ORIGINAL RESEARCH ARTICLE

Short preceding birth intervals and child mortality in Mozambique

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Abstract

This paper examines the risk of child mortality associated with short preceding birth intervals in Mozambique. We apply a piecewise log-rate model to a pooled dataset comprising 36,305 live births from the 1997 and 2003 Mozambique Demographic and Health Surveys (DHS). Our results show that the effects of short preceding intervals are strongest during the first month of life, particularly the first week, indicating prenatal maternal depletion as the dominant pathway. The rapid decline in mortality rates from intervals of less than six months to the category 30 to 35 months suggests an optimal waiting period of at least 30 months between one birth and the next pregnancy. 73 per cent of births had preceding intervals less than 30 months which, amidst low contraception use, indicates a potential for family planning programs to contribute to child survival and the attainment of Millennium Development Goal 4 in Mozambique. (*Afr J Reprod Health 2012; 16[4]: 29-42).*

Résumé

Cet article examine le risque de la mortalité infantile liée à de courts intervalles entre les naissances précédentes au Mozambique. Nous appliquons un taux de morceaux log-modèle à un ensemble de données commun qui comprennent 36,305 naissances vivantes tirées de l'enquête démographique et de santé (EDS) de 1997 de 2003 au Mozambique. Nos résultats montrent que les effets de courts intervalles précédents sont les plus forts pendant le premier mois de vie, surtout la première semaine, ce qui indique l'épuisement maternel prénatal comme la voie dominante. La baisse rapide des taux de mortalité à partir des intervalles de moins de six mois jusqu'à la catégorie de 30 à 35 mois, indiquent une période d'attente optimale d'au moins 30 mois entre une naissance et la prochaine grossesse. 73 pour cent des naissances ont précédé les intervalles de moins de 30 mois, ce qui, au milieu de faible utilisation de la contraception, indique un potentiel pour les programmes de planification familiale pour contribuer à la survie de l'enfant et de la réalisation des OMD 4 au Mozambique (*Afr J Reprod Health 2012; 16[4]: 29-42).*

Keywords: Child mortality, birth spacing, preceding birth intervals, contraception use, Mozambique

Introduction

Numerous studies (summarised by Rutstein[1]) have established that short preceding birth intervals are associated with an increased risk of child mortality. For children in developed countries, access to improved neonatal medical technology and - for the most part - having educated and employed mothers mitigates the risk associated with short preceding intervals[2,3]. In contrast, short preceding intervals remain a significant contributing factor to child mortality in developing countries[4,5]. A recent analysis of data from 52 Demographic and Health Surveys (DHS) from 44 developing countries found that children born with a preceding birth to pregnancy interval of less than six months have a mortality risk two to three times greater than children with an interval of 36 to 47 months at equivalent ages[5]. In this paper, we highlight child mortality risks and plausible causal mechanisms associated with short preceding birth intervals in Mozambique.

Located along the southeast African coast, Mozambique gained independence from Portugal in 1975 following a 10-year liberation war. A vicious civil war between the ruling FRELIMO party and opposition RENAMO erupted in the year after independence and lasted 16 years until 1992[6]. At independence, over 70 per cent of the predominantly rural-based African population lacked access to health care, with adult literacy estimated at around 5 per cent[7-9]. Government efforts to increase access to health care and improve education were however hindered by the civil war which saw the destruction of almost half of the primary health care network between 1982 and 1990[10] and the destruction of 58 per cent of schools operational in 1983 by 1991[8].

Infant mortality decline in Mozambique has been documented since 1960[10], although the decline stalled in the period coinciding with the civil war, and was most likely aggravated by increased medical costs and food prices arising from the introduction of the Economic Structural Adjustment Program in 1987[10]. Infant mortality was estimated at 231 deaths per 1000 live births in the 1960 Census, and had declined to 156 in the 1980 Census and to 144 deaths per 1000 live births in the 1997 Census[11]. Infant mortality rates in the 1997 DHS show a mortality rise from 133 deaths per 1000 live births in the period 1977-1982 to a rate of 161 in the period 1987-1992[12]. Rates in the 2003 DHS confirm the stalled trend, declining from 161 deaths per 1000 births in the period 1978-1983 to a rate of 148 in the period 1993-1998[13]. Infant mortality rates continued to decline in the post-war period to levels of 93 deaths per 1000 live births in the period 2003-2008 according to the 2008 Multiple Indicator Cluster Survey (MICS)[14] and 94 deaths per 1000 live births in the latest 2007 Census[15].

Child mortality rates however remain high. The mortality rate of children under the age of five years in Mozambique is among the twenty highest in the world[16]. This is, perhaps, unsurprising: health service coverage in the country is estimated at 40 to 50 per cent[17]; according to the 2007 Census, only 37 per cent of women are literate[15]; and more than half the Mozambican population is estimated to be living below the national poverty line in 2008/09[18]. Exposed to unfavorable socio-economic conditions and inadequate health care provision, we postulate that the majority of Mozambican children born following a short preceding birth interval are at a significantly higher risk of dying relative to children with longer preceding intervals.

For the purposes of this research, we adopt the World Health Organization (WHO) definition of a "short" preceding birth interval as being one of less than 24 months between one birth and the next pregnancy [19], or approximately 33 months between successive births. The child whose birth closes a preceding interval is referred to as the index child.

Boerma and Bicego[20] identify three distinct causal pathways linking short preceding birth intervals and child mortality. First, maternal depletion caused by inadequate postpartum recovery by the mother between gestational episodes impairs the intrauterine growth of the index child, which in turn is associated with low birth weight, pre-maturity and, consequently, higher mortality risk[21]. Second, sibling competition for scarce household resources exposes all siblings (including the index child) to poor nutrition, inadequate prenatal and postnatal health care, and unsatisfactory child minding thereby increasing chances of disease and accidents. Index children with short preceding intervals are associated with increased odds of stunting and being underweight[5]. Third, exposure of the index child to older, closely-aged siblings facilitates the spread of infectious diseases from the older to the younger children. Around two years of age, older siblings are more susceptible to infectious diseases such as measles and chicken pox, which have more severe secondary infection effects when transmitted to a younger child[22].

To establish the age at which effects of short preceding birth intervals are most hazardous, we model the age-related risk of child mortality associated with short preceding intervals. Maternal depletion outcomes associated with premature births and low birth weight should be evident in the neonatal period, whilst sibling competition and disease transmission effects are expected to be predominant in the post-neonatal period and in early childhood[20].

In the next section we describe the data used and the statistical model applied to elucidate linkages between birth interval length and child mortality. Our results, discussed in the final part of the paper, show that the effects of short preceding intervals are strongest in the neonatal period, with excess mortality among children born after a preceding birth to pregnancy interval of less than 30 months. We then proceed to discuss these results and their implications for child survival in Mozambique.

Methodology

Data description

Birth history data from the 1997 and 2003

Mozambique DHSs are analyzed. First births are excluded from the analysis as there is no preceding interval against which the index child's outcome can be gauged. Possible selection effects from including only multiparous women are unlikely to be significant since the study investigates differential mortality associated with long and short intervals. Weighted data in overlapping periods from the 1997 and 2003 DHS were pooled to increase sample size and precision of model estimates. The pooled dataset comprises a total of 36,305 live births born within the 20 year period from September 1978 to August 1998, of which 17,122 are from the 1997 DHS and 19,183 are from the 2003 DHS. Births that occurred less than a month before the survey were excluded from the analysis and as such, births from the 1997 DHS extended from September 1978 to July 1997, whilst births from the 2003 DHS extended from September 1978 to August 1998. To allow for temporal variations in child mortality without having to assume a constant trend, the pooled dataset was analyzed in five-yearly periods, from September 1978.

Following recommendations of the World Health Organization[19] the interval from the preceding birth to subsequent pregnancy is modeled in nine segments, less than 6 months, 6 to 11, 12 to 17, 18 to 23, 24 to 29, 30 to 35, 36 to 47, 48 to 59 and greater than or equal to 60 months. Since the DHS does not collect pregnancy histories, the calculation of the birth to pregnancy interval is based on the preceding birth to birth interval is based on the preceding birth to birth interval and subtracting an assumed nine month gestation. Just less than one per cent (0.94 per cent) of births in the 2003 DHS had a preceding birth to birth interval of less than 9 months, and were included in the shortest preceding birth to pregnancy interval category of less than 6 months. The 1997 DHS did not report any births with a preceding birth to birth interval of less than 9 months. An analysis of misclassification effects from assuming a nine month gestation found them to be trivial with at most about 0.2 per cent of births shifted into longer birth intervals[1].

Age at death was also modeled segmentally: 0 to 6 days (early neonatal mortality); 0 to 1 month (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 (mortality of children under five years).

Accurate reporting of children's date of birth and age at death data is important to determine correctly the preceding birth to pregnancy interval as well as the classification of age at death. The DHS asks mothers to provide their children's month and year of birth. Incomplete birth data in the DHS are imputed[23]. The completeness and resulting level of imputation of reported children's date of birth in the period September 1978 to August 1998 is shown in Table 1. 43.3 per cent of reported birth data in the 1997 DHS had at least the age, month or year imputed compared to 5.5 per cent in the 2003 DHS (Table 1).

Table 1: Percentage distribution of births with imputed age or date for the period September 1978 to August 1998, 1997 and 2003 DHS

	1997 DHS		**2003 DHS**	
Categories	**%**	**n**	**%**	**n**
Month and year provided	56.68	9704	94.46	18120
Month and age provided – Year imputed	0.03	5	0.01	2
Year and age provided – Month imputed	29.04	4972	3.07	588
Year provided – Age, month imputed	12.59	2155	2.29	439
Age provided – Year, month imputed	1.03	176	0.03	5
Month provided – Age, year imputed	-	-	0.05	10
None provided – All imputed	0.64	109	0.10	19
Total	100	17122	100	19183

The extent of imputation indicates the potential bias introduced into the derived intervals and estimates of ages at death, especially in the data from the 1997 DHS[23]. 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. Imputed values were however not excluded due to sample size concerns.

Heaping of the preceding birth to pregnancy interval was noted at 15 months (4.6 per cent of intervals) and 27 months (3.1 per cent) in the 1997 DHS, and intervals of 13 months (4.5 per cent) and 17 months (4.9 per cent) in the 2003 DHS. This heaping corresponds to inter-birth intervals of 24 and 36 months in the 1997 DHS and intervals of 22 and 26 months in the 2003 DHS. Both surveys collected birth history data starting with the oldest child. After reporting the date of birth of their oldest child, it is probable that some women estimated the date of birth of subsequently younger children in intervals of 2 or 3 years. Patterns in the 2003 DHS may have resulted from enumerator's attempts to avoid heaping at 24 months. However, only the preceding birth to pregnancy interval at 17 months coincides with a category limit which may result in misallocation of births between the categories 12 to 17 months and 18 to 23 months. No reallocation of intervals was done in the absence of information on the correct allocation.

The age at death was heaped at ages of 6 months, 12 months, 24 months and 36 months in both the 1997 and 2003 DHS. Similarly in the absence of information on the correct allocation of deaths, no adjustments were made to the heaping at age 12 months which coincides with the upper limit for infant mortality and lower limit for child mortality.

Statistical model

The risk of child mortality associated with the length of the preceding birth to pregnancy interval is investigated using a piecewise constant log-rate model. This class of model assumes that the risk period (defined as the period during which a child is at risk of dying) can be divided into segments with a constant hazard in each segment[24,25]. The piecewise constant hazard function is thus an approximation to the continuous hazard function, calculated as a step function or a piecewise function. The piecewise hazard rate model is defined as follows:[25]

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

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 $i=1,\ldots,I$ and I is the number of intervals

β is a column vector of unknown covariate parameters.

Poisson or negative binominal models can be used to estimate the parameters. The Poisson model assumes that the mean and variance of the response variable are equal. If the variance is greater than the mean, the data are said to be over-dispersed and the negative binominal form of the model is to be preferred[26]. Tests of the models indicated that the negative binomial model should be preferred. A uniform distribution of deaths is assumed where deaths occur halfway in the interval of death.

Model covariates

The Mosley and Chen framework[27] provides the main reference for selecting the covariates of child mortality. Variable inclusion is subject to availability in the Mozambique DHS data. Only those socio-economic variables that can be reasonably assumed to have remained constant between the time of birth of the index child and survey date are included: mother's educational attainment; mother's childhood place of residence; mother's linguistic group; mother's religion; region of residence; and partner's education. The partner's education attainment was included as a proxy for father's education. Following Mosley and Chen, partner's education is modeled relative to mother's education (partner's education attainment minus mother's education attainment) to establish its effect over and above the mother's education.

Bio-demographic variables modeled include the sex of the index child; sex of the previous child; survival status of the previous child; mother's age at birth; child's period of birth; whether the child was a single or multiple birth; and the subsequent birth to pregnancy interval. Since child mortality risks are analyzed to age five; effects of a subsequent pregnancy interval are restricted to age five. Consequently, mothers not reporting a subsequent pregnancy and those with a subsequent pregnancy more than five years afterwards are grouped into a single category.

Pairwise investigations of the covariates confirmed the expected high correlations between birth order and the mother's age at birth, and between the survival status of the previous child at conception of the index child and the survival status of the previous child by age 5. The mother's age at birth and the survival status of the previous child by age 5 were strongly correlated with the response variable, and were kept in the model. The reference category was chosen to be the modal category in the pooled dataset. The model covariates and their distributions are presented Table 2.

Interaction effects were tested to determine the presence of effect modifiers. Mother's educational attainment and region of residence are possible effect modifiers of the association between short birth spacing and child mortality. Better educated mothers are generally better off socio-economically, and hence more likely to have access to superior health care as well as resources such as hired child help[3]. Children whose mothers are resident in better-resourced regions offering improved health care are expected to experience reduced mortality risk[28]. In Mozambique, the more urbanized Southern region has better health care compared to the Central region and the least urbanized Northern region[29].

This study did not control for breastfeeding. Breastfeeding duration of the index child has a dual mortality reduction effect, providing nutrition and immunity to infection[30]. The association of index child breastfeeding with the length of the preceding birth interval has however been found to be minimal[20,31]. This is expected since it is the breastfeeding of the prior child that affects the index child's preceding birth interval by lengthening the period of postpartum infecundity[32]. The DHS did not collect breast-feeding data for periods extending more than five years before the date of the survey.

Results

Bivariate results

Bivariate model results showing uncontrolled effects of preceding birth to pregnancy intervals on child mortality are presented as estimated mortality rates (deaths per person-year) (Table 3). Mortality rates generally decline as the length of the preceding birth to pregnancy interval increases except for the slight increase at the open-ended interval for early neonatal and neonatal mortality and at the category 30 to 35 months at other ages at death. Rates of early neonatal and neonatal mortality display excess mortality at each category particularly for the shortest intervals of less than six months and 6 to 11 months, compared to other age segments.

Multivariate results

Significant covariates of child mortality and confounders of the association of child mortality with the preceding birth interval were controlled in the multivariate model to isolate the net effects of preceding birth to pregnancy intervals. Multivariate model results are presented as net mortality rates (per person-year) with 95 per cent confidence bounds for each prediction. The net mortality rates were calculated by holding all other covariates at their weighted mean value and can thus be interpreted as mortality rates experienced by children born to an average Mozambican woman in each respective category of the preceding birth to pregnancy interval.

Net mortality rates for the early neonatal and neonatal period are markedly higher at each category of the preceding birth to pregnancy interval, relative to other age segments particularly for shorter intervals (Table 4). The early neonatal mortality rate for intervals of less than six months is nine times the infant mortality rate and seventy-

Table 2: Model covariates for the period 1978 to 1998, 1997 and 2003 DHS

		1997 DHS		2003 DHS	
Variable	**Categories**	**%**	**n**	**%**	**n**
Length of preceding birth to pregnancy interval	<6	8.0	1363	6.1	1177
	6-11	10.2	1746	13.9	2669
	12-17®	24.3	4156	23.9	4580
	18-23	15.7	2688	20.4	3909
	24-29	14.9	2552	11.7	2239
	30-35	7.4	1268	8.0	1535
	36-47	8.6	1473	7.6	1454
	48-59	4.1	702	3.4	653
	60+	6.9	1175	5.0	965
Period of birth	1978-1983®	24.1	4130	39.8	7642
	1983-1988	34.2	5848	28.6	5478
	1988-1993	24.5	4199	19.8	3788
	1993-1998	17.2	2945	11.9	2275
Sex of index child	Male®	49.8	8534	50.5	9693
	Female	50.2	8588	49.5	9489
Sex of previous child	Male®	50.0	7699	51.3	8842
	Female	50.1	7713	48.7	8390
Length of subsequent birth to pregnancy interval	No subsequent pregnancy/ subsequent pregnancy in the period 60+ months	36.2	6201	17.7	3401
	Subsequent pregnancy: 0-12 months	14.8	2535	18.8	3605
	Subsequent pregnancy: 13-24 months®	27.4	4683	34.9	6686
	Subsequent pregnancy: 25-59 months	21.6	3703	28.6	5490
Survival status of the previous child	Previous birth dead by age 5	20.1	3363	21.8	4072
	Previous birth alive at age 5®	79.9	13342	78.2	14633
Mother's age at birth	10-19 years	11.9	2032	15.7	3013
	20-24 years®	30.6	5235	32.6	6258
	25-29 years	27.1	4632	27.5	5265
	30-49 years	30.5	5223	24.2	4646
Multiplicity of births	Single births®	96.7	16549	96.6	18529
	Multiple births	3.4	573	3.4	654
Mother's education attainment	No education®	52.9	9062	52.6	10088
	Primary education	45.0	7708	44.8	8602
	Secondary or higher	2.1	353	2.6	493
Partner's education attainment	Less than mother's education	7.6	1050	6.7	1202
	Equal to mother's education®	61.2	8409	59.2	10693
	Higher than mother's education	31.2	4288	34.1	6160
Region of residence	North	31.0	5282	36.9	6983
	Center®	40.5	6910	39.8	7534
	South	28.6	4877	23.3	4411
Mother's religion	No religion	22.0	3740	15.6	2987
	Catholic®	30.3	5148	30.7	5879
	Muslim	17.1	2902	20.1	3861
	Zionist	9.5	1610	7.7	1476
	Protestant/Evangelic	15.2	2579	25.5	4897
	Other religion	6.1	1033	0.4	84
Mother's linguistic group	Xitsonga and similar	17.7	2986	13.1	2516
	Emakua and similar	31.3	5264	36.6	7012
	Cisena and similar®	25.9	4367	25.1	4817
	Elomwe and Emarenjo	9.0	1507	7.3	1397
	Xitswa and similar	9.9	1674	9.5	1816
	Portuguese	1.7	283	3.2	619
	Other	4.5	755	5.2	1003
Mother's childhood place of residence	City	10.6	1813	12.8	2443
	Town	7.1	1205	9.3	1773
	Countryside®	82.4	14074	78.0	14919

®=Reference category

Table 3: Bivariate mortality rates (per person-year) by preceding birth to pregnancy interval, 1978 to 1998

PBPI	Early Neonatal	Neonatal	Post-neonatal	Infant	Child	Under Five
<6	12.408	13.619	0.464	1.820	0.168	1.867
6 to 11	7.042	7.810	0.318	1.079	0.172	1.118
12 to 17	4.388	4.208	0.195	0.554	0.122	0.549
18 to 23	3.119	3.025	0.191	0.473	0.074	0.454
24 to 29	2.783	2.047	0.096	0.239	0.047	0.202
30 to 35	1.511	1.209	0.112	0.256	0.056	0.229
36 to 47	1.764	1.146	0.074	0.144	0.027	0.102
48 to 59	0.944	0.602	0.048	0.107	0.013	0.066
60+	1.211	0.688	0.032	0.076	0.013	0.045

PBPI=Preceding birth to pregnancy interval

Table 4: Net mortality rates (per person-year) by preceding birth to pregnancy interval, 1978 to 1998

PBPI	Early Neonatal	Neonatal	Post-neonatal	Infant	Child	Under Five
<6	3.948	2.682	0.146	0.441	0.051	0.356
6 to 11	2.875	2.362	0.136	0.410	0.068	0.350
12 to 17	2.259	1.478	0.107	0.242	0.056	0.210
18 to 23	1.755	1.125	0.102	0.207	0.035	0.163
24 to 29	1.912	1.004	0.070	0.145	0.027	0.106
30 to 35	0.746	0.448	0.080	0.172	0.038	0.147
36 to 47	1.339	0.637	0.059	0.111	0.017	0.073
48 to 59	0.259	0.242	0.043	0.092	0.012	0.055
60+	0.792	0.410	0.022	0.064	0.016	0.045

PBPI=Preceding birth to pregnancy interval

seven times the child mortality rate, whilst neonatal mortality for intervals of less than six months is six times the infant mortality rate and fifty-two times the child mortality rate.

Figure 1 displays net mortality rates on a logarithmic scale to highlight trends of age segments with lower mortality. Close similarities exist in the trends and levels of early neonatal with neonatal mortality and of infant mortality with the mortality rates of children under the age of five. Early neonatal and neonatal mortality rates generally decline with fluctuations as the preceding birth to pregnancy interval increases in length. Infant mortality rates and mortality rates of children under the age of five initially decline modestly from preceding intervals of less than 6 months to intervals 6 to 11 months followed by a relatively rapid decline to the category 24 to 29 months. Thereafter, there is a slight upturn in net mortality rates which continue declining (Figure 1). Post-neonatal mortality rates by and large decline as the preceding interval increases, whilst child mortality rates are erratic.

A child's birth date (measured in quinquennial periods), was not a significant predictor of early neonatal and neonatal mortality, although it was significant at other ages at death. Only the post-war period (1993 to 1998) was significantly different (significantly lower) to the reference period (1978 to 1983) for post-neonatal mortality, infant mortality and mortality of children under the age of five years. An analysis of mortality rates by a child's birth period however adds little value since mortality rates associated with short preceding intervals are concentrated in the neonatal period. We thus limit subsequent results to the early neonatal period and the neonatal period.

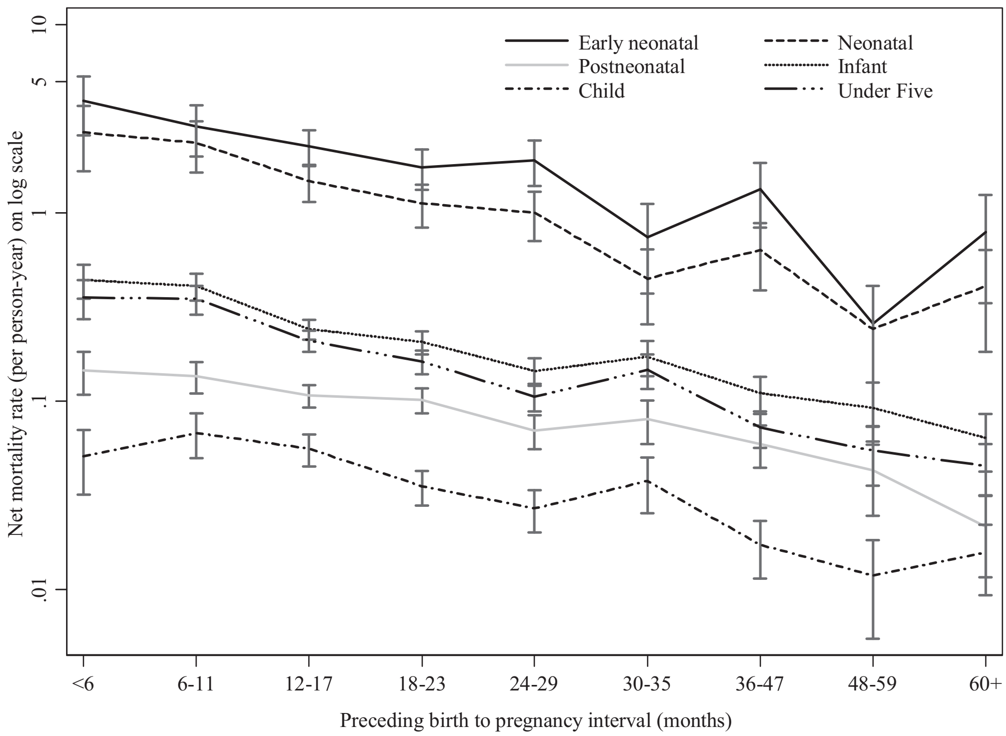

Figure 1: Net mortality rates (per person-year) on log scale, by preceding birth to pregnancy interval, 1978 to 1998

Early neonatal and neonatal mortality rates: 1978 to 1998

Early neonatal mortality rates are higher at each category of the preceding birth to pregnancy interval relative to neonatal mortality rates, taking into account the wide overlapping confidence bounds for predictions of shorter intervals (Figure 2). Both early neonatal and neonatal mortality rates decline fairly rapidly from intervals of less than six months to intervals 30 to 35 months in length, although the trend in early neonatal mortality fluctuates at longer intervals. Children conceived within six months of the preceding birth are exposed to mortality rates five times higher in the first seven days after birth and six times higher in the first month after birth compared to children conceived after an interval of between 30 to 35 months (Figure 2).

The geographic region of residence was found to be a significant predictor of both early neonatal and neonatal mortality. Education attainment of the mother was significant at the neonatal age; children of mothers with secondary or higher education had a lower mortality risk, although not significantly different at the 5 per cent level (Table 5). Intra-familial mortality risk was also a significant predictor of early neonatal and neonatal mortality, with children whose older siblings died by age 5 displaying significantly higher risk of mortality. Being born as one of multiple births significantly increases the risk of early neonatal mortality and particularly neonatal mortality (Table 5).

Statistically significant interaction effects of the preceding birth to pregnancy interval with the geographic region of residence were found for both early neonatal and neonatal mortality. The mortality risk associated with short preceding intervals was higher for children who reside in Northern Mozambique compared to the Central and Southern regions. Regional disparity in child mortality risk was wider for shorter preceding birth to pregnancy intervals, especially intervals less than 18 months (with fluctuations and wide confidence intervals at categories of 6 to 11 months and 24 to 29 months for the Northern region).

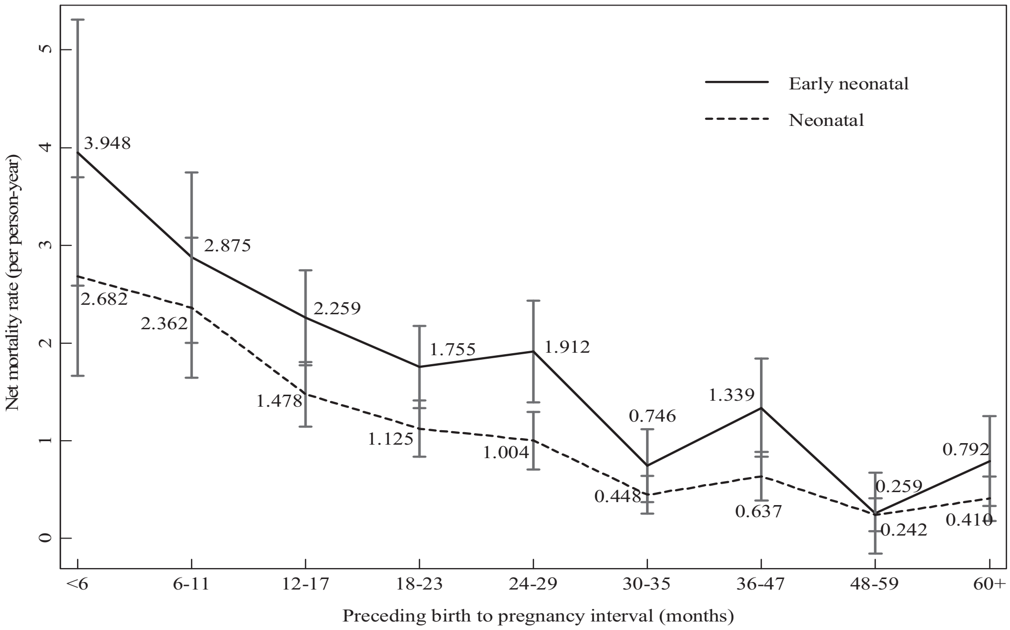

Figure 2: Net mortality rates (per person-year) for early neonatal mortality and neonatal mortality, by preceding birth to pregnancy interval, 1978 to 1998

Early neonatal mortality rates for the Southern and Central regions were similar; however, children from Southern Mozambique had lower neonatal rates compared to the Central Mozambique at intervals of less than 12 months.

Interaction effects of a mother's education attainment with the preceding birth to pregnancy interval were found to be significant at the neonatal age. Maternal education attainment reduces the risk of neonatal mortality among children born after short preceding intervals.

Discussion and conclusion

The effects of short preceding intervals on children under the age of five years in Mozambique were concentrated mainly in the neonatal period, particularly the first few days of life. Net mortality rates of early neonatal and neonatal mortality were markedly higher relative to other age at death segments at equivalent categories of preceding birth to pregnancy intervals, particularly so for shorter intervals. These results are consistent with findings from other studies[33,34] although uncontrolled prematurity bias may contribute to higher neonatal mortality risk in the shortest interval when birth-to-birth intervals are modeled[35-37]: we have modeled birth-to-pregnancy intervals, thereby circumventing the problem.

The elevated mortality risk in the neonatal period suggests maternal depletion as the most plausible primary causal pathway of short preceding intervals in Mozambique. According to the maternal depletion hypothesis, children born following a short preceding interval are exposed to impaired intrauterine growth and are at a higher risk of low birth weight and pre-term birth[20], which may be due to postpartum folate deficiency[38]. Other studies also cite maternal depletion as the dominant causal pathway of short preceding intervals[20,33,39] and corroborate the birth outcomes postulated by the maternal depletion hypothesis[37]. Children born with low birth weight or as pre-term births are expected to have a high fatality rate in early infancy[20]. A prospective cohort study of 908 women in Maputo found that low birth weight and preterm birth were amongst significant risk factors of perinatal mortality (perinatal mortality defined as fetal death in *utero* with gestational age of at least 22 weeks or early neonatal death)[40].

Table 5: Selected negative binomial regression coefficients for early neonatal and neonatal mortality, 1978 to 1998

Variable	Early Neonatal			Neonatal		
Preceding birth to pregnancy interval						
<6	0.722	**	(0.279)	0.787	*	(0.328)
6-11	0.378		(0.271)	0.538		(0.297)
12-17	Ref			Ref		
18-23	-0.187		(0.264)	-0.359		(0.283)
24-29	-0.014		(0.288)	-0.797	*	(0.344)
30-35	-1.666	**	(0.556)	-1.639	***	(0.475)
36-47	-0.256		(0.356)	-0.971	*	(0.415)
48-59	-1.116	*	(0.540)	-2.737	***	(0.717)
60+	-0.686		(0.435)	-2.523	***	(0.567)
Sex of index child						
Male	Ref			Ref		
Female	-0.157		(0.100)	-0.207	*	(0.103)
Subsequent birth to pregnancy interval						
No subsequent pregnancy/ subsequent pregnancy in the period 60+ months	0.237		(0.140)	0.224		(0.144)
Subsequent pregnancy: 0-12 months	1.516	***	(0.138)	1.850	***	(0.146)
Subsequent pregnancy: 13-24 months	Ref			Ref		
Subsequent pregnancy: 25-59 months	-0.391	**	(0.145)	-0.557	***	(0.145)
Multiplicity of births						
Single births	Ref			Ref		
Multiple births	1.861	***	(0.243)	2.612	***	(0.262)
Survival status of the previous child						
Previous birth dead by age 5	1.010	***	(0.115)	1.347	***	(0.121)
Previous birth alive at age 5	Ref			Ref		
Mother's education attainment						
No education				Ref		
Primary education				0.088		(0.252)
Secondary or higher				-1.520		(1.222)
Region of residence						
North	1.308	***	(0.235)	1.707	***	(0.312)
Centre	Ref			Ref		
South	0.178		(0.282)	1.240	*	(0.502)
Chi-square	*2460*	***		*4712*	***	
N	32556			32389		

PBPI=Preceding birth to pregnancy interval, Ref=Reference group
*Difference significant at $p \leq 0.05$; **$p \leq 0.01$; ***$p \leq 0.001$.
Note: Standard errors are presented in parentheses

The sibling competition hypothesis, which postulates that the causal connection between child mortality and birth interval length arises primarily from maternal difficulties in coping with two young children, is in all likelihood inapplicable to the Mozambican context due to much weaker post-neonatal effects. If sibling competition effects were operational in the first month, they would be expected to also be visible in the post-neonatal period. Child minding or child fostering of older closely spaced siblings by extended family members, which is common in Mozambique[29], may explain the weaker post-neonatal mechanisms observed.

The rapid decline in the trend of early neonatal and neonatal mortality rates from the shortest interval to the category 30 to 35 months suggests optimal gains in neonatal survival with preceding birth to pregnancy intervals of at least 30 months. Although this result corroborates the WHO's recommended spacing of at least 24 months[19], it nonetheless suggests an extra 6 months of spacing. 73 per cent of children born between September 1978 and August 1998 had preceding birth to pregnancy intervals of less than 30 months implying that the survival of the majority of births might have been prejudiced as a result of short birth spacing. Rutstein's analysis[5] however suggests that a preceding birth to pregnancy interval of at least 36 months is more beneficial to child survival, which is 6 months longer than the optimal interval suggested in our results. Differences in methods may partly account for the observed variations, although the much larger dataset in Rutstein's analysis, results in high precision estimates, and would exhibit trends otherwise masked in a smaller dataset. Notwithstanding, a national level analysis provides more context specific results.

Children resident in Northern Mozambique are exposed to a higher risk of early neonatal and neonatal mortality from short spacing; this is most likely due to regional differentials in health care access and general socio-economic status. Mozambican children born to educated mothers have a higher probability of surviving the detrimental effects of short preceding birth intervals in their first month of life, with better socio-economic conditions and better access to health care[3].

The results from the model should be interpreted taking into account potential bias from data imputation and age heaping at category limits. Furthermore, the violation of the assumption of independent events from the fact that a single mother can contribute to multiple births and hence multiple deaths can result in reduced standard errors and an overstatement of significant covariates in instances of borderline significance[22,41]. This study did not control for HIV and AIDS since the 1997 and 2003 Mozambique DHS did not collect individual level HIV data. Potential bias could result from increased AIDS related child mortality, reduced fecundity in HIV positive women, modified reproductive intentions among HIV positive mothers and increased adult mortality from AIDS related causes[42-44]. A 2009 national survey estimates prevalence of 13.1 per cent among women aged 15 to 49 years and prevalence of 2.3 per cent among children less than a year old and 1.7 per cent among children 1 to 4 years[45]. Further research needs to be undertaken on the influence of HIV and AIDS in this regard.

For the results of this study to have a greater chance of making an impact on child survival in Mozambique, it is important that advocates of family planning grasp local perceptions and understandings surrounding the concept of birth spacing. A qualitative study of fertility intentions and contraceptive choices in peri-urban Maputo, found that instead of referring to birth spacing or stopping, respondents referred to a waiting period, whose length was dependant on factors such as age, parity, socio-economic status, or marital outcomes[46]. This concept of a waiting period between births concurs with other studies[47,48]. Hence couples in Mozambique should be encouraged to wait for a period of at least 30 months or two and a half years between one birth and the next pregnancy to improve chances of their children surviving the risky neonatal period. The elevated neonatal mortality risks faced by children born following short preceding intervals of less than two and a half years must be highlighted in simple quantitative expressions to enable couples to fully comprehend the importance of an adequate waiting period between one birth and the next pregnancy.

The association of short birth intervals and increased child mortality risk is one of the strong motivations for family planning since the adoption of effective contraceptive methods will enable women to avoid short birth intervals. Current use of any contraceptive method among women 15 to 49 years who are married or in conjugal unions is estimated to have declined to 16.1 per cent in the 2008 MICS from 25.5 per cent in the 2003 DHS, having increased from 5.6 per cent in the 1997 DHS. The low prevalence of current contraception use of both modern and traditional methods in Mozambique implies that the majority of women have minimal control over birth spacing intervals resulting in a high proportion of short and hazardous preceding intervals. Results of this study emphasize the importance of family planning campaigns in reinforcing recommendations on longer birth spacing, thus contributing to the reduction of child mortality rates and enhancing the country's progress towards meeting Millennium Development Goal 4.

Contribution of Authors

Gonçalves performed the initial analysis and drafted the paper under Moultrie's supervision. Moultrie reviewed earlier drafts and edited the paper. Both authors approved the manuscript.

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