0.005	0.003	-
	Town	0.009	0.006	0.007	-
	Countryside	0.012	0.011	0.013	-

The lower predicted incidence for children of Zionists is a paradox considering their emphasis on religious healing compared to health care service, as Agadjanian (2001:137-138) notes, "Zionist theology places great emphasis on miraculous healing and protection from evil through faith and prayer". Children whose mothers speak Portuguese as a first language have the lowest incidence rates of postneonatal mortality.

Infant mortality

The length of the subsequent conception interval, the survival status of the previous child by age 5, the mother's age at birth and region of residence were consistent significant variables of infant mortality for the study period (Table 6.6).

Table 6.6 Predicted incidence rates of infant mortality for significant variables

Significant Variables	Categories	Birth periods			
		1978-1983	1983-1988	1988-1993	1993-1998
Sex of index child	Male	0.031	-	-	0.038
	Female	0.024	-	-	0.032
Length of the subsequent conception interval	0-12 months	0.075	0.093	0.126	0.169
	13-24 months	0.019	0.023	0.030	0.028
	25-59 months	0.011	0.012	0.012	0.009
	No subsequent conception/ 60+ months	0.015	0.019	0.016	0.016
Survival status of the previous child	Previous birth dead by age 5	0.078	0.091	0.109	0.101
	Previous birth alive at age 5	0.012	0.013	0.018	0.020
Mother's age at birth	10-19 years	0.048	0.062	0.083	0.064
	20-24 years	0.022	0.028	0.040	0.042
	25-29 years	0.023	0.023	0.025	0.028
	30-49 years	0.024	0.023	0.028	0.027
Mother's education attainment	No education	0.031	0.034	-	0.048
	Primary education	0.025	0.028	-	0.027
	Secondary or higher	0.010	0.004	-	0.004
Father's relative education attainment	Less than mother's education	0.045	-	0.059	0.032
	Equal to mother's education	0.026	-	0.034	0.037
	education	0.026	-	0.038	0.033
Region of residence	North	0.052	0.059	0.067	0.066
	Centre	0.028	0.028	0.027	0.031
	South	0.010	0.012	0.021	0.011
Mother's religion	No religion	-	-	0.029	-
	Catholic	-	-	0.049	-
	Muslim	-	-	0.048	-
	Zionist	-	-	0.019	-
	Protestant/Evangelic	-	-	0.027	-
	Other religion	-	-	0.048	-
Mother's linguistic group	Xitsonga and similar	-	0.010	0.017	-
	Emakua and similar	-	0.055	0.067	-
	Cisena and similar	-	0.034	0.032	-
	Elomwe and Emarenjo	-	0.042	0.027	-
	Xitswa and similar	-	0.016	0.030	-
	Portuguese	-	0.002	0.003	-
	Other	-	0.021	0.025	-
Mother's childhood place of residence	City	0.007	-	0.016	0.017
	Town	0.020	-	0.016	0.017
	Countryside	0.032	-	0.043	0.041

Predicted incidence for children with a subsequent conception within the first year and whose sibling died by age five have higher predicted incidence for infant mortality (which incorporates the hazardous first month) when compared to postneonatal mortality.

The fact that children born to teenage mothers are exposed to higher risk of mortality in the first year of life implies that behavioural practices including inadequate prenatal and postnatal child care practices by the younger mothers are also operational in addition to biological risks (Klitsch 2003). The regional trend of predicted incidence declines from North to South (with clear differentials in incidence rates).

The mother's education and father's relative education are significant in three of the four birth periods (not matching). Similar to neonatal mortality; the mother's education is not significant in the period coinciding to the aftermath of the civil war intensity (1988 to 1993). The impact of the father's relative education is not significant in explaining infant mortality in the period of high civil war intensity (1983 to 1988), which is similar to postneonatal mortality. The trend in predicted incidence by a father's relative education does not decline as relative education increases for the latest period 1993 to 1998.

The mother's childhood place of residence is also significant in three of the four birth periods showing no differentials in predicted incidence between mothers who grew up in a city or in a town in the last two birth periods. Children whose mother grew up in the countryside are exposed to higher incidence of infant mortality.

The mother's linguistic group is significant over the period (1983 to 1993) with higher predicted incidence among the Emakua and similar group and among the Elomwe and Emarenjo population groups found in Northern Mozambique. Religion is not an important variable in determining infant mortality in Mozambique as it is only significant during the period 1988 to 1993.

Child mortality

Three variables are significant for child mortality over all birth periods: length of the subsequent conception interval, the survival status of the previous child by age 5 and region of residence. However predicted incidence rates for significant variables of child mortality show relatively minimal differentials between categories (Table 6.7).

Table 6.7 Predicted incidence rates of child mortality for significant variables

Significant Variables	Categories	Birth periods			
		1978-1983	1983-1988	1988-1993	1993-1998
Length of the subsequent conception interval	0-12 months	0.006	0.005	0.011	0.005
	13-24 months	0.003	0.005	0.005	0.002
	25-59 months	0.002	0.004	0.003	0.002
	No subsequent conception/ 60+ months	0.002	0.002	0.002	0.001
Survival status of the previous child	Previous birth dead by age 5	0.008	0.011	0.012	0.003
	Previous birth alive at age 5	0.002	0.002	0.003	0.002
Mother's age at birth	10-19 years	-	0.007	0.012	-
	20-24 years	-	0.004	0.004	-
	25-29 years	-	0.003	0.003	-
	30-49 years	-	0.003	0.004	-
Mother's education attainment	No education	-	0.004	-	0.002
	Primary education	-	0.004	-	0.002
	Secondary or higher	-	0.001	-	0.000
Father's relative education attainment	Less than mother's education	-	0.007	0.003	-
	Equal to mother's education	-	0.004	0.006	-
	education	-	0.004	0.003	-
Region of residence	North	0.003	0.004	0.009	0.002
	Centre	0.004	0.005	0.003	0.002
	South	0.002	0.003	0.003	0.002
Mother's linguistic group	Xitsonga and similar	-	-	0.003	0.002
	Emakua and similar	-	-	0.009	0.002
	Cisena and similar	-	-	0.004	0.002
	Elomwe and Emarenjo	-	-	0.002	0.001
	Xitswa and similar	-	-	0.003	0.003
	Portuguese	-	-	0.000	0.000
	Other	-	-	0.001	0.001
Mother's childhood place of residence	City	-	0.002	0.002	0.002
	Town	-	0.002	0.002	0.001
	Countryside	-	0.005	0.006	0.002

Results of Table 6.7 may be indicative of the insufficiency of model variables to adequately capture the risk of child mortality. Macassa, Ghilagaber, Bernhardt *et al* (2003a) modelled child mortality in Mozambique for the ten years preceding the 1997 DHS and found parental education, parental occupation, sex of the child, age of the mother at childbirth, birth order/birth interval and place of residence (urban/rural) to be significantly associated with child mortality.

It is possible however that the significant variables in Table 6.7 are picking up real differentials in child mortality (12 to 59 months) and confirming earlier results from Chapter 2 that the first year of life (particularly the first month) is the most hazardous in Mozambique and thereafter the mortality risk is low resulting in minimal differentials between significant covariate categories.

Underfive mortality

Five variables are consistently significant for models of underfive mortality over the period of study (1978 to 1998): the length of the subsequent conception, the survival status of the previous child by age 5, the mother's age at birth, the mother's education attainment and the region of residence (Table 6.8).

Table 6.8 Predicted incidence rates of under five mortality for significant variables

Significant Variables	Categories	Birth periods			
		1978-1983	1983-1988	1988-1993	1993-1998
Sex of index child	Male	0.032	-	-	0.039
	Female	0.023	-	-	0.032
Length of the subsequent conception interval	0-12 months	0.079	0.087	0.123	0.184
	13-24 months	0.017	0.020	0.026	0.026
	25-59 months	0.010	0.010	0.010	0.009
	No subsequent conception/ 60+ months	0.014	0.016	0.012	0.014
Survival status of the previous child	Previous birth dead by age 5	0.080	0.088	0.104	0.108
	Previous birth alive at age 5	0.011	0.010	0.015	0.018
Mother's age at birth	10-19 years	0.045	0.058	0.081	0.068
	20-24 years	0.022	0.025	0.036	0.045
	25-29 years	0.024	0.020	0.022	0.027
	30-49 years	0.022	0.020	0.024	0.025
Mother's education attainment	No education	0.031	0.030	0.039	0.049
	Primary education	0.021	0.026	0.030	0.026
	Secondary or higher	0.060	0.002	0.009	0.008
Father's relative education attainment	Less than mother's education	0.046	-	0.055	0.030
	Equal to mother's education	0.026	-	0.031	0.038
	Higher than mother's education	0.025	-	0.034	0.033
Region of residence	North	0.052	0.055	0.064	0.068
	Centre	0.026	0.025	0.026	0.030
	South	0.011	0.009	0.014	0.011
Mother's religion	No religion	-	-	0.025	-
	Catholic	-	-	0.046	-
	Muslim	-	-	0.044	-
	Zionist	-	-	0.015	-
	Protestant/Evangelic	-	-	0.025	-
	Other religion	-	-	0.039	-
Mother's linguistic group	Xitsonga and similar	0.014	0.008	0.011	-
	Emakua and similar	0.051	0.052	0.064	-
	Cisena and similar	0.026	0.030	0.030	-
	Elomwe and Emarenjo	0.031	0.041	0.028	-
	Xitswa and similar	0.008	0.014	0.020	-
	Portuguese	0.003	0.001	0.002	-
	Other	0.034	0.017	0.023	-
Mother's childhood place of residence	City	0.007	-	0.013	0.016
	Town	0.026	-	0.013	0.014
	Countryside	0.031	-	0.040	0.042

Trends in predicted incidence discussed for neonatal mortality are closely similar for underfive mortality as well. The father's relative education attainment, the mother's linguistic group and the mother's childhood place of residence are significant in three of the four birth periods. The latest period 1993 to 1998 does not show the expected decline in incidence as father's education increases relative to the mother's education (also observed for infant mortality). The Emakua and similar linguistic group (predominant in Northern Mozambique) shows the highest predicted incidence rates with the linguistic group variable not significant for the period 19993 to 1998 (Table 6.8).

Interactions of the preceding birth interval with the mother's education attainment were found significant for neonatal mortality (1993 to 1998), postneonatal mortality (1988 to 1993) and for underfive mortality during the periods 1978 to 1983 and 1993 to 1998. Interactions of the preceding birth interval with the region of residence were significant for infant mortality (1978 to 1983), child mortality (1988 to 1993) and underfive mortality (1978 to 1983 and 1988 to 1993). Chapter 1 discussed provincial differentials in literacy levels and interactions between the mother's education attainment and the region of residence were found significant for infant mortality (1978 to 1983 and 1983 to 1988), child mortality (1983 to 1988 and 1993 to 1998) and underfive mortality (1983 to 1988 and 1993 to 1998).

6.3 Discussion

6.3.1 The association of short preceding birth intervals with child mortality

Multivariate model results confirm the association of short preceding birth intervals with child mortality[2] in Mozambique with shorter preceding birth intervals displaying the highest predicted incidence rates of mortality across the various ages at death (except for child mortality at the ages of 12 to 59 months). The neonatal period (first month of life), displays the highest predicted incidence rates of child mortality associated with short preceding birth intervals. Thus the effects of a short preceding birth interval are strongest in the neonatal period in Mozambique. Other studies also found effects of short preceding birth intervals to be strongest in the neonatal period (Koenig, Phillips, Campbell *et al* 1990, Mturi and Curtis 1995), although numerous others found stronger effects during the postneonatal period (Hobcraft, McDonald and Rutstein 1985, Pebley and Millman 1986, Boerma and Bicego 1992, Kuate Defo 1997, Whitworth and Stephenson 2002). Boerma and Bicego (1992) caution that the absence of stronger effects in the neonatal period may be a result of selective underreporting of neonatal deaths in retrospective data.

[2] Child mortality in the general sense

It has been argued that the higher predicted incidence of neonatal mortality is attributable to bias introduced from not controlling for prematurity (Winikoff 1983, Hobcraft, McDonald and Rutstein 1985, Conde-Agudelo, Rosas-Bermúdez and Kafury-Goeta 2006). A cut-off of 9 months as the minimum length of the preceding birth interval excluded premature births in this analysis (assuming a 9 month gestation period). Therefore the observed effects of short preceding birth intervals in the neonatal period can be assumed to be real effects among Mozambican children born following a short preceding birth interval.

The 16 year civil war (1976 to 1992) visibly masked effects of a short preceding birth interval on neonatal mortality with reduced incidence rates of neonatal mortality during quinquennial periods coinciding with the civil war (1978 to 1983 and 1983 to 1988). Koenig, Phillips, Campbell *et al* (1990) found similar effects in Bangladesh, suggesting that a famine had removed the association of short preceding birth intervals with post-neonatal mortality.

The markedly higher incidence of neonatal mortality signifies that pre-natal mechanisms of maternal depletion can be attributed as the dominant pathway through which short preceding birth intervals magnify child mortality in Mozambique. Boerma and Bicego (1992) found stronger pre-natal mechanisms in their analysis of 17 countries. Maternal depletion impairs fetal intrauterine growth of the index child increasing the chances of low birth weight which is associated with higher mortality risks in the neonatal period (Hobcraft, McDonald and Rutstein 1985, Miller 1991). A prospective cohort study of 908 women in Maputo found that low birth weight, preterm birth, small for gestational age and low weight gain during pregnancy were significant risk factors for perinatal mortality (defined as fetal death in *utero* with gestational age of 22 weeks or more or neonatal death within the first week of birth) in (Osman, Challis, Cotiro *et al* 2001). Although the study did not control for the length of the preceding birth interval, it is important to note that these risk factors are outcomes of short birth spacing. Conde-Agudelo, Rosas-Bermúdez and Kafury-Goeta (2006) established that short inter-pregnancy intervals of less than 6 months and between 6 to 17 months were associated with a significantly higher risk of low birth weight, preterm birth and small for gestational age compared to inter-pregnancy intervals in the range of 18 to 23 months. Therefore it can be inferred that a short preceding birth interval is one of the causal factors in the Maputo study (Osman, Challis, Cotiro *et al* 2001).

The stronger effects observed during the neonatal period may also reflect shortcomings of health service delivery in Mozambique, which lacks adequate neonatal medical technology required to mitigate the augmented risks of neonatal mortality associated with short preceding birth intervals (Rawlings, Rawlings and Read 1995). In a qualitative research of midwives' perceptions of barriers to quality perinatal care based in Maputo, four factors were identified as impeding care: (1) an unfavourable work environment with insufficient human resources, equipment and beds; (2) a failure to interact and relate to women in labour to ensure collaboration of the mother during childbirth; (3) a lack of knowledge and skills among midwives and (4) non appliance of best newborn care practices (Pettersson, Johansson, Pelembe *et al* 2006:149).

Child minding or child fostering of older closely spaced siblings by extended family members coupled with prolonged breastfeeding of the index child may explain the weaker postneonatal mechanisms observed. Postneonatal mechanisms of sibling competition for scarce household resources expose the index child to the risk of poor nutrition and inadequate prenatal and postnatal health care (Boerma and Bicego 1992). Child fostering was reported to be common in Mozambique (Arnaldo 2003).

6.3.2 Significant variables of child mortality

The length of the subsequent conception interval, the mother's region of residence and intra-familial mortality risks (survival status of previous birth by age 5) are consistent risk factors of child mortality across all ages at death. Reference to child mortality refers to its general use (inclusive of neonatal, postneonatal, infant, child and underfive mortality in this case).

A subsequent conception within a year of the index child's birth is the most hazardous to child survival with effects magnified in the post civil war period (1993 to 1998) except for child mortality (12 to 59 months). Retherford, Choe, Thapa *et al* (1989) found that breastfeeding explained almost all of the effects of a subsequent birth interval on infant mortality (0 to 18 months). A subsequent conception by a breastfeeding mother has the effect of curtailing breast milk production thus affecting breastfeeding of the index birth (McNeilly 1977). The length of a subsequent conception interval is significant in Mozambique due to universal breastfeeding (Arnaldo 2003). According to the DHS, 98% of children born in the five years preceding the Mozambique 2003 DHS were breastfed with median breastfeeding duration of 22 months for children below the age of 3 years.

Breastfeeding significantly reduces child morbidity and mortality associated with diarrhoea due to the nutritious and immune boosting properties of breast milk and furthermore breastfeeding avoids administering contaminated water and food (or huge amounts of contaminated food and water for non-exclusive breastfeeding) to the child (Retherford, Choe, Thapa *et al* 1989, Huffman and Martin 1994). Inferences of breastfeeding effects on child mortality are however limited by a lack of data on breastfeeding status of an index child at the time of the subsequent conception. An index child can be born with health complications which prevent breastfeeding altogether or develop an illness which results in the termination of breastfeeding (Palloni and Tienda 1986, Lantz, Partin and Palloni 1992).

The death of an immediately preceding sibling by age 5 was found to magnify the risk of child mortality. Perpetuation of mortality risks among immediate siblings contribute to a high incidence of child mortality.

Urbanization or economic development differentials most likely explain the observed patterns in predicted incidence by region. Southern Mozambique is more urbanized and heath service delivery is expected to be more accessible and better resourced (health personnel and equipment) compared to the Centre and the Northern region which is the least urbanized. The number of inhabitants per hospital bed was calculated as a proxy for health service delivery using the Ministry of Health 2003 data on the number of beds per province and the 2007 preliminary census results. The Southern region had the lowest hospital bed density with 757 inhabitants per hospital bed, compared to 1521 in the Centre and 1599 in the North. Macassa, Ghilagaber, Bernhardt *et al* (2006) also argue that levels of urbanization determine access to clean water and sanitation. Women and children in the Southern region have higher access to clean water and sanitation compared to women in the Central and Northern regions (Macassa, Ghilagaber, Bernhardt *et al* 2006).

The mother's age at birth was significant across all periods for infant mortality and underfive mortality. If biological effects of the birth age were the dominant effects, the variable would have been consistently significant for neonatal mortality. In Mozambique, teenage mothers have a composite effect of higher child mortality risk from low birth weight (biological mechanisms) and prenatal and postnatal child care practices (Klitsch 2003).

Mother's education attainment was found significant in all birth periods for underfive mortality. Period effects on the significance of mother's education (considered among the most important covariates of child mortality (Hobcraft 1993)) are evident in the postneonatal model with the mother's education not significant in the period just after independence (1978 to 1983) and also evident for infant and neonatal mortality where the variable is not significant in the period 1988 to 1993. These birth periods (1978 to 1983 and 1988 to 1993) are both post war periods; post independence war (1978 to 1983) and the post intensified civil war period (1988 to 1993). Thus low health service delivery in the post independence period and the destruction of health service delivery from the civil war eroded the gains in maternal education (Hobcraft 1993).

The father's education attainment modelled relative to the mother's education attainment was found significant in three of the four periods for postneonatal mortality, infant mortality and underfive mortality. The low level of education attainment among women in Mozambique amplifies the importance of a father's education attainment over and above that of the mother in providing household resources for the child's well-being (Mosley and Chen 1984).

Linguistic groups found in Northern Mozambique have the highest predicted incidence rates of child mortality, followed by groups found in Central Mozambique and those in the South. The review of traditional birth spacing practices (chapter 2), indicated that a minimum postpartum abstinence of forty days was found among the Yao, Emakua and Emakonde found in Northern Mozambique (Wembah-Rashid 1995). The Sena from Central Mozambique reported abstinence from birth until the baby's navel heals (Magalhães 1960, Ivens-Ferraz de Freitas 1971 cited in Arnaldo 2003). The Tsonga found in Southern Mozambique, postpartum abstinence of about one year in 2001 which is relatively longer than the other groups (Arnaldo 2003). Differences in health seeking behaviour may also explain the variations in predicted incidence (Macassa, Ghilagaber, Bernhardt *et al* 2006).

Religion is generally not a strong predictor of child mortality, although it was significant in the last two birth periods for neonatal and postneonatal mortality. Muslim women and Catholics have higher predicted incidence rates of child mortality. The minimum abstinence of forty days found in the predominantly Muslim Northern region most likely contributes to the higher risk (Wembah-Rashid 1995). 90 per cent of Muslim women in the aggregated dataset were resident in the Northern region. Trends in incidence are not clear for children of Catholic women although residence patterns may explain the observed incidence as 30 per cent of the women in the dataset were resident in the North and 42 per cent in the Central region both with higher incidence. The much lower predicted incidence for children of Zionists may also be explained from residential patterns as Zionists are predominantly based in Southern Mozambique (Agadjanian 2001).

Variable interactions were significant for underfive mortality, . The preceding birth interval had significant interactions with education attainment of the mother and the region of residence in the period 1978 to 1983. The period 1983 to 1988 had a significant interaction for the mother's education attainment with the region of residence. Interactions of the preceding birth interval with the mother's education attainment and the region of residence were significant for the 1988 to 1993 model. Finally the most recent period 1993 to 1998 had significant interactions between the preceding birth interval and the mother's education and between the mother's education and the region of residence.

Influence of HIV and AIDS on model results

HIV and AIDS is not modelled in this study since the 1997 and 2003 Mozambique DHS did not collect individual HIV data. HIV and AIDS is however hypothesised to affect the association of child mortality with the length of the preceding birth interval through breastfeeding effects, foetal loss in pregnant women living with HIV and influence on child mortality estimates (Du Plessis 2003, Mahy 2003).

Breast milk contains the human immunodeficiency virus (HIV) which can be transmitted to a child through breastfeeding. UNICEF (2002) recommends a short duration of breastfeeding as it reduces the risk of HIV transmission, and a discontinuance of breastfeeding in periods when the HIV viral load is high which occurs just after HIV infection and when HIV progresses to AIDS. Exclusive breastfeeding for at least the first three months has been shown to reduce HIV transmission relative to partial breastfeeding with supplementary foods (UNICEF 2002). HIV positive mothers who curtail breastfeeding increase the chances of an early subsequent conception in the absence of contraception use. Furthermore, the nutritional and immunity benefits of breast milk lost by the index child contribute to higher risk of child mortality if replacement food and health care are not adequate.

Foetal loss effects in HIV positive women is a limitation to the study if it is in between two live births since it artificially increases the length of the preceding birth interval (limitation of abortions and miscarriages discussed in chapter 1). The fecundity reducing effect of HIV infection relates to involuntary spacing.

Mahy (2003), reviews the influence of HIV and AIDS on child mortality estimates and notes than in high HIV prevalence settings child mortality estimates are underestimated by approximately five per cent since dead mothers (from increased AIDS related adult mortality) cannot be interviewed. Thus predicted incidence rates of child mortality based on birth histories of women alive at survey date have an HIV and AIDS induced bias.

This chapter has presented the model results of the association of child mortality with short preceding birth intervals and discussed the implications of the results. Conclusions on the association of birth spacing and child mortality in Mozambique are presented in the following final chapter.

7 CONCLUSIONS

This thesis set out to establish the association of short preceding birth intervals with child mortality in Mozambique. The association is considered one of the strongest and most important in demography, however a multivariate analysis confirming the association and establishing the strength and mechanisms of the association has never been conducted in Mozambique. This research provides results of a multivariate analysis of child mortality with the length of the preceding birth interval at ages at death of less than 1 month (neonatal mortality), 1-11 months (postneonatal mortality), 0-11 months (infant mortality), 12-59 months (child mortality) and 0-59 months (underfive mortality).

In the introduction to the research, it was established that a short preceding birth interval can be avoided by preventing conception through the uptake of effective contraceptive methods or adherence to traditional birth spacing practices like prolonged breastfeeding and postpartum abstinence. In addition women of high socio-economic stature can afford adequate child health care and also afford to hire extra child help, which mitigates the negative effects of a short preceding birth interval. Affordable and accessible neonatal medical technology within a country's health system including quality neonatal intensive care units and doctors specializing in neonatal or obstetric care can also averts the hazardous effects of a short preceding birth interval. However an ordinary Mozambican woman has low education attainment, lives in poor settings and has access to a health care system described as having a critical shortage of medical personnel. Hence children born following a short preceding birth interval are hypothesized to be at a higher risk of dying in Mozambique.

Chapter 2 provided a review of the literature on birth spacing and child mortality. Although varying in data sources, methods, cut-off points for "short" birth spacing and geographical location; similar conclusions were reached on the effects of a short preceding birth interval on child mortality: children born following a short preceding birth interval are at a higher risk of dying. The hazardous effects of a short preceding birth interval have been found to be strongest during the first year of life, particularly in the postneonatal period.

The Poisson log rate model for piecewise constant rates was discussed in chapter 3 as the model to be applied in the model of child mortality with the length of the preceding birth interval. In the presence of real overdispersion in the data the negative binomial variant of the Poisson model will be modelled with the response variable characterized by a Poisson process with overdispersion.

Chapter 4 concluded that age misreporting detected in both the 1997 and 2003 DHS and birth displacement in the 1997 DHS was not severe as to preclude genuine model results. Furthermore there is suggestive evidence of omission of dead children in the 2003 DHS for the five years preceding the survey.

Chapter 5 established that it can be reasonably assumed that the hazard rate is constant in each 6 month category and set the model period from September 1978 to September 1998. It was concluded that differences in data from the 1997 and 2003 DHS for the period 1978 to 1998 were minimal and that data can be aggregated and analyzed with reasonable accuracy. The modelling procedure led to the use of the negative binomial model over the Poisson model due to the presence of overdispersion.

Effects of a short preceding birth interval on child mortality were found to be strongest in the first month of life (neonatal period) in Mozambique in the discussion of results in Chapter 6. Hence the high observed annual neonatal mortality is contributed in part by short preceding birth intervals. Using incidence rates for the latest period 1993 to 1998 with minimal masking effects; the magnitude of predicted incidence rates of neonatal mortality for the shortest preceding birth interval category (9 to 14 months) are ten fold and nine fold predicted incidence rates of infant mortality and underfive mortality respectively, forty-three fold predicted incidence rates for postneonatal mortality and a massive five hundred and eighty five fold predicted incidence rates for child mortality.

Pre-natal mechanisms of maternal depletion are attributed as the dominant pathway through which short preceding birth intervals magnify child mortality in Mozambique by impairing fetal intrauterine growth which increases the chances of low birth weight and pre-term birth; both associated with higher mortality risk in the neonatal period.

An optimal birth spacing period for neonatal mortality (exhibiting the strongest effects of a short preceding birth interval) was approximated at 42 months or three and a half years. However the optimal spacing period based on infant mortality and underfive mortality models was estimated at 36 months. Given the fact the child mortality is concentrated at the neonatal age in Mozambique, the estimated optimal birth spacing period for neonatal mortality will be adopted for child mortality in general, as a decline in neonatal mortality will have consequences for other ages at death.

The optimal birth spacing period for neonatal falls within optimal birth spacing advocated under the banner of "Three to five saves lives" (Setty-Venugopal and Upadhyay 2002). However results of this study suggest an extra 6 month spacing period for women in Mozambique to have minimum spacing of three and a half years. Over seventy per cent (71%) of births in the period 1988 to 1993 and sixty-six per cent of births in the period 1993 to 1998 had a preceding birth interval shorter than the optimal birth spacing category of 39 to 44 months in the aggregated data set.

In a qualitative research of fertility intentions and contraceptive choices among men and women in peri-urban Maputo; Agadjanian (2005) states that economic, marital and social uncertainties influence reproductive decisions and intentions of whether one intends to space births or stop childbirth. Instead of referring to birth spacing or stopping childbirth, Agadjanian found that respondents referred to a "waiting period" which depending on factors of age, parity, economic, social or marital outcomes could either result in birth spacing or stopping childbirth. According to Agadjanian (2005: 628):

> "These complex and seemingly contradictory reproductive intentions, where stopping and spacing preferences are indistinguishable, should be better defined as waiting…Regardless of its actual outcome (which in the conditions of relatively little and improper contraceptive use is likely to be a pregnancy and birth), the waiting period is subjectively meant for both spacing and stopping."

Therefore in the context of birth "waiting" it is essential that women in Mozambique are encouraged to wait for a period of three and a half years in order to guarantee minimal mortality risk for their children particularly in the first month after birth. Sparse cases in categories of longer preceding birth intervals make it difficult to determine a maximum spacing period since longer intervals are associated with reproductive complications of the mother (Winikoff 1983, Rutstein 2005). However the recommended five year period (Setty-Venugopal and Upadhyay 2002) can be adopted so that a "waiting" period of "three and a half years to five years" is encouraged among couples in Mozambique.

The higher mortality risks faced by children born following a short preceding birth interval must be highlighted in simple quantitative expressions to enable women to fully comprehend how essential optimal birth spacing is to ensure that their children survive the first month of life. Investment in neonatal care technology and within the system of perinatal care (including adequate, trained human resources) needs to be ensured in hospitals across Mozambique in order to mitigate neonatal mortality from low birth weight or prematurity.

The magnified risk of child mortality for children born following short preceding birth intervals has been shown in this study. These results directly inform and highlight the hazard of short birth spacing and inform policy. However there is scope for further research related to child mortality and short birth spacing.

Further research needs to be directed towards an understating of socio-cultural factors that motivate short birth spacing in the face of weakening traditional practices. There is potential for further anthropological or sociological research to determine and understand socio-cultural practices and processes within the context of birth spacing in Mozambique.

There is also need to study intrafamilial child mortality risks and patterns (a significant covariate of child mortality across all ages at death and birth periods) and identify sources of intrafamilial risk which expose subsequent children to a higher risk of mortality. Early intervention may help prevent recurrent intra-familial child mortality.

Finally, effects of HIV and AIDS on the association between child mortality and the length of the preceding birth interval need to be better understood and modeled using DHS data that collects individual HIV data in order to separate effects of short birth spacing and HIV induced effects given the high prevalence of HIV in Mozambique.

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9 APPENDIX

Table A.1 Neonatal mortality incidence rate ratios for negative binomial models for birth periods 1993 to 1998 and 1988 to 1993

1993-1998 model		1988-1993 model	
Significant variables	IRR	Significant variables	IRR
PBI: 9-14 months	1.153	PBI: 9-14 months	2.568 **
PBI: 15-20 months	0.710	PBI: 15-20 months	1.891 *
PBI: 21-26 months®	1.000	PBI: 21-26 months®	1.000
PBI: 27-32 months	0.479	PBI: 27-32 months	0.815
PBI: 33-38 months	0.529	PBI: 33-38 months	0.436 **
PBI: 39-44 months	0.257 **	PBI: 39-44 months	0.472 *
PBI: 45-50 months	0.429	PBI: 45-50 months	0.256 **
PBI: 51-56 months	0.128 **	PBI: 51-56 months	1.457
PBI: 57+ months	0.033 ****	PBI: 57+ months	0.128 ****
No subsequent conception or subsequent conception: 60+ months	0.833	No subsequent conception or subsequent conception: 60+ months	1.075
Subsequent conception: 0-12 months	8.771 ****	Subsequent conception: 0-12 months	5.525 ****
Subsequent conception: 13-24 months®	1.000	Subsequent conception: 13-24 months®	1.000
Subsequent conception: 25-59 months	0.427 ***	Subsequent conception: 25-59 months	0.533 **
Previous birth dead by age 5	2.463 ****	Mother's age at birth: 10 to 19 years	0.791
Previous birth alive at age 5®	1.000	Mother's age at birth: 20 to 24 years®	1.000
Mother: no education®	1.000	Mother's age at birth: 25 to 29 years	0.418 ****
Mother: primary education	0.287 ***	Mother's age at birth: 30 to 49 years	0.392 ****
Mother: secondary education	0.000	Previous birth dead by age 5	4.618 ****
Northern Region	1.934 **	Previous birth alive at age 5®	1.000
Central Region®	1.000	Father's education less than mother's education	2.257 **
Southern Region	1.191	Father's education equal to mother's education®	1.000
No religion	0.620	Father's education higher than mother's education	1.045
Catholic®	1.000	Northern Region	4.470 ****
Muslim	0.958	Central Region®	1.000
Zion	0.766	Southern Region	3.488 ****
Protestant/Evangelic	0.473 **		
Other	0.473		

1993-1998 model			1988-1993 model	
Significant variables	IRR		Significant variables	IRR
PBI:9-14*Mother: primary education	2.140		No religion	0.622
PBI:9-14*Mother: secondary education	0.536		Catholic®	1.000
PBI:15-20*Mother: primary education	2.434		Muslim	0.671
PBI:15-20*Mother: secondary education	2E+07		Zion	0.582
PBI:27-32*Mother: primary education	1.739		Protestant/Evangelic	0.581 *
PBI:27-32*Mother: secondary education	3.060		Other	2.333 *
PBI:33-38*Mother: primary education	1.123		Childhood: City	0.590
PBI:33-38*Mother: secondary education	2.553		Childhood: Town	0.374 **
PBI:39-44*Mother: primary education	0.249		Childhood: Countryside®	1.000
PBI:39-44*Mother: secondary education	5.658			
PBI:45-50*Mother: primary education	0.679			
PBI:45-50*Mother: secondary education	4E+07			
PBI:51-56*Mother: primary education	5.331			
PBI:51-56*Mother: secondary education	9.798			
PBI:57+*Mother: primary education	32.099 ****			
PBI:57+*Mother: secondary education	7.9E+08			
Chi-square	1423.76 ****		*Chi-square*	1328.8 ****
N	9995		N	8384

PBI=Length of preceding birth interval, ®=Reference group, *p≤0.1, **p≤0.05, ***p≤0.01, ****p≤0.001.

Table A.2 Neonatal mortality incidence rate ratios for negative binomial models for birth periods 1983 to 1988 and 1978 to 1983

1983-1988 model		1978-1983 model	
Significant variables	IRR	Significant variables	IRR
PBI: 9-14 months	0.957	PBI: 9-14 months	1.753
PBI: 15-20 months	1.797 *	PBI: 15-20 months	2.460 **
PBI: 21-26 months®	1.000	PBI: 21-26 months®	1.000
PBI: 27-32 months	0.712	PBI: 27-32 months	0.900
PBI: 33-38 months	0.349 ***	PBI: 33-38 months	2.250 *
PBI: 39-44 months	0.196 ***	PBI: 39-44 months	0.745
PBI: 45-50 months	0.140 ***	PBI: 45-50 months	0.610
PBI: 51-56 months	0.236 *	PBI: 51-56 months	0.121
PBI: 57+ months	0.314 **	PBI: 57+ months	0.006 **
No subsequent conception or subsequent conception: 60+ months	1.999 **	Index child: male®	1.000
Subsequent conception: 0-12 months	4.294 ****	Index child: female	0.477 ***
Subsequent conception: 13-24 months®	1.000	Previous child: male®	1.000
Subsequent conception: 25-59 months	0.650	Previous child: female	0.551 **
Mother's age at birth: 10 to 19 years	2.501 ***	No subsequent conception or subsequent conception: 60+ months	1.098
Mother's age at birth: 20 to 24 years®	1.000	Subsequent conception: 0-12 months	4.324 ****
Mother's age at birth: 25 to 29 years	1.107	Subsequent conception: 13-24 months®	1.000
Mother's age at birth: 30 to 49 years	1.155	Subsequent conception: 25-59 months	0.639
Previous birth dead by age 5	4.905 ****	Previous birth dead by age 5	5.565 ****
Previous birth alive at age 5®	1.000	Previous birth alive at age 5®	1.000
Mother: no education®	1.000	Mother: no education®	1.000
Mother: primary education	0.685	Mother: primary education	0.737
Mother: secondary education	0.095 **	Mother: secondary education	0.560
Northern Region	3.514 ****	Northern Region	2.673 ***
Central Region®	1.000	Central Region®	1.000
Southern Region	1.004	Southern Region	0.576
Childhood: City	1.718		
Childhood: Town	0.950		
Childhood: Countryside®	1.000		
Chi-square	1021.86 ****	*Chi-square*	527.07 ****
N	7367	N	4912

PBI=Length of preceding birth interval, ®=Reference group, *$p \leq 0.1$, **$p \leq 0.05$, ***$p \leq 0.01$, ****$p \leq 0.001$.

Table A.3 Postneonatal mortality incidence rate ratios for negative binomial models for birth periods 1993 to 1998 and 1988 to 1993

1993-1998 model		1988-1993 model	
Significant variables	IRR	Significant variables	IRR
PBI: 9-14 months	1.299	PBI: 9-14 months	1.243
PBI: 15-20 months	0.964	PBI: 15-20 months	1.445
PBI: 21-26 months®	1.000	PBI: 21-26 months®	1.000
PBI: 27-32 months	0.679 **	PBI: 27-32 months	1.409
PBI: 33-38 months	0.856	PBI: 33-38 months	0.810
PBI: 39-44 months	0.559 **	PBI: 39-44 months	1.406
PBI: 45-50 months	0.276 ****	PBI: 45-50 months	1.165
PBI: 51-56 months	0.519 *	PBI: 51-56 months	0.129 **
PBI: 57+ months	0.343 ****	PBI: 57+ months	0.208 ****
No subsequent conception or subsequent conception: 60+ months	0.821	Index child: male®	1.000
Subsequent conception: 0-12 months	3.962 ****	Index child: female	0.775 **
Subsequent conception: 13-24 months®	1.000	No subsequent conception or subsequent conception: 60+ months	0.537 ****
Subsequent conception: 25-59 months	0.599 ***	Subsequent conception: 0-12 months	1.000
Mother's age at birth: 10 to 19 years	1.052	Subsequent conception: 13-24 months®	2.220 ****
Mother's age at birth: 20 to 24 years®	1.000	Subsequent conception: 25-59 months	0.591 ****
Mother's age at birth: 25 to 29 years	0.666 ***	Mother's age at birth: 10 to 19 years	1.671 ***
Mother's age at birth: 30 to 49 years	0.629 ***	Mother's age at birth: 20 to 24 years®	1.000
Previous birth dead by age 5	2.857 ****	Mother's age at birth: 25 to 29 years	1.033
Previous birth alive at age 5®	1.000	Mother's age at birth: 30 to 49 years	1.188
Mother: no education®	1.000	Previous birth dead by age 5	2.492 ****
Mother: primary education	0.710 **	Previous birth alive at age 5®	1.000
Mother: secondary education	0.098 ****	Mother: no education®	1.000
Father's education less than mother's education	1.765 **	Mother: primary education	0.776
Father's education equal to mother's education®	1.000	Mother: secondary education	0.000
Father's education higher than mother's education	0.773 *	Father's education less than mother's education	2.074 ****
Northern Region	1.465 **	Father's education equal to mother's education®	1.000
Central Region®	1.000	Father's education higher than mother's education	1.232
Southern Region	0.647 **	Northern Region	1.900 **
No religion	1.001	Central Region®	1.000
Catholic®	1.000	Southern Region	1.490
Muslim	0.681 **	No religion	1.051
Zion	1.292	Catholic®	1.000
Protestant/Evangelic	1.566 ***	Muslim	0.816
Other	0.588	Zion	0.832
		Protestant/Evangelic	1.311
Chi-square	613.800 ****	Other	0.880
N	7709		

1993-1998 model		1988-1993 model	
Significant variables	IRR	Significant variables	IRR
		Xitsonga and similar	0.704
		Emakua and similar	0.957
		Cisena and similar®	1.000
		Elomwe and Emarenjo	1.078
		Xitswa and Similar	0.863
		Portuguese	0.418
		Other	0.428 **
		Childhood: City	0.446 ****
		Childhood: Town	0.614 **
		Childhood: Countryside®	1.000
		PBI:9-14*Mother: primary education	1.668
		PBI:9-14*Mother: secondary education	1.065
		PBI:15-20*Mother: primary education	0.755
		PBI:15-20*Mother: secondary education	0.617
		PBI:27-32*Mother: primary education	0.704
		PBI:27-32*Mother: secondary education	1.1E+07
		PBI:33-38*Mother: primary education	1.002
		PBI:33-38*Mother: secondary education	3.5E+08
		PBI:39-44*Mother: primary education	0.292 **
		PBI:39-44*Mother: secondary education	0.933
		PBI:45-50*Mother: primary education	0.806
		PBI:45-50*Mother: secondary education	1.448
		PBI:51-56*Mother: primary education	8.288 **
		PBI:51-56*Mother: secondary education	13.194
		PBI:57+*Mother: primary education	2.870 *
		PBI:57+*Mother: secondary education	14.530
		Chi-square	636.510 ****
		N	7792

PBI=Length of preceding birth interval, ®=Reference group, *$p \leq 0.1$, **$p \leq 0.05$, ***$p \leq 0.01$, ****$p \leq 0.001$.

Table A.4 Postneonatal mortality incidence rate ratios for negative binomial models for birth periods 1983 to 1988 and 1978 to 1983

1983-1988 model		1978-1983 model	
Significant variables	IRR	Significant variables	IRR
PBI: 9-14 months	1.247628	PBI: 9-14 months	1.88535 ***
PBI: 15-20 months	1.075627	PBI: 15-20 months	1.568744 **
PBI: 21-26 months®	1	PBI: 21-26 months®	1
PBI: 27-32 months	0.955464	PBI: 27-32 months	1.603726 **
PBI: 33-38 months	0.549188 ***	PBI: 33-38 months	0.6926059
PBI: 39-44 months	1.133818	PBI: 39-44 months	0.3600578 **
PBI: 45-50 months	0.486451 **	PBI: 45-50 months	0.7367589
PBI: 51-56 months	0.720185	PBI: 51-56 months	0.6097897
PBI: 57+ months	0.150143 ****	PBI: 57+ months	0.2008736 **
No subsequent conception or subsequent conception: 60+ months	0.819385	Index child: male®	1
Subsequent conception: 0-12 months	2.317228 ****	Index child: female	0.7483633 **
Subsequent conception: 13-24 months®	1	No subsequent conception or subsequent conception: 60+ months	0.9895025
Subsequent conception: 25-59 months	0.682041 **	Subsequent conception: 0-12 months	2.42818 ****
Previous birth dead by age 5	3.244325 ****	Subsequent conception: 13-24 months®	1
Previous birth alive at age 5®	1	Subsequent conception: 25-59 months	0.9028768
Mother: no education®	1	Mother's age at birth: 10 to 19 years	1.441038 **
Mother: primary education	0.967551	Mother's age at birth: 20 to 24 years®	1
Mother: secondary education	0.245689	Mother's age at birth: 25 to 29 years	1.096951
Northern Region	1.802425 **	Mother's age at birth: 30 to 49 years	0.6293621
Central Region®	1	Previous birth dead by age 5	3.125278 ****
Southern Region	0.768428	Previous birth alive at age 5®	1
Xitsonga and similar	0.648962	Father's education less than mother's education	1.810157 ***
Emakua and similar	0.625591 *	Father's education equal to mother's education®	1
Cisena and similar®	1	Father's education higher than mother's education	0.8679295
Elomwe and Emarenjo	1.174132	Northern Region	1.271256
Xitswa and Similar	0.747338	Central Region®	1
Portuguese	0.078999 **	Southern Region	0.4529661 ****
Other	0.430599 **	Childhood: City	0.3828325 ***
Childhood: City	0.688266 *	Childhood: Town	0.7794307
Childhood: Town	0.595725 **	Childhood: Countryside®	1
Childhood: Countryside®	1		
Chi-square	312.77 ****	*Chi-square*	100.46 ****
N	6857	N	3916

PBI=Length of preceding birth interval, ®=Reference group, *$p \leq 0.1$, **$p \leq 0.05$, ***$p \leq 0.01$, ****$p \leq 0.001$.

Table A.5 Infant mortality incidence rate ratios for negative binomial models for birth periods 1993 to 1998 and 1988 to 1993

1993-1998 model

Significant variables	IRR
PBI: 9-14 months	1.830 ***
PBI: 15-20 months	1.161
PBI: 21-26 months®	1.000
PBI: 27-32 months	0.635 ***
PBI: 33-38 months	0.692 *
PBI: 39-44 months	0.430 ****
PBI: 45-50 months	0.320 ****
PBI: 51-56 months	0.448 **
PBI: 57+ months	0.417 ****
Index child: male®	1.000
Index child: female	0.811 *
No subsequent conception or subsequent conception: 60+ months	0.796
Subsequent conception: 0-12 months	4.836 ****
Subsequent conception: 13-24 months®	1.000
Subsequent conception: 25-59 months	0.388 ****
Mother's age at birth: 10 to 19 years	1.051
Mother's age at birth: 20 to 24 years®	1.000
Mother's age at birth: 25 to 29 years	0.730 **
Mother's age at birth: 30 to 49 years	0.818
Previous birth dead by age 5	2.829 ****
Previous birth alive at age 5®	1.000
Mother: no education®	1.000
Mother: primary education	0.604 ****
Mother: secondary education	0.182 ***
Father's education less than mother's education	1.449
Father's education equal to mother's education®	1.000
Father's education higher than mother's education	0.703 **
Northern Region	1.783 ****
Central Region®	1.000
Southern Region	0.727 **
Childhood: City	0.912
Childhood: Town	0.654 *
Childhood: Countryside®	1.000
Chi-square	1462.450 ****
N	8943

1988-1993 model

Significant variables	IRR
PBI: 9-14 months	1.903 ***
PBI: 15-20 months	2.003 ****
PBI: 21-26 months®	1.000
PBI: 27-32 months	0.985
PBI: 33-38 months	0.651 **
PBI: 39-44 months	1.072
PBI: 45-50 months	0.549 **
PBI: 51-56 months	0.705
PBI: 57+ months	0.255 ****
No subsequent conception or subsequent conception: 60+ months	0.749 *
Subsequent conception: 0-12 months	3.576 ****
Subsequent conception: 13-24 months®	1.000
Subsequent conception: 25-59 months	0.472 ****
Mother's age at birth: 10 to 19 years	1.238
Mother's age at birth: 20 to 24 years®	1.000
Mother's age at birth: 25 to 29 years	0.772 *
Mother's age at birth: 30 to 49 years	0.849
Previous birth dead by age 5	3.543 ****
Previous birth alive at age 5®	1.000
Father's education less than mother's education	1.553 **
Father's education equal to mother's education®	1.000
Father's education higher than mother's education	1.201
Northern Region	2.165 ****
Central Region®	1.000
Southern Region	2.089
No religion	0.757
Catholic®	1.000
Muslim	0.745 *
Zion	0.722
Protestant/Evangelic	0.892
Other	1.917 **

1993-1998 model		1988-1993 model	
Significant variables	IRR	Significant variables	IRR
		Xitsonga and similar	0.604
		Emakua and similar	1.108
		Cisena and similar®	1.000
		Elomwe and Emarenjo	0.913
		Xitswa and Similar	0.843
		Portuguese	0.165 ***
		Other	0.763
		Childhood: City	0.663 **
		Childhood: Town	0.522 ***
		Childhood: Countryside®	1.000
		Chi-square	1595.85 ****
		N	8351

PBI=Length of preceding birth interval, ®=Reference group, *p≤0.1, **p≤0.05, ***p≤0.01, ****p≤0.001.

Table A.6 Infant mortality incidence rate ratios for negative binomial models for birth periods 1983 to 1988 and 1978 to 1983

1983-1988 model		1978-1983 model	
Significant variables	IRR	Significant variables	IRR
PBI: 9-14 months	0.982	PBI: 9-14 months	2.717 ***
PBI: 15-20 months	1.450 **	PBI: 15-20 months	1.097
PBI: 21-26 months®	1.000	PBI: 21-26 months®	1.000
PBI: 27-32 months	0.792	PBI: 27-32 months	1.130
PBI: 33-38 months	0.360 ****	PBI: 33-38 months	0.596
PBI: 39-44 months	0.706	PBI: 39-44 months	0.070 **
PBI: 45-50 months	0.285 ****	PBI: 45-50 months	3.0E-09
PBI: 51-56 months	0.464 *	PBI: 51-56 months	0.307
PBI: 57+ months	0.191 ****	PBI: 57+ months	2.7E-09
No subsequent conception or subsequent conception: 60+ months	1.138	Index child: male®	1.000
Subsequent conception: 0-12 months	3.568 ****	Index child: female	0.734 **
Subsequent conception: 13-24 months®	1.000	No subsequent conception or subsequent conception: 60+ months	0.961
Subsequent conception: 25-59 months	0.710 **	Subsequent conception: 0-12 months	2.901 ****
Mother's age at birth: 10 to 19 years	1.335 *	Subsequent conception: 13-24 months®	1.000
Mother's age at birth: 20 to 24 years®	1.000	Subsequent conception: 25-59 months	0.651 **
Mother's age at birth: 25 to 29 years	0.843	Mother's age at birth: 10 to 19 years	1.435 **
Mother's age at birth: 30 to 49 years	1.002	Mother's age at birth: 20 to 24 years®	1.000
Previous birth dead by age 5	4.148 ****	Mother's age at birth: 25 to 29 years	1.212
Previous birth alive at age 5®	1.000	Mother's age at birth: 30 to 49 years	1.275
Mother: no education®	1.000	Previous birth dead by age 5	3.925 ****
Mother: primary education	0.837	Previous birth alive at age 5®	1.000
Mother: secondary education	0.940	Mother: no education®	1.000
Northern Region	2.313 ***	Mother: primary education	0.795
Central Region®	1.000	Mother: secondary education	3.3E-09
Southern Region	1.578	Father's education less than mother's education	1.406
Xitsonga and similar	0.399 **	Father's education equal to mother's education®	1.000
Emakua and similar	0.655 *	Father's education higher than mother's education	0.897
Cisena and similar®	1.000	Northern Region	1.283
Elomwe and Emarenjo	1.319	Central Region®	1.000
Xitswa and Similar	0.546	Southern Region	0.625
Portuguese	0.088 ***	Childhood: City	0.492 **
Other	0.528 **	Childhood: Town	0.732
Mother: primary education*Northern Region	1.420	Childhood: Countryside®	1.000
Mother: primary education*Southern Region	0.628		
Mother: secondary education*Northern Region	3.1E-08		
Mother: secondary education*Southern Region	0.346		
Chi-square	1018.06 ****		
N	7339		

1983-1988 model		1978-1983 model	
Significant variables	IRR	Significant variables	IRR
		PBI:9-14*Northern Region	0.243 **
		PBI:9-14*Southern Region	0.876
		PBI:15-20*Northern Region	2.769 **
		PBI:15-20*Southern Region	1.200
		PBI:27-32*Northern Region	1.199
		PBI:27-32*Southern Region	1.069
		PBI:33-38*Northern Region	0.815
		PBI:33-38*Southern Region	2.098
		PBI:39-44*Northern Region	43.236 ***
		PBI:39-44*Southern Region	7.199
		PBI:45-50*Northern Region	2.1E+08
		PBI:45-50*Southern Region	8.0E+08
		PBI:51-56*Northern Region	1.067
		PBI:51-56*Southern Region	1.336
		PBI:57+*Northern Region	7.4E+07
		PBI:57+*Southern Region	2.9E+07
		Mother: primary education*Northern Region	1.180
		Mother: primary education*Southern Region	0.739
		Mother: secondary education*Northern Region	4.1E+08
		Mother: secondary education*Southern Region	2.9E+08
		Chi-square	331.11 ****
		N	4183

PBI=Length of preceding birth interval, ®=Reference group, *p≤0.1, **p≤0.05, ***p≤0.01, ****p≤0.001.

Table A.7 Child mortality incidence rate ratios for negative binomial models for birth periods 1993 to 1998 and 1988 to 1993

1993-1998 model		1988-1993 model	
Significant variables	IRR	Significant variables	IRR
PBI: 9-14 months	0.781	PBI: 9-14 months	0.542
PBI: 15-20 months	1.124	PBI: 15-20 months	0.795
PBI: 21-26 months®	1.000	PBI: 21-26 months®	1.000
PBI: 27-32 months	0.560 ***	PBI: 27-32 months	0.618
PBI: 33-38 months	0.576 **	PBI: 33-38 months	0.464
PBI: 39-44 months	0.586 *	PBI: 39-44 months	0.808
PBI: 45-50 months	0.233 ***	PBI: 45-50 months	0.122 **
PBI: 51-56 months	0.347 **	PBI: 51-56 months	0.780
PBI: 57+ months	0.177 ****	PBI: 57+ months	0.061 ***
No subsequent conception or subsequent conception: 60+ months	0.648 *	No subsequent conception or subsequent conception: 60+ months	0.362 ****
Subsequent conception: 0-12 months	2.511 ****	Subsequent conception: 0-12 months	2.016 ***
Subsequent conception: 13-24 months®	1.000	Subsequent conception: 13-24 months®	1.000
Subsequent conception: 25-59 months	1.010	Subsequent conception: 25-59 months	0.603 **
Previous birth dead by age 5	1.441 **	Mother's age at birth: 10 to 19 years	1.936 **
Previous birth alive at age 5®	1.000	Mother's age at birth: 20 to 24 years®	1.000
Mother: no education®	1.000	Mother's age at birth: 25 to 29 years	0.889
Mother: primary education	1.454 **	Mother's age at birth: 30 to 49 years	1.028
Mother: secondary education	0.000	Previous birth dead by age 5	2.825 ****
Northern Region	0.682	Previous birth alive at age 5®	1.000
Central Region®	1.000	Father's education less than mother's education	0.538 *
Southern Region	2.793 *	Father's education equal to mother's education®	1.000
Xitsonga and similar	0.954	Father's education higher than mother's education	0.632 **
Emakua and similar	0.736	Northern Region	1.298
Cisena and similar®	1.000	Central Region®	1.000
Elomwe and Emarenjo	0.253 ****	Southern Region	0.815
Xitswa and Similar	1.060	Xitsonga and similar	1.667
Portuguese	0.171 *	Emakua and similar	0.972
Other	0.540 *	Cisena and similar®	1.000
Childhood: City	1.136	Elomwe and Emarenjo	0.569
Childhood: Town	0.320 ***	Xitswa and Similar	1.769
Childhood: Countryside®	1.000	Portuguese	0.091 *
Mother: primary education*Northern Region	1.457	Other	0.235 ***
Mother: primary education*Southern Region	0.207 ****	Childhood: City	0.586 *
Mother: secondary education*Northern Region	2.382	Childhood: Town	0.454 **
Mother: secondary education*Southern Region	6.9E+06	Childhood: Countryside®	1.000
Chi-square	35.200 ****		
N	6908		

1993-1998 model		1988-1993 model	
Significant variables	IRR	Significant variables	IRR
		PBI:9-14*Northern Region	1.252
		PBI:9-14*Southern Region	0.575
		PBI:15-20*Northern Region	2.690
		PBI:15-20*Southern Region	0.463
		PBI:27-32*Northern Region	1.137
		PBI:27-32*Southern Region	0.651
		PBI:33-38*Northern Region	0.968
		PBI:33-38*Southern Region	0.913
		PBI:39-44*Northern Region	0.790
		PBI:39-44*Southern Region	1.843
		PBI:45-50*Northern Region	70.120 ****
		PBI:45-50*Southern Region	0.265
		PBI:51-56*Northern Region	0.356
		PBI:51-56*Southern Region	0.760
		PBI:57+*Northern Region	2.970
		PBI:57+*Southern Region	3.616
		Chi-square	434.50 ****
		N	5676

PBI=Length of preceding birth interval, ®=Reference group, *p≤0.1, **p≤0.05, ***p≤0.01, ****p≤0.001.

Table A.8 Child mortality incidence rate ratios for negative binomial models for birth periods 1983 to 1988 and 1978 to 1983

1983-1988 model

Significant variables	IRR
PBI: 9-14 months	1.818
PBI: 15-20 months	1.721 *
PBI: 21-26 months®	1.000
PBI: 27-32 months	1.240
PBI: 33-38 months	1.269
PBI: 39-44 months	1.127
PBI: 45-50 months	1.226
PBI: 51-56 months	0.679
PBI: 57+ months	0.824
No subsequent conception or subsequent conception: 60+ months	0.548 **
Subsequent conception: 0-12 months	1.077
Subsequent conception: 13-24 months®	1.000
Subsequent conception: 25-59 months	0.884
Mother's age at birth: 10 to 19 years	1.373
Mother's age at birth: 20 to 24 years®	1.000
Mother's age at birth: 25 to 29 years	0.900
Mother's age at birth: 30 to 49 years	0.881
Previous birth dead by age 5	3.884 ****
Previous birth alive at age 5®	1.000
Mother: no education®	1.000
Mother: primary education	0.557 **
Mother: secondary education	0.488
Father's education less than mother's education	1.704 *
Father's education equal to mother's education®	1.000
Father's education higher than mother's education	0.872
Northern Region	0.336 ****
Central Region®	1.000
Southern Region	0.505 **
Childhood: City	0.554 *
Childhood: Town	0.624
Childhood: Countryside®	1.000
Mother: primary education*Northern Region	3.454 ***
Mother: primary education*Southern Region	1.899
Mother: secondary education*Northern Region	2.3E-08
Mother: secondary education*Southern Region	6.2E-08
Chi-square	116.78 ****
N	4336

1978-1983 model

Significant variables	IRR
PBI: 9-14 months	0.634
PBI: 15-20 months	0.807
PBI: 21-26 months®	1.000
PBI: 27-32 months	0.731
PBI: 33-38 months	0.629
PBI: 39-44 months	1.231
PBI: 45-50 months	0.332
PBI: 51-56 months	0.308
PBI: 57+ months	0.136 **
No subsequent conception or subsequent conception: 60+ months	0.681
Subsequent conception: 0-12 months	1.903 ***
Subsequent conception: 13-24 months®	1.000
Subsequent conception: 25-59 months	0.617 *
Previous birth dead by age 5	4.340 ****
Previous birth alive at age 5®	1.000
Northern Region	0.752
Central Region®	1.000
Southern Region	0.697
Chi-square	59.80 ****
N	3221

PBI=Length of preceding birth interval, ®=Reference group, *p≤0.1, **p≤0.05, ***p≤0.01, ****p≤0.001.

Table A.9 Under five mortality incidence rate ratios for negative binomial models for birth periods 1993 to 1998 and 1988 to 1993

1993-1998 model

Significant variables	IRR
PBI: 9-14 months	1.708
PBI: 15-20 months	0.837
PBI: 21-26 months®	1.000
PBI: 27-32 months	0.500 ***
PBI: 33-38 months	0.593 *
PBI: 39-44 months	0.429 **
PBI: 45-50 months	0.354 **
PBI: 51-56 months	0.237 ***
PBI: 57+ months	0.132 ****
Index child: male®	1.000
Index child: female	0.786 **
No subsequent conception or subsequent conception: 60+ months	0.791
Subsequent conception: 0-12 months	5.552 ****
Subsequent conception: 13-24 months®	1.000
Subsequent conception: 25-59 months	0.411 ****
Mother's age at birth: 10 to 19 years	1.069
Mother's age at birth: 20 to 24 years®	1.000
Mother's age at birth: 25 to 29 years	0.673 ***
Mother's age at birth: 30 to 49 years	0.761 *
Previous birth dead by age 5	3.082 ****
Previous birth alive at age 5®	1.000
Mother: no education®	1.000
Mother: primary education	0.540 **
Mother: secondary education	0.024 **
Father's education less than mother's education	1.410
Father's education equal to mother's education®	1.000
Father's education higher than mother's education	0.677 ***
Northern Region	2.076 ****
Central Region®	1.000
Southern Region	1.148
Childhood: City	0.876
Childhood: Town	0.571 **
Childhood: Countryside®	1.000

1988-1993 model

Significant variables	IRR
PBI: 9-14 months	2.997 ****
PBI: 15-20 months	3.144 ****
PBI: 21-26 months®	1.000
PBI: 27-32 months	1.385
PBI: 33-38 months	0.644
PBI: 39-44 months	1.238
PBI: 45-50 months	0.417 **
PBI: 51-56 months	1.135
PBI: 57+ months	0.136 ****
No subsequent conception or subsequent conception: 60+ months	0.645 ***
Subsequent conception: 0-12 months	3.824 ****
Subsequent conception: 13-24 months®	1.000
Subsequent conception: 25-59 months	0.455 ****
Mother's age at birth: 10 to 19 years	1.242
Mother's age at birth: 20 to 24 years®	1.000
Mother's age at birth: 25 to 29 years	0.760 *
Mother's age at birth: 30 to 49 years	0.828
Previous birth dead by age 5	3.853 ****
Previous birth alive at age 5®	1.000
Mother: no education®	1.000
Mother: primary education	0.811
Mother: secondary education	0.739
Father's education less than mother's education	1.738 ***
Father's education equal to mother's education®	1.000
Father's education higher than mother's education	1.103
Northern Region	3.244 ****
Central Region®	1.000
Southern Region	2.002
No religion	0.707 *
Catholic®	1.000
Muslim	0.707 **
Zion	0.698
Protestant/Evangelic	0.932
Other	1.832 **

1993-1998 model		1988-1993 model	
Significant variables	IRR	Significant variables	IRR
PBI:9-14*Mother: primary education	1.194	Xitsonga and similar	0.659
PBI:9-14*Mother: secondary education	1.1E-07	Emakua and similar	1.190
PBI:15-20*Mother: primary education	1.911 *	Cisena and similar®	1.000
PBI:15-20*Mother: secondary education	130.801 **	Elomwe and Emarenjo	0.975
PBI:27-32*Mother: primary education	1.422	Xitswa and Similar	0.970
PBI:27-32*Mother: secondary education	0.670	Portuguese	0.141 ****
PBI:33-38*Mother: primary education	1.180	Other	0.794
PBI:33-38*Mother: secondary education	2.4E-06	Childhood: City	0.642 **
PBI:39-44*Mother: primary education	1.095	Childhood: Town	0.521 ****
PBI:39-44*Mother: secondary education	2.3E-06	Childhood: Countryside®	1.000
PBI:45-50*Mother: primary education	0.504	PBI:9-14*Northern Region	0.582
PBI:45-50*Mother: secondary education	16.658	PBI:9-14*Southern Region	0.220 **
PBI:51-56*Mother: primary education	2.250	PBI:15-20*Northern Region	0.574
PBI:51-56*Mother: secondary education	1.4E-05	PBI:15-20*Southern Region	0.336 **
PBI:57+*Mother: primary education	4.984 ****	PBI:27-32*Northern Region	0.511 *
PBI:57+*Mother: secondary education	277.689 ***	PBI:27-32*Southern Region	0.699
Mother: primary education*Northern Region	0.781	PBI:33-38*Northern Region	0.754
Mother: primary education*Southern Region	0.451 **	PBI:33-38*Southern Region	1.299
Mother: secondary education*Northern Region	0.028	PBI:39-44*Northern Region	0.341 **
Mother: secondary education*Southern Region	0.269	PBI:39-44*Southern Region	1.829
		PBI:45-50*Northern Region	1.361
		PBI:45-50*Southern Region	1.341
		PBI:51-56*Northern Region	0.110 **
		PBI:51-56*Southern Region	0.923
		PBI:57+*Northern Region	1.124
		PBI:57+*Southern Region	3.211 *
Chi-square	2221.84 ****	*Chi-square*	2360.34 ****
N	8943	N	8351

PBI=Length of preceding birth interval, ®=Reference group, *p≤0.1, **p≤0.05, ***p≤0.01, ****p≤0.001.

Table A.10 Under five mortality incidence rate ratios for negative binomial models for birth periods 1983 to 1988 and 1978 to 1983

1983-1988 model		1978-1983 model	
Significant variables	IRR	Significant variables	IRR
PBI: 9-14 months	0.979	PBI: 9-14 months	2.699 ***
PBI: 15-20 months	1.492 **	PBI: 15-20 months	1.258
PBI: 21-26 months®	1.000	PBI: 21-26 months®	1.000
PBI: 27-32 months	0.802	PBI: 27-32 months	1.110
PBI: 33-38 months	0.374 ****	PBI: 33-38 months	0.486 *
PBI: 39-44 months	0.722	PBI: 39-44 months	0.463
PBI: 45-50 months	0.331 ****	PBI: 45-50 months	0.023 *
PBI: 51-56 months	0.431 **	PBI: 51-56 months	0.227
PBI: 57+ months	0.220 ****	PBI: 57+ months	0.000
No subsequent conception or subsequent conception: 60+ months	1.068	Index child: male®	1.000
Subsequent conception: 0-12 months	3.677 ****	Index child: female	0.769 *
Subsequent conception: 13-24 months®	1.000	No subsequent conception or subsequent conception: 60+ months	0.918
Subsequent conception: 25-59 months	0.714 **	Subsequent conception: 0-12 months	1.000
Mother's age at birth: 10 to 19 years	1.352 **	Subsequent conception: 13-24 months®	3.114 ****
Mother's age at birth: 20 to 24 years®	1.000	Subsequent conception: 25-59 months	0.590 ***
Mother's age at birth: 25 to 29 years	0.831	Mother's age at birth: 10 to 19 years	1.367 *
Mother's age at birth: 30 to 49 years	1.013	Mother's age at birth: 20 to 24 years®	1.000
Previous birth dead by age 5	5.040 ****	Mother's age at birth: 25 to 29 years	1.204
Previous birth alive at age 5®	1.000	Mother's age at birth: 30 to 49 years	1.232
Mother: no education®	1.000	Previous birth dead by age 5	4.820 ****
Mother: primary education	0.822	Previous birth alive at age 5®	1.000
Mother: secondary education	0.664	Mother: no education®	1.000
Northern Region	2.160 ***	Mother: primary education	0.707
Central Region®	1.000	Mother: secondary education	0.653
Southern Region	1.487	Father's education less than mother's education	1.620 *
Xitsonga and similar	0.373 **	Father's education equal to mother's education®	1.000
Emakua and similar	0.727	Father's education higher than mother's education	0.899
Cisena and similar®	1.000	Northern Region	1.380
Elomwe and Emarenjo	1.490 *	Central Region®	1.000
Xitswa and Similar	0.552	Southern Region	0.335 *
Portuguese	0.056 ****	Xitsonga and similar	1.917
Other	0.503 **	Emakua and similar	1.056
Mother: primary education*Northern Region	1.511 *	Cisena and similar®	1.000
Mother: primary education*Southern Region	0.666	Elomwe and Emarenjo	1.431
Mother: secondary education*Northern Region	2.9E-10	Xitswa and Similar	2.131
Mother: secondary education*Southern Region	0.293	Portuguese	0.158 **
		Other	1.628
Chi-square	1669.27 ****		
N	7339		

1983-1988 model		1978-1983 model	
Significant variables	IRR	Significant variables	IRR
		Childhood: City	0.487 ***
		Childhood: Town	0.669
		Childhood: Countryside®	1.000
		PBI:9-14*Mother: primary education	1.211
		PBI:9-14*Mother: secondary education	59.816 **
		PBI:15-20*Mother: primary education	0.765
		PBI:15-20*Mother: secondary education	3.1E-09
		PBI:27-32*Mother: primary education	1.077
		PBI:27-32*Mother: secondary education	0.196
		PBI:33-38*Mother: primary education	1.749
		PBI:33-38*Mother: secondary education	1.5E-08
		PBI:39-44*Mother: primary education	0.731
		PBI:39-44*Mother: secondary education	1.9E-08
		PBI:45-50*Mother: primary education	1.013
		PBI:45-50*Mother: secondary education	818.130 ****
		PBI:51-56*Mother: primary education	2.544
		PBI:57+*Mother: primary education	0.155
		PBI:57+*Mother: secondary education	7.4E-08
		PBI:9-14*Northern Region	0.222 ***
		PBI:9-14*Southern Region	0.556
		PBI:15-20*Northern Region	3.356 ***
		PBI:15-20*Southern Region	0.996
		PBI:27-32*Northern Region	1.311
		PBI:27-32*Southern Region	0.941
		PBI:33-38*Northern Region	0.696
		PBI:33-38*Southern Region	2.002
		PBI:39-44*Northern Region	8.949 ***
		PBI:39-44*Southern Region	1.971
		PBI:45-50*Northern Region	19.660
		PBI:45-50*Southern Region	26.111
		PBI:51-56*Northern Region	0.915
		PBI:51-56*Southern Region	0.319
		PBI:57+*Northern Region	9.8E+07
		PBI:57+*Southern Region	8.0E+07
		Chi-square	604.99 ****
		N	4158

PBI=Length of preceding birth interval, ®=Reference group, *p≤0.1, **p≤0.05, ***p≤0.01, ****p≤0.001.