Short birth spacing and child mortality in Mozambique

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ABSTRACT

A short preceding birth interval is associated with increased child mortality risk. High socio-economic status and access to health care mitigate the high mortality risk. The legacy of colonialism and two almost successive wars in Mozambique resulted in widespread poverty, low literacy and low contraceptive use and an inadequate health care system. A piecewise log rate model is applied to examine child mortality risk associated with short preceding birth intervals in Mozambique using the 1997 and 2003 DHS data. Effects of a short preceding birth interval are strongest during the first month, suggesting pre-natal mechanisms of maternal depletion as the dominant pathway. An optimal birth spacing period of three and a half years was estimated to reduce the high risk of neonatal mortality, thus advocating an extra "waiting period" of 6 months under the optimal spacing banner of "Three to five saves lives" for couples in Mozambique.

1. INTRODUCTION

The relationship between short 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.

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). Furthermore, 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).

The contribution of short birth spacing to child mortality however remains a significant problem in developing countries (Norton 2005). An estimated 35 per cent of deaths among children under the age of 5 could have been averted from spacing births by at least 36 months in developing countries (excluding China) in 2003 (Rutstein 2005).

This research investigates effects of a short preceding birth interval on child mortality in Mozambique. Birth spacing is defined as the interval between two consecutive live births. The length of the preceding birth interval is the main explanatory variable and child mortality the outcome variable.

2. BACKGROUND

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 (Kaplan 1984). 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). 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).

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). 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) estimate that almost half of the primary health care network (delivering maternal and child health including family planning services) was destroyed between 1982 and 1990.

As a consequent, 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. The latest Human Development Report for Mozambique estimates National Health Service coverage at between 40 to 50 per cent (UNDP 2007a).

Current contraception use of both modern and traditional methods among all 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). Low contraception use (both modern and traditional methods) increases the chances of short birth spacing. 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%) was estimated to be living below the national poverty line between 2002 and 2003 (INE 2004b).

Under conditions of low socio-economic status and inadequate child health care services, children born following a short preceding birth interval are hypothesized to be exposed to a higher risk of child mortality in Mozambique.

Results of this research will highlight the risk and mechanisms of short preceding birth intervals, inform policy and contribute to the reduction of child mortality rates in Mozambique.

3. REVIEW OF BIRTH SPACING AND CHILD MORTALITY IN MOZAMBIQUE

Preceding birth intervals in the 1997 and 2003 DHS are skewed to the right. Heaping was noted 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. 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 subsequently younger children in intervals of 2 years/3 years. The heaping patterns in the 2003 DHS most likely resulted from enumerator's attempts to avoid the 1997 DHS heaping patterns 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."

More than half of preceding birth intervals across quinquennial birth periods in the 1997 and 2003 DHS data are less than the recommended minimum birth spacing period of 36 months (Setty-Venugopal and Upadhyay 2002) (Table 1). Proportions of preceding birth intervals less than 36 months have generally been decreasing over quinquennial periods. Low contraception use of both modern and traditional methods among women of reproductive age estimated at 18.2 per cent in 2003, from 6 per cent in 1997 is a main contributory factor of short birth spacing in Mozambique (Gaspar, Cossa, Santos *et al* 1998, Instituto Nacional de Estatística and Ministério de Saúde 2005).

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

Table 1: Weighted per cent distribution of preceding birth interval categorizes (in months) for quinquennial birth periods, 1997 and 2003 DHS

DHS Reference	Period of birth	<12	12-24	24-36	36-48	48-60	60+	Total	<36
1997 DHS	1992-1997	2.2	16.9	35.1	22.6	10.4	12.8	100	**54.2**
	1987-1992	5.3	27.8	33.6	16.6	7.2	9.5	100	**66.7**
	1982-1987	3.8	29.0	39.9	15.4	5.5	6.4	100	**72.7**
	1977-1982	4.2	34.2	39.8	14.0	3.3	4.5	100	**78.2**
	1972-1977	5.3	35.9	34.1	16.8	4.0	3.9	100	**75.3**
	1967-1972	2.7	41.9	40.1	11.4	1.8	2.1	100	**84.7**
2003 DHS	1998-2003	0.7	15.8	39.1	21.6	10.5	12.5	100	**55.5**
	1993-1998	2.7	29.1	36.6	16.1	6.6	8.9	100	**68.4**
	1988-1993	2.9	28.2	38.5	15.6	6.6	8.3	100	**69.5**
	1983-1988	3.1	30.1	41.3	14.6	5.1	5.9	100	**74.4**
	1978-1983	3.0	37.2	39.9	13.3	3.9	2.7	100	**80.1**
	1973-1978	6.8	39.8	40.2	10.1	1.9	1.2	100	**86.8**

Furthermore, population movement and displacement of communities in Mozambique as a result of the civil war is hypothesized to have disrupted social control mechanisms maintaining traditional 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). Social control is necessary to insure compliance with society practices and this is facilitated by social cohesion (Meier 1982). A Giddensian analysis would however suggest that social control (or at least the threat of social sanction), while necessary, is not sufficient to maintain social practices (Giddens 1984).

Whilst prolonged breastfeeding has remained widespread in Mozambique (Arnaldo 2003) (median duration of 22 months in the 1997 DHS and 22.7 months in the 2003 DHS), traditional practices of postpartum sexual abstinence and other practices that contributed to longer spacing are hypothesized to have been weakened. For example 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).

Postpartum sexual abstinence

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). 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 also 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 prohibited as it is believed to endanger the child's health (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).

Postpartum amenorrhea

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 (Wembah-Rashid 1995). In Northern Mozambique, *coitus interruptus* was practiced in postpartum sexual relations if the mother had experienced menstruation (Wembah-Rashid 1995).

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).

Bi-variate analysis of preceding birth intervals with child mortality in Mozambique

Short preceding birth intervals of less than 24 months are consistently associated with higher rates of child mortality across the various ages at death in the bi-variate analysis (Table 2).

Table 2: Neonatal, postneonatal, infant, child and under five mortality rates by preceding birth interval categories (in months) for the five years preceding the survey, 1997 and 2003 DHS

DHS Reference	Period	Neonatal	Postneonatal	Infant	Child	Under 5
1997 DHS	<24	95	119	214	93	287
	24-36	57	75	132	77	198
	36-48	47	30	77	84	154
	48+	13	67	80	59	134
2003 DHS	<24	64	107	171	69	228
	24-36	31	53	84	64	142
	36-48	24	39	64	43	104
	48+	17	45	62	39	98

Hypothesised mechanisms of a short preceding birth interval on child mortality

A short preceding birth interval is hypothesized to affect child mortality in three ways. First, maternal depletion caused by inadequate nutritional recovery of the mother after the preceding birth coupled with breastfeeding impairs fetal intrauterine growth of the index[2] child. 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 including food, health services 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 younger 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 younger index child (Whitworth and Stephenson 2002).

4. METHODOLOGY

A 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. A 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 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). 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

[2] Index child is the child under study

models to deal with censored observations. Censored observations are observations with partial information on the duration of the risk period (Yamaguchi 1991).

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:

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

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

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

β 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 be reasonably assumed as piecewise otherwise inconsistent parameters are obtained (Holford 1976, Friedman 1982). Child mortality risks have been shown to differ with varying categories of the length of the preceding birth interval implying that the hazard can be assumed piecewise (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 be different among heterogeneous groups and for these differences to be characterized by modelling time independent categorical explanatory variables. The above mentioned studies that support the piecewise nature of the hazard also highlighted differences among heterogeneous groups through the modelling of time 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). This assumption refers to the link function of the log rate model and the relationship is shown when discussing the Poisson model.

The Poisson regression model is applied as the log rate model in computing piecewise constant rates. 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 $Y_1,...,Y_N$ as independent random variables, the generalized linear model for Poisson regression can be represented as (Dobson 2001):

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

where Y_i = the number of events observed from exposure n_i for the *i*th 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):

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

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 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. 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. Three model testing parameters were applied to Poisson models to test for and confirm real overdispersion; the Pearson chi-square dispersion value, Lagrange multiplier and Z tests (Hilbe 2007).

The data were found to be overdispersed and the negative binomial variant of the Poisson model was 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.

Model fit of the fitted negative binomial models was tested using the likelihood ratio chi-square test with the null hypothesis being that the overdispersion parameter α is equal to zero (in which case the model is equivalent to a Poisson model). A dispersion parameter that is significantly greater than zero indicates the negative binomial model as a better model fit relative to the Poisson model.

Limitations of log rate model for piecewise constant rates

The specification of the number of intervals in log rate piecewise models is subjectively determined 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, $I \to \infty$) 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).

5. DATA ANALYSIS

The 1997 and 2003 DHS data files were aggregated based on the date of birth of reported children (month and year). Data were weighted before aggregation. 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. The final aggregated data set used in data analysis extended over the 20 year period September 1978 to September 1998.

The aggregation of weighted data however leads to narrower standard deviations of estimated coefficients. This affects the standard deviations of coefficients and not the coefficients themselves thus maintaining the integrity of model results. Hence marginally significant results may be best taken as statistically insignificant (Moultrie 2002).

A separate model was run for each quinquennial birth period between 1978 and 1998 instead of creating a dummy variable for the period of birth (common approach). Therefore four quinquennial models were run 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, to have a total of 20 models. This approach was taken to allow significant variables of child mortality to be determined for each birth period and highlight period determinants of child mortality in Mozambique.

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. A maximum parity of 15 was set to minimize data errors in birth history data introduced by very distant events.

Categories of preceding birth intervals 6 months in length were employed in modelling the risk of child mortality associated with the length of the preceding birth interval in Mozambique. The minimum preceding birth interval length was set at 9 months with an open interval of preceding birth intervals 57 months or longer. The lower limit was set at 9 months 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 may confound analysis (Rutstein 2005). 0.8 per cent of children in the 2003 DHS had a preceding birth interval of less than 9 months.

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 3).

Table 3: 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

Covariates

The Mosley and Chen (1984) framework of proximate and socio-economic determinants of child mortality in developing countries provided the main basis for covariates of child mortality. The inclusion of variables is subject to their availability in the 1997 and 2003 DHS data and variables that can be reasonably assumed to have remained constant between the time of birth of the index child and the survey date were modelled to avoid the problem of current status data.

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). 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. 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.

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.

A summary of the eleven covariates modelled with respective categories and frequency distributions for the period 1978 to 1998 for the 1997 and 2003 DHS is presented in Table 4. The most frequently occurring category or mode of each variable was selected as the reference category avoid the number of cases influencing the significance of model estimates.

Table 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

6. Model Results

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. 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.

Once the main effects model was determined, variable interactions were tested to determine the presence of effect modifiers. 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). 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 is hypothesized to have better health service delivery compared to the Central region and the North which is the least urbanized (Arnaldo 2003). Three way interactions were also tested if two way interactions were found significant (refer to model outputs in the appendix).

Model results are presented in the form of predicted incidence rates

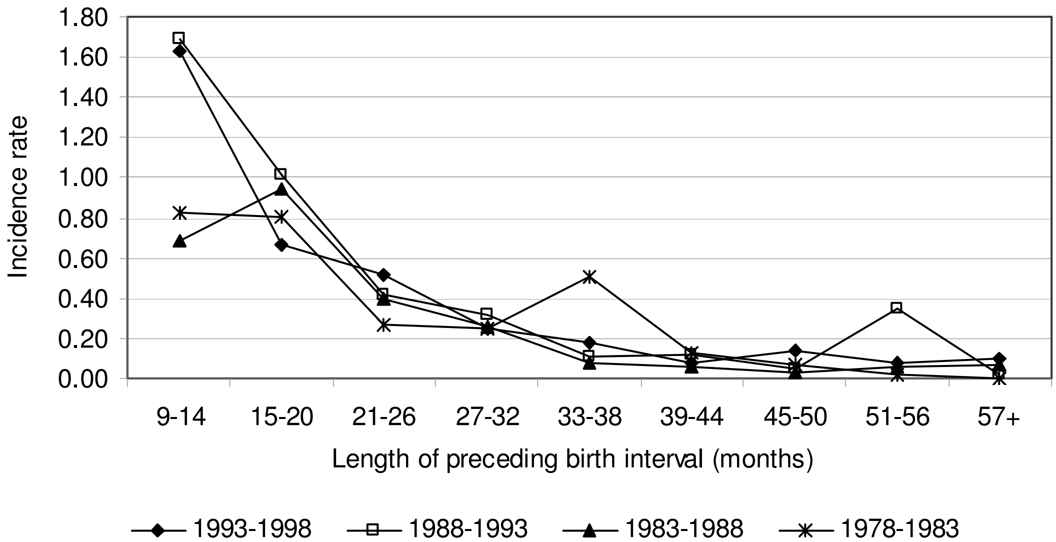
Neonatal mortality (less than 1 month)

Two general patterns can be noted in the predicted incidence of neonatal mortality. The two most recent birth periods 1988 to 1993 and 1993 to 1998 display a declining trend in predicted incidence 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, 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 1). A generally declining trend is noted thereafter. The observed fluctuations result from scanty data for categories of longer preceding birth intervals.

The observed trend for the shortest preceding birth interval during the period 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).

A visual inspection of the plot of predicted rates (Figure 1) shows that rates level off in the preceding birth interval category of 39 to 44 months. 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 gain from additional 6 month spacing.

Figure 1: Predicted incidence rates for neonatal mortality for each length of preceding birth interval category and quinquennial birth period



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 5).

Table 5: 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

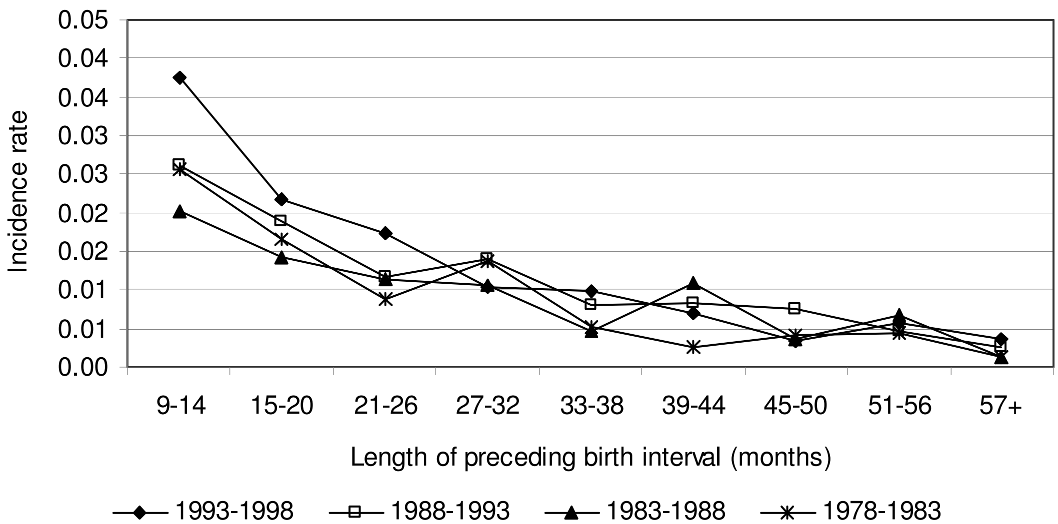
Children born during the period 1993 to 1998 with a preceding birth interval of between 9 to 14 months have a relative risk of neonatal mortality twenty fold that of children born following the suggested optimal spacing of between 39 to 44 months (Table

5). 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.

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 2). The trend in postneonatal incidence rates is however highly erratic for preceding birth interval categories of 27 months and longer, making it difficult to estimate an optimal birth spacing period for postneonatal mortality. Relative risks were not calculated.

Figure 2: Predicted incidence rates for postneonatal mortality for each length of preceding birth interval category and quinquennial birth period



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 3). Incidence rates appear to level off in the category 33 to 38 months (mid point of approximately 36 months) although fluctuating in subsequent categories. Thus an optimal birth spacing period of 36 months is implied for infant mortality in Mozambique.

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). 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).

Figure 3: Predicted incidence rates for infant mortality for each length of preceding birth interval category and quinquennial birth period

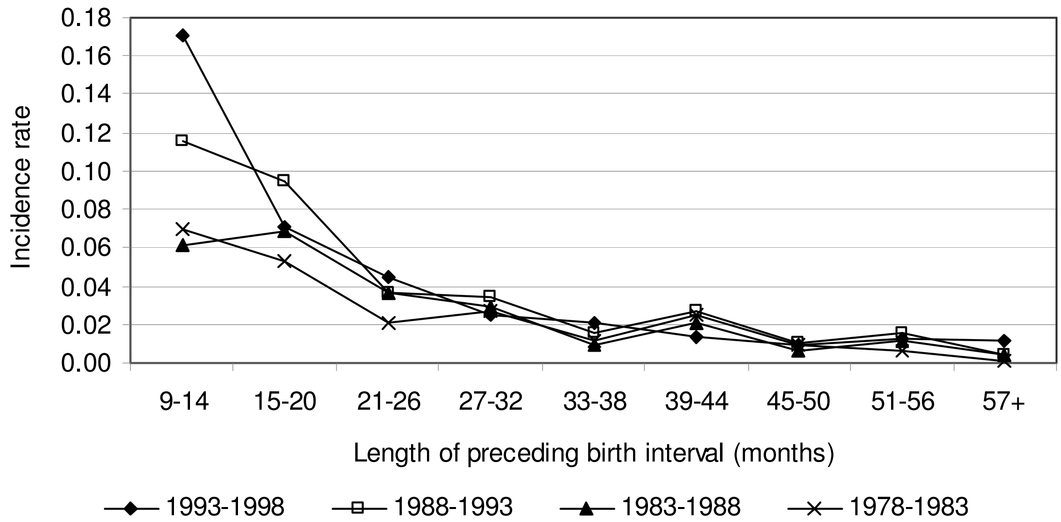


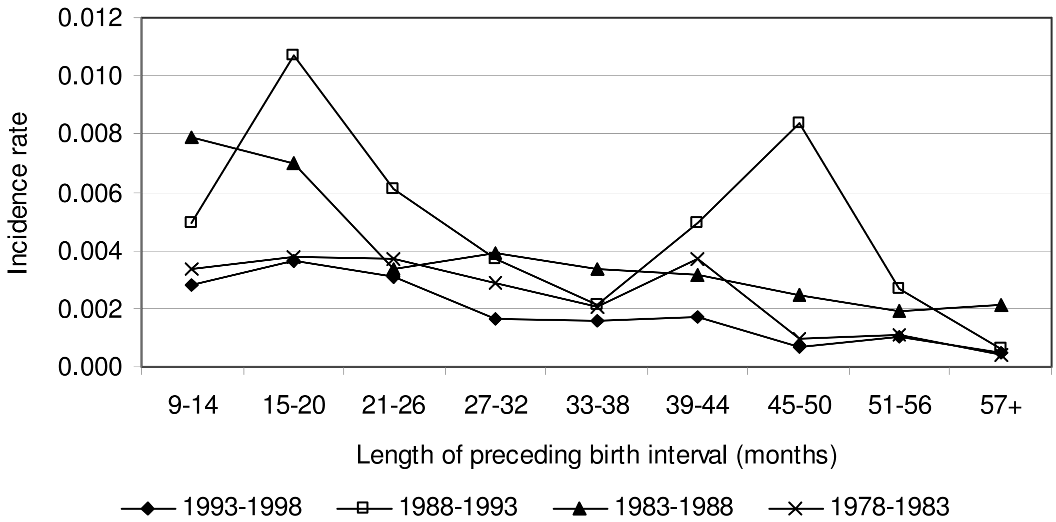
Table 6: Relative risk of infant mortality for each length of preceding birth interval category (in months) and quinquennial birth period

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 4). 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.

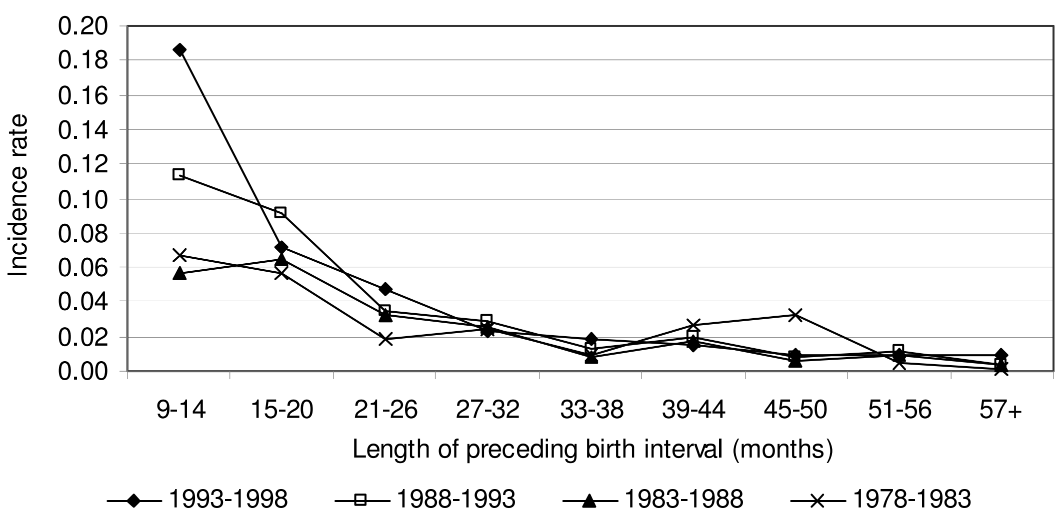
Figure 4: Predicted incidence rates for child mortality for each length of preceding birth interval category and quinquennial birth period



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 5). 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 5: 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 5). 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 5). 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 7 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 7).

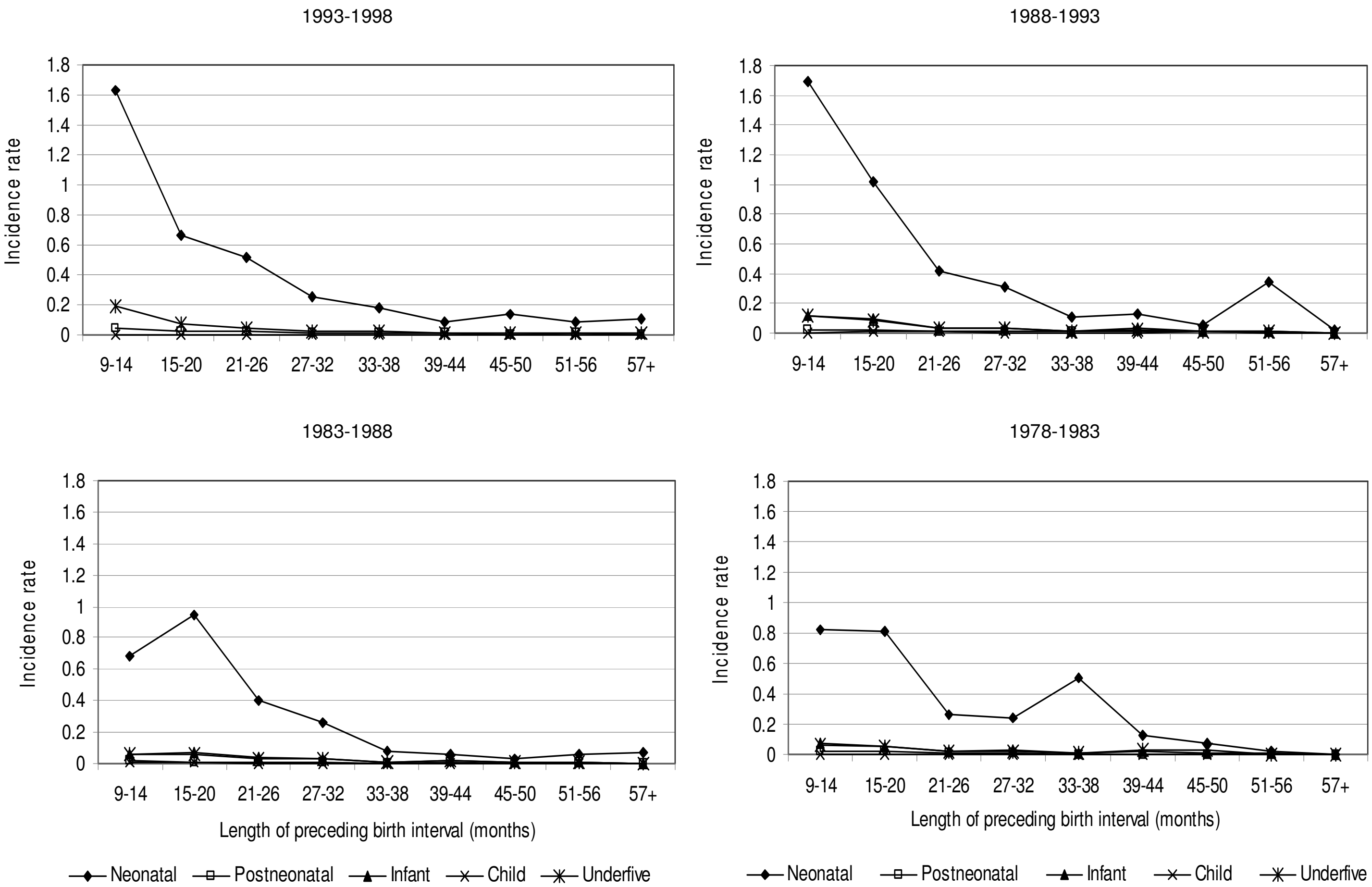
Table 7: Relative risk of underfive mortality for each length of preceding birth interval category (in months) and quinquennial birth period

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

Comparison of predicted incidence across the various ages at death

Predicted incidence rates at the various ages at death were plotted for each birth period (Figure 6). Incidence rates of neonatal mortality associated with categories of shorter preceding birth intervals are markedly higher compared to other ages at death signifying that the effect of short preceding birth intervals is strongest in the first month of life. 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.

Figure 6: Predicted incidence rates for each birth period, across the various ages at death and preceding birth interval categories



7. DISCUSSION

Multivariate model results confirm the association of short preceding birth intervals with child mortality[3] 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. Some 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)

[3] Child mortality in the general sense

caution that the absence of stronger effects in the neonatal period may be a result of selective underreporting of neonatal deaths in retrospective data.

Child minding or child fostering of older closely spaced siblings by extended family members may explain the weaker postneonatal mechanisms observed. Child fostering was reported to be common in Mozambique (Arnaldo 2003). 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).

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 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. 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) (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).

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 this suggested 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.

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.

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 likely 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); foetal loss in pregnant HIV positive women and increased adult mortality from AIDS related deaths resulting in biased child mortality estimates (Du Plessis 2003, Mahy 2003).

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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≤0.1, **p≤0.05, ***p≤0.01, ****p≤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≤0.1, **p≤0.05, ***p≤0.01, ****p≤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≤0.1, **p≤0.05, ***p≤0.01, ****p≤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		1988-1993 model	
Significant variables	IRR	Significant variables	IRR
PBI: 9-14 months	1.830 ***	PBI: 9-14 months	1.903 ***
PBI: 15-20 months	1.161	PBI: 15-20 months	2.003 ****
PBI: 21-26 months®	1.000	PBI: 21-26 months®	1.000
PBI: 27-32 months	0.635 ***	PBI: 27-32 months	0.985
PBI: 33-38 months	0.692 *	PBI: 33-38 months	0.651 **
PBI: 39-44 months	0.430 ****	PBI: 39-44 months	1.072
PBI: 45-50 months	0.320 ****	PBI: 45-50 months	0.549 **
PBI: 51-56 months	0.448 **	PBI: 51-56 months	0.705
PBI: 57+ months	0.417 ****	PBI: 57+ months	0.255 ****
Index child: male®	1.000	No subsequent conception or subsequent conception: 60+ months	0.749 *
Index child: female	0.811 *	Subsequent conception: 0-12 months	3.576 ****
No subsequent conception or subsequent conception: 60+ months	0.796	Subsequent conception: 13-24 months®	1.000
Subsequent conception: 0-12 months	4.836 ****	Subsequent conception: 25-59 months	0.472 ****
Subsequent conception: 13-24 months®	1.000	Mother's age at birth: 10 to 19 years	1.238
Subsequent conception: 25-59 months	0.388 ****	Mother's age at birth: 20 to 24 years®	1.000
Mother's age at birth: 10 to 19 years	1.051	Mother's age at birth: 25 to 29 years	0.772 *
Mother's age at birth: 20 to 24 years®	1.000	Mother's age at birth: 30 to 49 years	0.849
Mother's age at birth: 25 to 29 years	0.730 **	Previous birth dead by age 5	3.543 ****
Mother's age at birth: 30 to 49 years	0.818	Previous birth alive at age 5®	1.000
Previous birth dead by age 5	2.829 ****	Father's education less than mother's education	1.553 **
Previous birth alive at age 5®	1.000	Father's education equal to mother's education®	1.000
Mother: no education®	1.000	Father's education higher than mother's education	1.201
Mother: primary education	0.604 ****	Northern Region	2.165 ****
Mother: secondary education	0.182 ***	Central Region®	1.000
Father's education less than mother's education	1.449	Southern Region	2.089
Father's education equal to mother's education®	1.000	No religion	0.757
Father's education higher than mother's education	0.703 **	Catholic®	1.000
Northern Region	1.783 ****	Muslim	0.745 *
Central Region®	1.000	Zion	0.722
Southern Region	0.727 **	Protestant/Evangelic	0.892
Childhood: City	0.912	Other	1.917 **
Childhood: Town	0.654 *		
Childhood: Countryside®	1.000		
Chi-square	1462.450 ****		
N	8943		

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			1978-1983 model		
Significant variables	IRR		Significant variables	IRR	
PBI: 9-14 months	1.818		PBI: 9-14 months	0.634	
PBI: 15-20 months	1.721	*	PBI: 15-20 months	0.807	
PBI: 21-26 months®	1.000		PBI: 21-26 months®	1.000	
PBI: 27-32 months	1.240		PBI: 27-32 months	0.731	
PBI: 33-38 months	1.269		PBI: 33-38 months	0.629	
PBI: 39-44 months	1.127		PBI: 39-44 months	1.231	
PBI: 45-50 months	1.226		PBI: 45-50 months	0.332	
PBI: 51-56 months	0.679		PBI: 51-56 months	0.308	
PBI: 57+ months	0.824		PBI: 57+ months	0.136	**
No subsequent conception or subsequent conception: 60+ months	0.548	**	No subsequent conception or subsequent conception: 60+ months	0.681	
Subsequent conception: 0-12 months	1.077		Subsequent conception: 0-12 months	1.903	***
Subsequent conception: 13-24 months®	1.000		Subsequent conception: 13-24 months®	1.000	
Subsequent conception: 25-59 months	0.884		Subsequent conception: 25-59 months	0.617	*
Mother's age at birth: 10 to 19 years	1.373		Previous birth dead by age 5	4.340	****
Mother's age at birth: 20 to 24 years®	1.000		Previous birth alive at age 5®	1.000	
Mother's age at birth: 25 to 29 years	0.900		Northern Region	0.752	
Mother's age at birth: 30 to 49 years	0.881		Central Region®	1.000	
Previous birth dead by age 5	3.884	****	Southern Region	0.697	
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	****	*Chi-square*	59.80	****
N	4336		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		1988-1993 model	
Significant variables	IRR	Significant variables	IRR
PBI: 9-14 months	1.708	PBI: 9-14 months	2.997 ****
PBI: 15-20 months	0.837	PBI: 15-20 months	3.144 ****
PBI: 21-26 months®	1.000	PBI: 21-26 months®	1.000
PBI: 27-32 months	0.500 ***	PBI: 27-32 months	1.385
PBI: 33-38 months	0.593 *	PBI: 33-38 months	0.644
PBI: 39-44 months	0.429 **	PBI: 39-44 months	1.238
PBI: 45-50 months	0.354 **	PBI: 45-50 months	0.417 **
PBI: 51-56 months	0.237 ***	PBI: 51-56 months	1.135
PBI: 57+ months	0.132 ****	PBI: 57+ months	0.136 ****
Index child: male®	1.000	No subsequent conception or subsequent conception: 60+ months	0.645 ***
Index child: female	0.786 **	Subsequent conception: 0-12 months	3.824 ****
No subsequent conception or subsequent conception: 60+ months	0.791	Subsequent conception: 13-24 months®	1.000
Subsequent conception: 0-12 months	5.552 ****	Subsequent conception: 25-59 months	0.455 ****
Subsequent conception: 13-24 months®	1.000	Mother's age at birth: 10 to 19 years	1.242
Subsequent conception: 25-59 months	0.411 ****	Mother's age at birth: 20 to 24 years®	1.000
Mother's age at birth: 10 to 19 years	1.069	Mother's age at birth: 25 to 29 years	0.760 *
Mother's age at birth: 20 to 24 years®	1.000	Mother's age at birth: 30 to 49 years	0.828
Mother's age at birth: 25 to 29 years	0.673 ***	Previous birth dead by age 5	3.853 ****
Mother's age at birth: 30 to 49 years	0.761 *	Previous birth alive at age 5®	1.000
Previous birth dead by age 5	3.082 ****	Mother: no education®	1.000
Previous birth alive at age 5®	1.000	Mother: primary education	0.811
Mother: no education®	1.000	Mother: secondary education	0.739
Mother: primary education	0.540 **	Father's education less than mother's education	1.738 ***
Mother: secondary education	0.024 **	Father's education equal to mother's education®	1.000
Father's education less than mother's education	1.410	Father's education higher than mother's education	1.103
Father's education equal to mother's education®	1.000	Northern Region	3.244 ****
Father's education higher than mother's education	0.677 ***	Central Region®	1.000
Northern Region	2.076 ****	Southern Region	2.002
Central Region®	1.000	No religion	0.707 *
Southern Region	1.148	Catholic®	1.000
Childhood: City	0.876	Muslim	0.707 **
Childhood: Town	0.571 **	Zion	0.698
Childhood: Countryside®	1.000	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.