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Changing Childhood Mortality Conditions in Kenya: An Examination of Levels, Trends and Determinants in the Late 1980s and the 1990s

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Abstract

This paper examines the observed reversal in childhood mortality conditions in Kenya since the late 1980s, and the determinants of child mortality. Data from the 1998 Demographic and Health Survey are used to achieve these two objectives. Direct estimation techniques are used to examine regional levels and trends of mortality since the 1980s. It is clear from these analyses that regional mortality levels in Kenya are quite diversified. Nyanza has the highest mortality among children, while Central has the lowest. Although, mortality increased in the country in the early 1990s, most of the increases occurred in Nyanza province. Weibull hazard models, which also incorporate unobserved heterogeneity (frailty), are used to examine the correlates of childhood mortality. These hazard models clearly show that biodemographic factors are more important in explaining infant mortality, while the socioeconomic and socio-cultural factors (including hygienic factors) are more important in explaining child mortality. The results also show that the risk of death were higher for children born in the 1990s compared to those born before 1980. In spite of including all these factors into the model, the unobserved heterogeneity is still significant. The results suggest that mortality trends in the country are likely to be related to unmeasured factors especially HIV/AIDS prevalence.

Key words: Child mortality changes, Determinants of child mortality, Kenya

1. Introduction

High mortality among children remains a serious public health concern in many developing countries. Like most sub-Saharan African countries, Kenya started experiencing declines in child mortality in the late 1940s (see Hill and Hill, 1988; Hill, 1992), and these declines continued through most of the 1970s and 1980s (Ewbank, Henin & Kekovole, 1986; Brass, 1993; Hill, Bicego & Mahy, 2001). However, data from the 1998 Demographic and Health Survey (DHS) show that childhood mortality conditions worsened during the 1990s. This study considers in particular the recent resurgence in childhood mortality in Kenya and the socioeconomic, biodemographic and household environmental factors associated with mortality among children. This analysis is conducted separately for infancy (0-11 months and childhood (12-59 months) because the effect of factors associated with mortality among children varies by the age of the child (Sastry, 1997a; Manda, 1999).

The apparent resurgence of childhood mortality in the last decade provides a strong justification for undertaking a trend analysis. As Loaiza and Ekouevi (1990) have observed, monitoring of trends in infant and child mortality is important, in part, because it provides a basis for evaluating the performance of health programmes over time; and it serves as a basis for the government and its international development partners to set new goals in meeting the health needs of the society. Kenya experienced adverse social and economic conditions in the late 1980s and early 1990s, which might have had an impact on the health of children.

Although this study does not directly address the relationship between fertility and mortality, declines in mortality have always been seen as foreshadowing fertility declines. This is a central thrust of the classic demographic transition theory (Notestein, 1945). The recent Demographic and Health Surveys have shown that besides Botswana, Lesotho and Zimbabwe, Kenya is the only other sub-Saharan country that has experienced unexpected rapid fertility declines in the recent decades (Caldwell, Orubuloye & Caldwell, 1992; Robinson, 1992; Brass, 1993; Obungu, Kizito & Bicego, 1994; Kirk and Pillet, 1998). Caldwell et al. (1992) have suggested that a necessary threshold for such a transition to occur is a decline in infant mortality to about 70 per 1000 live births and child mortality to about 40 per 1,000 live births[1]. Kenya had achieved both conditions in 1989 as its infant mortality stood at 59.6 per 1000 and childhood mortality at 31.5 per 1000 live births (National Council for Population and Development (NCPD), Central Bureau of Statistics & Macro International, 1989). However, both the 1993 and 1998 demographic and health surveys show that mortality conditions deteriorated over the decade. For instance, between 1993 and 1998, infant mortality rose from 61.7 to 74 per 1000 live births (NCPD et al., 1993; 1999).

An analysis of fertility and child mortality trends between the 1950s and the late 1980s by Brass, however, did not find any convincing evidence for the hypothesis that mortality declines had significant, immediate and direct effect on the appreciable fertility declines registered in all regions of the country (Brass, 1993). The results showed that the declines in mortality and fertility were not in close accordance. However, Brass concludes that it is possible that the steady declines in childhood mortality from the 1950s and earlier contributed to the awareness of changing social conditions, which in

[1] Infant mortality is the probability, expressed as a rate per 1,000 live births, of a child dying between birth and the first birthday, while child mortality is the probability, also expressed as a rate per 1,000 live births, of a child dying between exact age one and the fifth birthday.

turn had an effect on fertility declines. Far from disproving the relationship between mortality and fertility declines, these results suggest that there is much to gain from efforts to improve mortality conditions.

2. Data and Methods

2.1 Data

The present study utilises data from the 1998 Demographic and Health Survey (DHS) for Kenya undertaken by National Council for Population and Development (NCPD) and Macro International of USA. The survey was based on individual interviews of women in the reproductive ages, 15-49 years and their partners in the sampled households. Information was collected on birth history, child mortality, child and maternal health, reproduction and family planning. Since a woman's complete birth history, including dates of birth and death of each child is available; it is easy to obtain direct estimates of child mortality. The survey also included a full array of potential child mortality determinants some of which are analysed in this study.

2.2 Analytical methods

The dependent variable in the analysis of mortality determinants is the duration of survival since birth measured in months. The levels and trends of mortality will be analysed by applying direct estimation techniques to the birth history data (see Rutstein, 1984). The major limitation of these techniques is that they do not allow the simultaneous analysis of potential determinants of mortality. Consequently, we utilise survival regression procedures initially proposed by Cox (1972) to examine the effect of various factors on the risk of death. The main advantage of survival or hazard models is that they account for the problem of censoring in reproductive histories data. A fundamental discriminating criteria between various survival models, is the distribution that the timing function is assumed to follow (Cleves, Gould, and Gutierrez, 2004). Based on preliminary analysis documented in Omariba (2004), in this analysis we utilise the Weibull proportional hazards model.

Since there could be more than one child in a family we estimate models with a term for frailty to account for the fact that siblings are not independent observations and also to capture the effect of unobserved factors (frailty). Generally, frailty models capture the total effect of all unmeasured and/or unmeasurable factors that influence the individual's risk of death. In the context of child survival, the frailty effect reflects the magnitude of genetic, behavioural, and environmental factors (Sastry, 1997a). In this study the frailty is assumed to follow a gamma distribution (Oakes, 1982; Sastry, 1996). The estimated parameter relating to the distribution of unobserved heterogeneity is interpreted as the variance of the frailty distribution (Sastry, 1997b; Cleves et al., 2004). When the variance estimate is significantly different from zero it would suggest that there are unmeasured and unmeasurable factors shared by siblings that affect the risk of death. It will also indicate that siblings' survival risks are correlated.

3. Results

3.1 Levels of infant and child mortality

This section presents estimates of the levels of infant and mortality in Kenya from the 1998 DHS data for children born within ten years before the survey. The results are also presented by the regions of the country covered in the DHS. Since mortality levels are one of the indicators of the standard of living of a population, they help to identify segments of the population that could benefit from programs aimed at improving child health and survival.

Table 1 presents the rates of infant and child mortality for regional populations and for the nation as a whole. The mortality rates are expressed as deaths per 1,000 children initially exposed to the risk of death. Examining the figures adjusted for age heaping[2] reveals that there is some amount of heaping of deaths at age 12 months, which suggests that infant mortality is understated while child mortality is overstated. Using the adjustment factors increased the national infant mortality rate by 4 percent, but it decreased the childhood mortality rate by 13 percent. Overall, the adjustment factors increased infant mortality but decreased child mortality for all the regions. These results suggest that in some areas there is substantial underreporting of infant deaths and over-reporting of child deaths, whereas in other areas it was modest. Again, the results are consistent with previous research in sub-Saharan Africa (see Sullivan, Rutstein, and Bicego, 1994; Woldemicael, 1999).

2 The adjustment factors are calculated by assuming that half of the reported deaths at age 12 months actually occurred in the preceding age group, 0-11 months. In the case of infant mortality, half of the deaths reported at age 12 months are added to the number of deaths reported for 0-11 months and this total is divided by the number of deaths at 0-11 months. On the other hand, half of the deaths occurring at age 12 months are subtracted from the number of deaths occurring at age 12-59 months and divided by the deaths at age 12-59 months. The reported mortality rates are then multiplied by the adjustment factors to produce the adjusted rate.

Table 1: Childhood mortality rates in Kenya, births within ten years prior to the 1998 DHS

Region	Infant mortality	Child mortality
Nairobi	41.0(42.6)	26.0(23.6)
Central	30.0(30.6)	10.8(9.7)
Coast	67.2(72.0)	27.1(20.9)
Eastern	50.0(51.5)	28.0(25.2)
Nyanza	148.5(156.0)	70.7(61.9)
Rift Valley	55.0(56.7)	18.3(15.7)
Western	65.2(69.1)	77.4(70.7)
Kenya	**72.3(75.4)**	**32.9(28.6)**

Note: Adjusted estimates are in parentheses.
Source: Author's calculations based on births in Kenya for the period June 1988-June 1998 from the 1998 DHS.

The results in Table 1 indicate that most of the deaths among children in Kenya occur in infancy. These estimates are consistent with what would be expected for a country with high mortality: a greater concentration of deaths in the first year of life due to a prominence of infectious diseases (see, Sullivan et al., 1994). Whether we consider the adjusted or unadjusted estimates, infant mortality rate for Kenya is over 70 per 1,000 live births, which suggests that about 1 in 14 children in Kenya do not live to see their first birthday. The results show that out of 1,000 children who survived to their first birthday, about 25 died before age five. These estimates are similar to other estimates for Kenya obtained from the 1998 DHS. For instance, infant mortality for 5-9 and 0-4 years before 1998 in the DHS report was 67.8 and 73.4 per 1,000 live births respectively (NCPD et al., 1999).

The results also show that there are substantial variations in infant and childhood mortality by region of residence. Nyanza province has much higher infant mortality compared to the other provinces, while Central province has the lowest mortality for both indices. Infant mortality in Nyanza province is over three times (156 per 1,000 live births) as much as that of Central and Nairobi provinces, 30.6 and 42.6 per 1,000 live births respectively. The other regions of the country, especially Coast and Western provinces, also exhibit relatively high mortality. The infant mortality rate for Coast province is 72, while that of Western is 69.1.

Regarding child mortality, Western province has the highest rate in the country; its child mortality rate is over twice as high as the country's level, 71 compared to 28.6. Similarly, the adverse mortality conditions observed in infancy for Nyanza persist during the childhood period; its child mortality (62) is about twice as high as the national level. Again, Central province emerges as a region of low child mortality followed by Rift Valley, Coast, Nairobi and Eastern in that order.

3.2 Trends of infant mortality

This section presents time trends of infant mortality in Kenya from the 1998 DHS data for children born within ten years before the survey. The rates are estimated for three-year intervals to provide some degree of smoothing. The presentation in this section is largely descriptive and serves the objective of determining whether the changes in mortality in the decade preceding the 1998 DHS characterized all the regions of the country. Essentially, we are estimating mortality rates for synthetic cohorts[3]. As Rutstein (1984) has noted, there are three reasons for using synthetic cohorts to estimate mortality rates from survey data such as DHS. First, age is the most important factor related to mortality and combining it with the date of birth yields time period. Second,

3 For the most recent period before the survey, the rates are adjusted for censoring because some children were partially exposed to the risk of death in this period. For instance, children born after July 1997 were not exposed to the risk of infant mortality for a full twelve months. It was assumed that the censored children were only exposed to the risk of death for half of the time in a particular period. Half of the censored cases were subtracted from the denominator in the estimation of the rates.

using synthetic cohorts allows the calculation of probabilities of death for the periods of time closest to the survey date. Lastly, the probability of death is more dependent on period-related events such as epidemics, famines and wars, conditions that affect all or several cohorts simultaneously and is less dependent on factors specific to a given cohort.

Tables 2 presents the unadjusted and adjusted rates of infant mortality for the national and regional populations in Kenya, while Figure 1 is a graphical depiction of these mortality trends based on adjusted mortality rates. There are four distinct trends of infant mortality in the ten-year period preceding the 1998 DHS. The first characterizes the country and the Coast region, which started with lower infant mortality in 1988, increased in the intervening period, 1991-94, before declining again in the last period, 1994-98. For the country, infant mortality increased by about 6 percent between the periods 1988-91 and 1991-1994, 74 to 78 per 1,000 live births. However, it declined in the last period, 1994-98 to 75 per 1,000 live births. Infant mortality increased from 64 to 82 infant deaths per 1, 000 live births between 1988-1991 and 1991-1994 periods in Coast province, an increase of about 30 percent. However, it declined in the subsequent period to stand at 71 infant deaths per 1,000 live births.

Nairobi, Rift Valley and Western provinces fall in the second category in which infant mortality was declining throughout the decade. In Nairobi, infant mortality declined from 55 to 38 infant deaths per 1,000 live births between the 1988-1991 and 1991-1994 periods, a decline of about 31 percent. In comparison, the decline between the 1991-1994 and 1994-1998 is relatively small, about 2 percent. In Rift Valley province, infant mortality declined by about 3 percent between the first and the second periods. It declined further in the last period, 1994-1998, to stand at 55 deaths per 1,000 live births representing a decline of about 8 percent between this period and the 1988-1991 period. The largest decline in this category was registered in Western province where infant mortality declined from about 87 deaths per 1,000 live births in the 1988-1991 period to about 70 per 1,000 live births in the subsequent period (1991-1994) and stood at 57 infant deaths per 1,000 live births in the 1994-1998 period. If the decline between 1988-1991 and 1994-1998 periods is considered, mortality declined by slightly over one-third in the province, which is quite a substantial decline within a relatively short period. The results for infant mortality in Western province contrast sharply with those for child mortality presented in the next section; child mortality was in upward trend in the region. This suggests that the effect of the determinants of mortality could be acting differently for the two childhood age-periods.

Table 2: Infant mortality trends in Kenya for births within ten years prior to the 1998 DHS

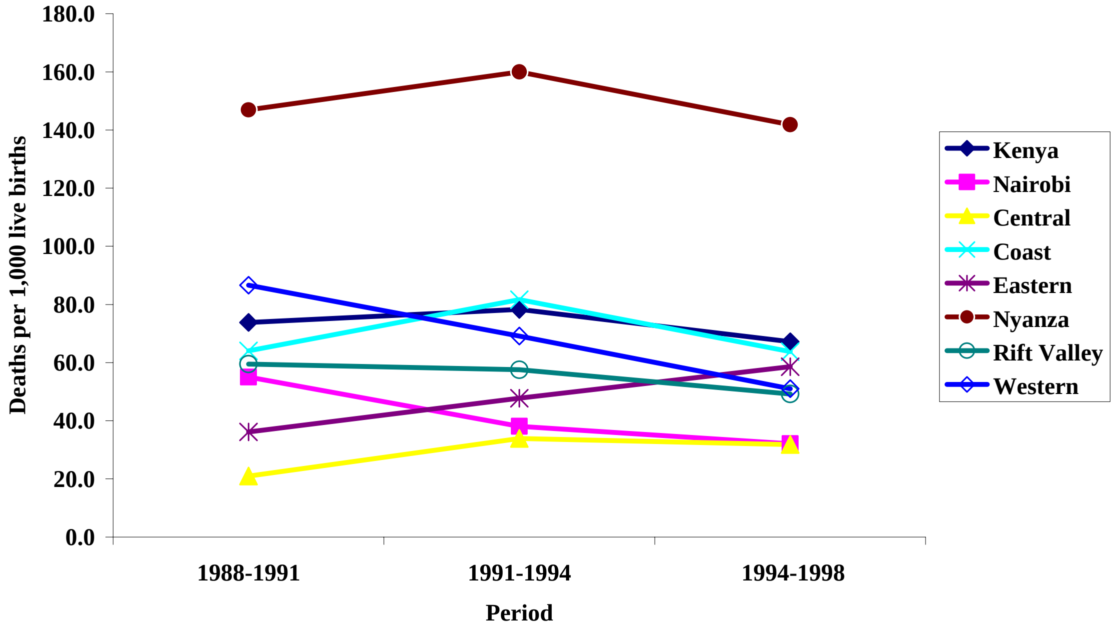
	Period		
Region	**June 1988-May 1991**	**June 1991-June 1994**	**June 1994-June 1998**
Nairobi	50.0(55.0)	38.1(38.1)	36.6(36.6)
Central	21.0(21.0)	31.9(33.9)	37.0(37.0)
Coast	57.7(64.0)	76.4(81.7)	68.0(71.0)
Eastern	35.0(36.2)	44.4(47.7)	66.0(66.0)
Nyanza	143.1(147.0)	151.4(160.0)	151.0(159.5)
Rift Valley	57.4(59.5)	55.5(57.5)	52.4(54.6)
Western	82.9(86.6)	64.4(69.2)	51.1(56.7)
Kenya	**70.8(73.8)**	**74.1(78.3)**	**72.2(75.3)**

Notes: The figures in parentheses are the adjusted estimates, [a] – The interval July 1994-July 1998 is four years. Source: Author's calculations based on births in Kenya for the period June 1988-June 1998 from the 1998 DHS.

The third pattern is exhibited by Eastern and Central provinces. Both regions present a contrasting scenario to that of the country and the other regions, a constant upward trend. In Eastern province, infant mortality increased from 36 deaths per 1,000 live births in the 1988-1991 period to 48 deaths per 1,000 live births in the subsequent period and stood at 66 deaths per 1,000 live births in the 1994-1998 period. This represents an increase of over four-fifths between the 1988-1991 and 1994-1998 periods. In Central province infant mortality increased by over two-thirds between the 1988-1991 and the 1991-1994 periods. The increase in the latest period before the survey was modest, about 9 percent. However, the region still had the lowest infant mortality in the country during the decade.

The good mortality conditions in Central province sharply contrast with those of Nyanza province which had the highest infant mortality rates throughout the period. In Nyanza, infant mortality increased by about 9 percent between the first and second periods, but remained unchanged in the latest period before the survey. Despite this little change in the decade, Nyanza's infant mortality is about four times as high as that of Central province.

Figure 1: Infant mortality trends in Kenya for births within ten years prior to the 1998 DHS by region



3.3 Trends of child mortality

This section presents time trends of child mortality in Kenya from the 1998 DHS data for children born within ten years before the survey. Unlike infant mortality, the rates are estimated for five-year intervals due to the small number of deaths involved. Tables 3 present the unadjusted and adjusted rates of child mortality for the national and regional populations in Kenya, while Figure 2 is a graphical depiction of these mortality trends based on adjusted mortality rates.

Although there is regional variation in child mortality trends, the variation is far less as compared to that observed for infant mortality. There are two broad patterns of child mortality in the 1988-1998 period. The first characterises the country and three regions, Coast, Nyanza and Western in which mortality increased between the two periods, 1988-1993 and 1993-1998. Using the unadjusted rates, child mortality for the whole country increased by about 8 percent between the two periods, from 32.1 deaths per 1,000 live births in 1988-1993 to 34.7 deaths per 1,000 live births in the 1993-1998 period. However, the adjusted rates suggest that child mortality remained more or less the same in the decade. Not only did child mortality increase in Nyanza and Western provinces between the two periods, but both have higher than the national level child mortality rates throughout the decade. The rest of the country had below the national level mortality rates. Child mortality in Nyanza is over twice the national level, 65.5 compared to 28.6 in the latest period before the survey. Similarly, child mortality is one and half times higher in Western province compared to the national level for the period 1993-1998. Although the increase was modest in Nyanza province, the region has the highest child mortality rates in the country in the decade. Mortality conditions were also poorer in Western province; child mortality increased by about 11 percent between the two periods. Although its child mortality rates are lower than those of the country, mortality increased by about 40 percent in Coast province (adjusted rates).

The second pattern is that portrayed by Central, Eastern and Rift Valley provinces; mortality declined in these regions between the two periods. Just as in the case of infant mortality, Central province exhibits better child mortality conditions than the rest of the country. In Rift Valley child mortality declined from 16.5 in the 1988-1993 period to 13.8 in the 1993-1998 period, a decline of about 16 percent. A surprising finding relates to Eastern province where unlike infant mortality, child mortality not only declined between the two periods, but its mortality level is second lowest after Central province. The clearest difference is between child mortality rates for Central and those for Nyanza and Western provinces. Child mortality is 13 times lower in Central than in

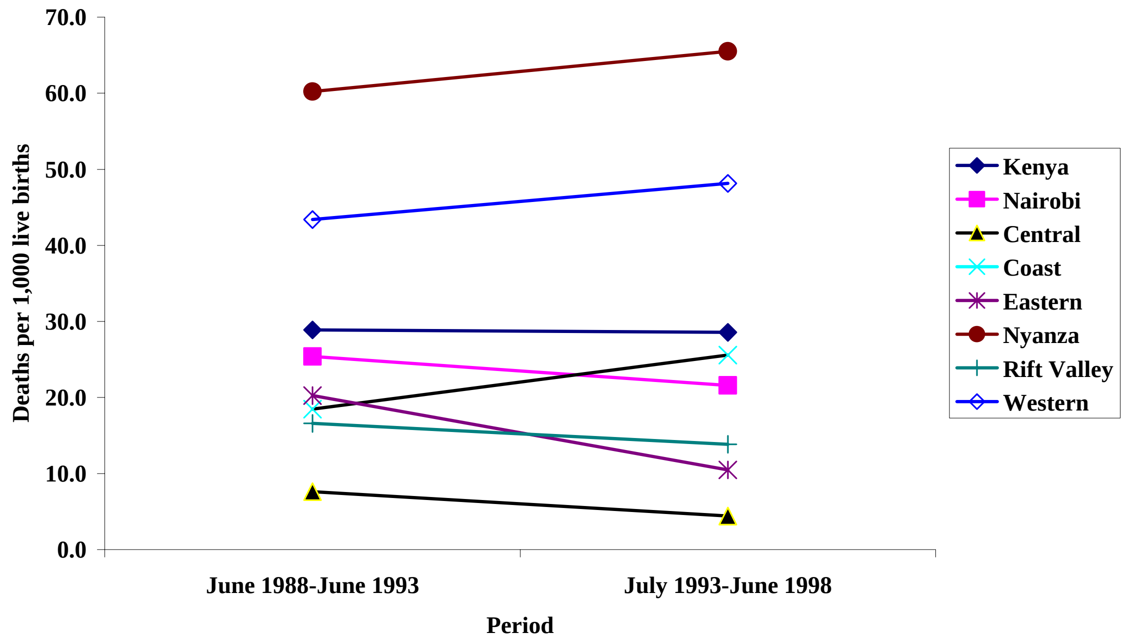
Nyanza, and about 10 times lower than in Western. These results suggest that mortality could remain high in a country due to a few areas having disproportionately more child deaths than others.

Table 3: Child mortality trends in Kenya for births within ten years prior to the 1998 DHS

	Period	
Region	**June 1988-June 1993**	**July 1993-June 1998**
Nairobi	28.2(25.4)	21.6(21.6)
Central	8.7(7.6)	4.4(4.4)
Coast	24.6(18.5)	31.7(25.6)
Eastern	21.6(20.2)	13.1(10.5)
Nyanza	66.7(60.2)	79.4(65.5)
Rift Valley	18.7(16.5)	17.6(13.8)
Western	46.3(43.3)	57.8(48.1)
Kenya	**32.1(28.6)**	**34.7(28.6)**

Note: The figures in parentheses are the adjusted estimates.
Author's calculations based on all births in Kenya for the period June 1988-June 1998 from the 1998 DHS.

Figure 2: Child mortality trends in Kenya for births within ten years before the 1998 DHS



3.4 Determinants of mortality

A major limitation of the analysis in the preceding section is that it is not possible to examine the effect of several differentials of mortality simultaneously. Consequently, this section examines the determinants of child mortality in Kenya using regression techniques which allow for an inclusion of several variables. The selection of the factors analysed in this study is based on the Mosley and Chen (1984) conceptual framework and existing literature on child mortality (see, for example, Kuate-Defo, 1996; Sastry, 1997c; Manda, 1999; Rutstein, 2000). In the Mosley and Chen framework all socioeconomic and socio-cultural determinants of child mortality operate through a common set of five proximate determinants (maternal factors; household environmental contamination; nutrient deficiency; injury; and personal illness control) to affect child health. The socioeconomic factors included in this study are maternal education, migration status, household socioeconomic status, year of child birth, while the socio-cultural factors are ethnicity, marital status and type of marriage, and religion. The proximate factors include survival status of the preceding sibling, preceding birth interval[4], maternal age at birth of child, source of water and type of toilet facility. The distribution of the variables selected for this analysis by number of births and deaths is presented in Table 4. The mechanisms through which the factors affect child survival are discussed in the context of the study's findings.

3.4.1 Determinants of infant mortality

Table 5 presents the results of the relationship between infant mortality and the selected factors. Three hazard models controlling for both the correlation between infant survival risks and unobserved factors are estimated. Model I only includes the period of a child's birth, Model II adds maternal education, migration status, household socioeconomic status, ethnicity, religion, marital status and type of marriage, source of water and type toilet facility, while the full model adds the survival status of the preceding sibling, preceding birth interval and maternal age at birth of child. This strategy is followed so as to assess the change in the relative contribution of the period of child's birth as more controls are introduced.

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[4] The inclusion of survival status of the previous child and birth interval in the analysis necessitates that we utilise the whole birth history of each woman in the sample. The binary sequence analysis also requires that we consider all of the woman's birth history as it seeks to ascertain whether the risks of death among siblings are correlated. Therefore, unlike in the levels and trends analysis in chapter five, all children born at least one month before the 1998 DHS are included in the analysis.

Table 4: Percentage distribution of children by covariates used in analysis of child mortality in Kenya

	Births		Deaths	
Variables	**Number**	**Percent**	**Number**	**Percentage**
Migration status				
Rural nonmigrant	18676	80.0	1840	79.1
Urban nonmigrant	1234	5.3	91	3.9
Urban-rural migrant	1798	7.7	271	11.7
Rural-urban migrant	1640	7.0	123	5.3
Maternal education level				
Primary	13549	58.0	1359	58.5
None	5458	23.4	718	30.9
Secondary or higher	4341	18.6	248	10.7
Household socioeconomic status				
Medium	13503	57.8	1354	58.2
Low	7048	30.2	822	35.4
High	2797	12.0	149	6.4
Year of birth				
<1980	4555	19.5	569	24.5
1980-1984	4115	17.6	400	17.2
1985-1989	5218	22.3	464	20.0
1990-1994	5588	23.9	603	25.9
1995-1998	3872	16.6	289	12.4
Ethnicity				
Kikuyu	3124	13.4	114	4.9
Kamba	2333	10.0	196	8.4
Kalenjin	4568	19.6	335	14.4
Kisii	1733	7.4	132	5.7
Luhya	3548	15.2	423	18.2
Luo	3326	14.2	734	31.6
Meru	1380	5.9	71	3.1
Mijikenda	1938	8.3	213	9.2
Taita	827	3.5	65	2.8
Somali/Others	571	2.4	42	1.8
Religion				
Protestant	14829	63.5	1459	62.8
Catholic	6298	27.0	624	26.8
Muslim	1204	5.2	138	5.9
Other	1017	4.4	104	4.5

Table 4 continued

	Births		Deaths	
Variable	Number	Percentage	Number	Percentage
Marital status and type of marriage				
Monogamous marriage	15985	68.5	1379	59.3
Polygynous marriage	3725	16.0	538	23.1
Single	3638	15.6	408	17.5
Source of drinking water				
River, lake, rain water	11971	51.3	1285	55.3
Well water	5697	24.4	597	25.7
Piped water	5680	24.3	443	19.1
Type of toilet facility				
Pit latrine	17796	76.2	1605	69.0
Water closet	1320	5.7	61	2.6
No facility	4232	18.1	659	28.3
Previous child survival status [a]				
Alive	15399	87.3	1233	53.0
Dead	2233	12.7	531	22.8
Preceding birth interval [a]				
19-35 months	9390	53.3	945	40.6
<19 months	3029	17.2	472	20.3
36+ months	5213	29.5	347	14.9
Age of mother at birth of child				
<20	5758	24.7	752	32.3
20-24	7697	33.0	664	28.6
25-19	5386	23.1	449	19.3
30-34	3005	12.1	289	12.4
>35	1502	6.4	171	7.4
Total (if no inapplicable cases)	23348	100	2325	100

Notes: [a] The numbers do not add up to 23,348 because 5716 children are first births and hence have no preceding sibling. The preceding child survival status and birth interval does not apply to this group of children.

The results of Model I show that there are significant differences in the risk of child death by year of birth. Children born in the 1990s face significantly higher risks of death in infancy while those born in 1980s face lower risks of death compared to those born before 1980. For instance, a child born in the 1995-1998 period was 38 percent more likely, while a child born in the 1985-1989 period was 21 percent less likely to die compared to a child born before 1980.

Model II includes other socioeconomic factors, socio-cultural and household environmental conditions. The results demonstrate that the period effects remain not only significant, but their magnitude increases in the presence of control variables. Children born in the 1900-1994 period are 36 percent while those born in the 1995-1998 period are 54 percent more likely to die compared to those born before 1980. Also, except for household socioeconomic status and source of water, the control variables are significantly associated with the risk of death in infancy and their effect is in the expected theoretical direction.

Model III which adds controls for biodemographic factors is limited to second and higher order births because information on the survival status of previous child and preceding birth interval does not apply to first births. The model shows significant improvements over Model II as indicated by the higher likelihood ratio and model's Chi-Square statistics. The shape parameter, γ, for all models shows that the hazard is declining throughout infancy. The model exhibits substantial changes in the effects of the covariates from the preceding models. Overall, the magnitude of effect of maternal education, ethnicity, religion, marital status and type of marriage, and type of toilet facility is depressed, while that of year of birth is increased.

Table 5: Hazard ratios of infant mortality associated with socioeconomic, socio-cultural, biodemographic and household environmental conditions

Variables	Model I	Model II	Model III
Year of birth			
<1980 [a]	1.00	1.00	1.00
1980-1984	0.84(0.07)**	0.89(0.07)	1.02(0.11)
1985-1989	0.79(0.06)***	0.86(0.07)*	1.02(0.10)
1990-1994	1.23(0.10)***	1.36(0.11)***	1.66(0.17)***
1995-1998	1.38(0.12)***	1.54(0.14)***	1.85(0.22)***
Migration status			
Rural nonmigrant [a]		1.00	1.00
Urban nonmigrant		0.73(0.12)*	0.78(0.15)
Urban-rural migrant		1.17(0.12)	1.17(0.13)
Rural-urban migrant		0.82(0.12)	0.89(0.15)
Maternal education level			
Primary [a]		1.00	1.00
None		1.14(0.09)*	1.09(0.09)
Secondary or higher		0.72(0.07)***	0.76(0.08)***
Household economic status			
Medium [a]		1.00	1.00
Low		1.03(0.07)	1.02(0.07)
High		0.82(0.10)	0.87(0.12)
Ethnicity			
Kikuyu [a]		1.00	1.00
Kamba		1.89(0.28)***	1.54(0.26)***
Kalenjin		1.51(0.20)***	1.35(0.20)**
Kisii		1.15(0.20)	1.06(0.21)
Luhya		2.31(0.31)***	1.95(0.29)***
Luo		4.66(0.61)***	3.50(0.52)***
Meru		1.08(0.20)	0.99(0.21)
Mijikenda		1.49(0.27)**	1.24(0.26)
Taita		1.56(0.31)**	1.48(0.33)*
Somali/Others		1.94(0.45)***	1.84(0.46)***
Religion			
Protestant [a]		1.00	1.00
Catholic		1.12(0.08)	1.14(0.08)*
Muslim		1.79(0.29)***	1.74(0.31)***
Other		1.10(0.10)	1.03(0.20)

Table 5 continued

Variables	Model I	Model II	Model III
Marital status and type of marriage			
Monogamous union [a]		1.00	1.00
Polygynous union		1.28(0.10)***	1.21(0.10)**
Single		1.18(0.10)**	1.16(0.11)
Source of drinking water			
River, Lake, Rain water [a]		1.00	1.00
Well water		0.95(0.07)	0.93(0.07)
Piped water		1.02(0.09)	1.05(0.10)
Type of toilet facility			
Pit latrine [a]		1.00	1.00
Water closet		0.71(0.13)*	0.77(0.17)
No facility		1.25(0.10)***	1.20(0.10)**
Previous child survival status			
Alive [a]			1.00
Dead			2.05(0.15)***
Preceding birth interval			
19-35 [a]			1.00
<19 months			1.48(0.11)***
36 or more months			0.68(0.05)***
Age of mother at birth of child			
20-24 [a]			1.00
Below 20			1.22(0.11)***
25-29			0.94(0.8)
30-34			1.20(0.11)**
35 or more			1.37(0.16)***
Sample size	23348	23348	17632 [b]
Number of failures	1620	1620	1217
Negative Log Likelihood	9701	9483	7009
Likelihood Ratio Chi-Square	59	494	573
Degrees of Freedom	4	29	36
Theta	**1.43(0.13)*** **	**0.81(0.09)*** **	**0.45(0.09)**
Likelihood Ratio Chi-Square of Theta=0	321	157	39
γ	0.24(0.01)	0.24(0.01)	0.25(0.007)

Notes: [a]= Reference category; Standard errors are in parenthesis; Factor significance levels: ***=1% or better; **=5%; *= 10%; [b]= Including the preceding child survival status and birth interval in Model 3 reduces the number of observation because only second and higher order births are analyzed; γ is the shape parameter of the Weibull model.

Children of mothers with secondary education are about 20 percent less likely to die compared to those of mothers with primary education. This suggests that about 9 percent of the effect of secondary or higher education operates through biodemographic factors, household environmental conditions and other background factors. Children born in the period 1990-1994 are one and half times while those born in the period 1995-1998 are about twice as likely to die relative to those born before 1980. This increase as in Model II means that its relationship is better revealed in the presence of other background and biodemographic factors as well as household environmental conditions. It also possible that there are other effects that are not controlled that may be associated with the period of birth.

The large disparity between the *Luo* and the *Kikuyu* substantially decreases in the model including biodemographic factors. Compared to Models II, where children of *Luo* mothers are about five times more likely to die than those of the *Kikuyu*, they are now three and half times more likely to die. The hazard ratios for the other ethnic groups also decline substantially in the presence of biodemographic factors. This suggests that a large proportion of the effects of ethnicity operate through observed biodemographic factors including birth spacing, survival status of preceding child and maternal age. Regarding religion, children of Muslim mothers are about 74 percent more likely to die in infancy compared to children of Protestant mothers. Compared to children of mothers in monogamous unions, children of mothers in polygynous unions are 21 percent more likely to die in infancy, while those of single mothers are 16 percent more likely to die but the relationship is not significant.

Household environmental conditions, particularly the type of toilet facility in the household, significantly associate with infant mortality. Living in a household with no toilet facility increases the risk of child death by 20 percent compared to living in a household with a pit latrine. Although the association is not statistically significant, living in households with a water closet reduces the risk of infant death by one-fifth.

The estimated variance parameters associated with the frailty effect, θ, are 1.43, 0.83 and 0.45 in Model I, Model II and Model III respectively. These parameters are highly significant and indicate that survival risks in infancy continue to be differentiated due to unobserved factors shared by siblings. However, there is a large reduction in the magnitude of the random term between Model II and Model III which includes the biodemographic factors. In particular, the effects of the survival status of the preceding child are reduced substantially; children whose immediate preceding sibling was dead were twice as likely to die in infancy compared to children whose immediate preceding sibling was alive. This suggests that the death of a previous child is acting as a proxy for unmeasured family factors and is also an indicator of correlated mortality risks among siblings (Curtis, Diamond & McDonald, 1993; Sastry, 1997b; Omariba, 2004).

Concerning birth intervals, children who were born less than 19 months after their preceding sibling are about one and half times more likely to die compared to those born 19-35 months after the preceding sibling. Conversely, a child born 36 or more months after the previous sibling was about 30 percent less likely to die during infancy. As is expected young and old maternal age at birth are associated with higher risk of child death. For example, relative to a child born when the mother was aged 20-24 years, a child born when their mother was aged below 20 is 17 percent, while one born when the mother was aged 35 and over is 33 percent more likely to die.

3.4.2 Determinants of child mortality

Table 6 presents the results of the relationship between child mortality and the selected factors. The same analytical strategy used for infant mortality is followed for child mortality. The respective negative log likelihood and Chi-Square statistics indicate that the overall models are significant. The shape parameter, γ, indicates that the hazard is declining in childhood. Again, the frailty effects are substantial and significant (1.98, 0.92 and 0.98) for child mortality; the risks of child death between families continue to differ even after controlling for a number of known determinants of mortality. The results of the parameter estimates are largely in line with theoretical expectations and patterns observed for infant mortality. However, it is clearly evident that the relative effect of the covariates on child mortality is larger than that observed for infant mortality.

In this section we provide an overview of the patterns shown in the table comparing them with those of infant mortality where appropriate. The results of Model I show that there are no statistically significant differences in the risk of death between children born in the 1980-1984 and 1985-1989 periods and those born before 1980. However, compared to the latter, children born in the 1990-1994 period were 68 percent and those born in the 1995-1998 period were 36 percent more likely to die. The results of Model II show that except for migration status, religion and marital status and type of marriage, the other socioeconomic and socio-cultural factors are significantly associated with child mortality.

Table 6: Hazard ratios of child mortality associated with socioeconomic, socio-cultural, biodemographic and household environmental factors

Variables	Model I	Model II	Model III
Year of birth			
<1980a	1.00	1.00	1.00
1980-1984	1.02(0.12)	1.10(0.13)	1.32(0.19)**
1985-1989	1.19(0.13)	1.33(0.15)**	1.53(0.22)***
1990-1994	1.68(0.19)***	1.92(0.23)***	2.30(0.35)***
1995-1998	1.36(0.24)*	1.59(0.28)**	1.68(0.40)**
Migration status			
Rural nonmigrant [a]		1.00	1.00
Urban nonmigrant		0.96(0.24)	1.03(0.31)
Urban-rural migrant		1.11(0.16)	1.08(0.18)
Rural-urban migrant		1.23(0.24)	1.26(0.30)
Maternal education level			
Primary [a]		1.00	1.00
None		1.26(0.13)**	1.26(0.15)**
Secondary or higher		0.55(0.08)***	0.55(0.10)***
Household economic status			
Medium [a]		1.00	1.00
Low		1.18(0.11)*	1.18(0.13)
High		0.75(0.15)*	0.84(0.19)
Ethnicity			
Kikuyu [a]		1.00	1.00
Kamba		2.85(0.79)***	2.58(0.81)***
Kalenjin		2.30(0.60)***	2.02(0.60)**
Kisii		5.17(1.39)***	4.56(1.39)***
Luhya		7.11(1.77)***	6.02(1.69)***
Luo		9.58(2.39)***	8.57(2.41)***
Meru		1.76(0.60)*	1.66(0.62)
Mijikenda		4.30(1.32)***	3.27(1.16)***
Taita		3.00(1.01)**	2.75(1.05)***
Somali/Others		1.60(0.83)	1.07(0.70)
Religion			
Protestant [a]		1.00	1.00
Catholic		1.05(0.11)	1.02(0.12)
Muslim		0.87(0.22)	0.77(0.24)
Other		0.73(0.19)	0.77(0.23)

Table 6 continued

Variables	Model I	Model II	Model III
Marital status and type of marriage			
Monogamous union [a]		1.00	1.00
Polygynous union		1.11(0.12)	1.21(0.15)
Single		1.16(0.14)	1.29(0.18)*
Source of drinking water			
River, Lake, Rain water [a]		1.00	1.00
Well water		0.89(0.10)	0.91(0.11)
Piped water		1.05(0.14)	0.99(0.15)
Type of toilet facility			
Pit latrine [a]		1.00	1.00
Water closet		0.60(0.18)*	0.64(0.22)
No facility		1.43(0.16)***	1.25(0.16)*
Previous child survival status			
Alive [a]			1.00
Dead			1.16(0.14)
Preceding birth interval			
19-35 [a]			1.00
<19 months			1.29(0.14)**
36 or more months			0.75(0.09)***
Age of mother at birth of child			
20-24 [a]			1.00
Below 20			1.40(0.18)***
25-29			1.03(0.12)
30-34			0.96(0.14)
35 or more			1.14(0.22)
Sample size	21671	21728	16378 [b]
Number of failures	705	705	547
Negative Log Likelihood	4111	3940	3014
Likelihood Ratio Chi-Square	24	367	301
Degrees of Freedom	4	29	36
Theta	**1.98(0.28)*** **	**0.92(0.18)*** **	**0.98(0.22)*** **
Likelihood Ratio Chi-Square of Theta=0	133	54	38
γ	0.58(0.02)	0.58(0.02)	0.59(0.02)

Notes: See the notes for Table 5.

The effect of year of birth increases when we include controls for socioeconomic and socio-cultural factors and household environmental conditions. Children born in the 1990-1994 period are about twice as likely, while those born in the 1995-1998 period are over one and half times more likely to die compared to children born before 1980. Unlike infant mortality, however, children born in the 1985-1989 period are more likely to die in childhood, an increase of 33 percent in the risk of death.

Just as in the case of infant mortality, children of mothers with no education face increased risks of death, while those of secondary or higher education are less likely to die in comparison with those of mothers with primary education (Model II). However, whereas in infancy, children of mothers with no education face an increased risk of death of 14 percent, in childhood the increase is one-third. In infancy, the reduction in the risk of death among children of mothers with secondary education is about 30 percent, but in childhood the risk is reduced by about 50 percent. This pattern is also maintained in the full model including biodemographic factors. The estimated effects of maternal education on child mortality in Kenya, therefore, correspond closely to findings from elsewhere in the less developed world (Desai and Alva, 1998; Rutstein, 2000).

Living in a low socioeconomic household increases the risk of death by over one-fifth, but living in a high socioeconomic one reduces the risk of death by about one third. Again, the effect of household socioeconomic status is stronger for child mortality than for infant mortality.

Although children of *Luo* mothers are the most disadvantaged, being about ten times more likely to die, the differences between children of other ethnic groups and those of the *Kikuyu* are larger and starker than in infancy. For example, whereas in infancy children of *Luhya* mothers are only twice as likely to die compared to those of the *Kikuyu*, they are seven times more likely to die in childhood.

As with infant mortality, among household environmental factors, only the type of toilet facility is significantly associated with child death. Living in a household with a water closet is associated with a two-fifths reduction in the risk of child death, while living in households without a toilet facility increased the risk of child death by a similar magnitude. These results are in congruence with previous research showing that the type of toilet facility is a more important determinant of child survival compared to water supply (Gubhaju, Streatfield & Majumder, 1991; Timaeus & Lush, 1995; Esrey, 1996).

As indicated by the log likelihood and Chi-Square statistics, Model III of the significantly improves on Model II. However, the effect of household socioeconomic status is not significant while the marital status category 'Single' is significant at 10 percent level. The direction of the effect of education, year of birth, ethnicity and type of toilet facility is similar to that in Model II attesting to the robustness of these factors in explaining death in childhood. However, whereas the magnitude of effects of education remains largely unchanged that of ethnicity is substantially depressed. The attenuation of the parameters suggests that some of their effects operate through biodemographic factors.

As in infancy, the effect of year of birth substantially increases between Models II and III. Although child mortality conditions were on the upward trend in the 1980s and 1990s, it is children born in the early 1990 to the mid-1990s who were the most disadvantaged. Again, the mortality differences by year of birth are more prominently revealed in the presence of biodemographic factors and household environmental conditions. Although the effect of having a water closet in the household is in the expected direction, the relationship is not statistically significant. However, living in households without a toilet facility increased the risk of child death by about one-fifth.

The magnitude of the effects of biodemographic factors clearly demonstrates that they are less important in childhood than in infancy. For instance, whereas in infancy a birth interval of less than 19 months is associated with an almost 50 percent increase in the risk of death, in childhood the increase is only about one-third relative to an interval of 19-35 months. Similarly, an interval of or 36 or more months reduces the risk of death by about 32 percent in infancy, but by 25 percent in childhood. Regarding maternal age at birth, only young age (below 20) is significantly associated with the risk of death; children born at this age face 40 percent higher risk of death compared to those born when their mother was aged 20-24. This sharply contrasts with infancy where young and old maternal ages at birth were positively associated with heightened risk of death. The main surprising finding relates to the survival status of the preceding child; the death of the preceding child is not significantly associated with the risk of death in childhood. Since the death of the preceding child is likely a proxy for unobserved family effects, its effect expectedly disappears in the presence of frailty.

4. Discussion and conclusions

This paper has examined the levels and trends of infant and child mortality in Kenya over the period 1988-1998 and the determinants mortality among children. The levels of mortality over the period 1988-1998 show that some parts of the country, namely Central and Nairobi, have achieved improvements in mortality despite overall high mortality levels. Nyanza and Western provinces exhibit higher than national mortality levels whereas Eastern and Rift Valley fall in between the two groups. These findings are also consistent with mortality patterns that have been observed before in the country (Brass and Jolly; 1993; Brass, 1993).

The findings point to differences among provinces in levels of social and economic development as well as climatic and ecological conditions associated with causes of diseases, the latter being particularly the case for malaria. Central province, for instance, is considered more developed in terms of education, health facilities and economic production than other areas in Kenya. Western, Coast and Nyanza provinces, on the other hand, are not only malaria-prone areas, but they are relatively less developed. In the case of Rift Valley, the epidemiological setting of the region is less conducive to the spread of measles and malaria (Ewbank et al., 1986; Brass and Jolly, 1993).

These results suggest that child mortality could remain high in certain regions of the country even though there are overall declines and that large increases in a few areas could increase the national mortality levels even though there is no change in other areas. Three provinces including Nyanza, Coast and Western seem to have the highest mortality levels. In particular, Nyanza registered the highest mortality in the country with its infant and child mortality being twice as high as the national levels. Although we attempt to explain why provinces differ in the following pages, a comprehensive discussion of the results is not possible. This is because we lack information on the socioeconomic changes, disease patterns and other relevant determinants of mortality specific to the provinces during the period under study.

Mortality trends in the country during the ten years preceding the 1998 DHS are quite diversified. The largest differences were observed for infant mortality which suggests that most of the changes in childhood mortality in this decade occurred among infants. The results are in agreement with the established fact that infant mortality is most sensitive to changes in socioeconomic and health conditions compared to mortality in other ages (e.g., UN, 1986; 1988; National Research Council, 1993; Eloundou-Enyegue et al., 2000). Overall, for some provinces mortality increased between 1988 and early 1990s and then declined again. However, the period 1991-94 seems to have witnessed the worst mortality conditions in the entire decade. These results are also supported by those from the Weibull hazard models.

Just as other developing countries, Kenya registered significant declines in mortality among children after the Second World War (see National Research Council, 1993; Brass and Jolly, 1993), representing a decline of about 60 percent in the 40 year period. These declines were largely attributed to government actions such as disease control, improved medical technologies and increased availability of medical facilities (United Nations, 1973; Huw, 1990; Rutstein 2000). The emerging mortality trends in Kenya can therefore be interpreted as suggesting that the conditions which led to declines in the past have changed. However, the period 1988-98 should be viewed as one of relative stability in mortality conditions as compared to the period 1945-1985 during which the country experienced substantial declines. Arguably, achieving declines from high levels is easier than from somewhat lower levels because when mortality is very high, fewer causes of death are involved than when it is relatively lower.

For the country as a whole, there are several developments that could be a reflection of the emerging trends in childhood mortality in the decade under review. The higher risk of death in the 1990s coincided with the political changes that saw Kenya revert to multiparty democracy and the suspension of bilateral and multilateral aid. The latter development aid may have affected programmes such as immunization and maternal health which are largely dependent on donor funding. The volatile political conditions, especially through most of the early 1990s, may have affected the economy by disrupting production and limiting foreign investments. Declining government expenditure on health and the introduction of user fees in health services due to implementation of structural adjustment programs (Mwabu, 1995; Isaksson, 2001) may have further limited access to healthcare.

The consistently high infant mortality in Nyanza province points to the presence of a pandemic in the population that is decimating young lives. Nyanza is the region most affected with the HIV/AIDS pandemic. For example, about 17 percent of Kenya's 31 million people lived in Nyanza in 2000 (Blacker, 1996). However, its HIV/AIDS prevalence rate in 2000 was 22 percent compared to 13.5 percent for the country (Kenya Ministry of Health, 2001). The hazard regression results also support research pointing to the potential effects of HIV/AIDS (Hill et al., 2001; Nyambedha, Wandibba & Aagaard-Hansen, 2001). The effect of unmeasured factors is also substantial and significant. The HIV/AIDS pandemic affects child survival both directly and indirectly. The direct effect operates through mother-to-child infection during pregnancy or at delivery. On the other hand, the indirect effects are manifested through death of parents. Orphans suffer a myriad of problems including lack of food and abuse from relatives while some are forced into child labour (Nyambedha, Wandibba & Aagaard-Hansen; 2003; Yamano and Jayne, 2004), which compromises their health.

Significant associations between the selected factors and infant and child mortality were also observed. However, the relative effect of the factors differed between infancy and the childhood period; biodemographic factors were more important in infancy while socioeconomic, socio-cultural and hygienic factors were important in childhood. In the final models controlling for all factors the most important among these are education, ethnicity, marital status and type of marriage, toilet facility, birth interval and maternal age at birth of the child. Other factors including religion and survival status of previous child were significant only for infant mortality, while migration status, household socioeconomic status and source of water were not significant for both infant and child mortality. We now briefly discuss the results in turn starting with biodemographic factors.

The death of the previous child affects the risk of death through the truncation of the interval to the subsequent birth (Frankenberg, 1998; Grummer-Strawn, 1998; Palloni & Rafalimana, 1999) which is in turn associated with the maternal depletion syndrome that can lead to preterm and low birthweight births and pregnancy complications (Zenger, 1993; Curtis et al., 1993). Parents may also make deliberate efforts to replace the dead child, what is called the replacement hypothesis (see LeGrand, Koppenhaver, Mondain, & Randall, 2003; Gyimah & Rajulton 2004). The death of a child could also lead to maternal depression thereby, compromising the health of the child both in the womb and in early infancy (see Steer, Scholl, Hediger & Fischer, 1992). A depressed woman may not adhere to proper dietary habits during pregnancy, may suffer sleep loss and her general ability to care for the child may be compromised. Although it is difficult to precisely determine what mechanism is operating in a given situation, the exercise is important for selecting between policy options. If the death of the preceding child reflects the birth spacing mechanism, improving availability and use of contraception could reduce the risk of child death. However, policy options responding to the depression and replacement mechanisms are less certain.

Maternal depletion effects should be weaker when the preceding child is dead because the physiological demands of lactation are no longer present (Zenger, 1993). In Kenya, the cessation of breastfeeding due o a child's death is also likely to lead to earlier subsequent conception because only about 32 percent of married women use modern contraception (NCPD et al., 1999). Our results also show that short birth intervals are independently associated with deleterious effects on child survival. Besides the maternal depletion syndrome, short birth intervals increase the number of children of almost similar ages in the household. Consequently, this heightens susceptibility of these children to infectious diseases due to their physical proximity (Zenger, 1993; Alam 1995) and leads to siblings' competition for household resources including individualized maternal care (Gribble, 1993). However, the difference in the magnitude of effects suggests that the physiological effects of birth intervals are stronger in infancy, while those of competition for household resources are stronger in childhood.

The effects of maternal age were greater in infancy, although young maternal age was also significant for child mortality. The effects of maternal age at birth are both physiological and socio-psychological. The immature reproductive systems of young mothers and primaparity and the depleted physiological system of older mothers due to repeated pregnancies makes them susceptible to pregnancy complications and bearing low birthweight babies (Trussell and Hammerslough, 1983; Miller, 1993; Alam, 2000), both of which are associated with a higher risk of child death (see Solis, Pullum & Frisbie, 2000). The socio-psychological hypothesis holds that younger mothers are also not yet ready to take parental responsibilities, may not have decisionmaking authority in the household and lack financial resources to seek medical care for their children (Alam, 2000).

Household environmental conditions reflect the level of environmental contamination, which determines the transmission of infectious agents to children (Mosley and Chen, 1984). The source of water measures the level of water contamination, while type of toilet measures faecal contamination. These factors also serve as a proxy for household hygiene and standards of cleanliness, and food preparation and storage practices. Although the results on type of toilet facility were consistent with the theoretical expectations and previous research, the effect of source of water was statistically significant. The result is surprising because only about 20 percent of children live in households using piped water. Since the majority of the population relies on unsafe water sources, the effect of water on child health largely depends on conditions of use including manner of storage and whether families treat the water before using it. However, DHS does not collect this information.

Higher child survival among educated mothers has been attributed to higher socioeconomic status and improvement of maternal basic childcare skills including domestic management of child illness, preventive care strategies and effective use of modern health services (Caldwell, 1979; 1994; Das Gupta, 1990). Education also changes traditional familial relationships regarding decisionmaking giving mothers a greater say in childcare issues (Caldwell, 1986; O'Toole and Wright, 1991). Educated mothers are therefore more likely to make decisions regarding childcare including nutrition and seeking medical attention for their sick children without waiting for their husbands. Nonetheless, at higher levels of education it is difficult to measure the effect on child health that is actually attributable to education. Highly educated mothers are not only likely to be working in occupations that afford them the means to improve the household standard of living, but they may also marry men who are highly educated and wealthy (Ware, 1984). Other research suggests that the presence of health facilities and safe water and sanitation in a community could make the effect of maternal education less important (Basu, 2000). This is because where they are available, these facilities benefit everyone in the community.

Although ethnic mortality differentials could be due to differential levels of socioeconomic developments between areas inhabited by the various groups (see Omariba, 2004; Brockerhoff & Hewett, 2000), cultural differences in childcare practices and beliefs on disease causation and patterns of diseases could be more important. Regarding beliefs on disease causation and the pattern of diseases, the results on the higher mortality among the *Luo* compared to other tribes are particularly noteworthy. For example, although they both inhabit Nyanza province, the risk of child death in all models was consistently higher among the *Luo* than the *Kisii*. The high mortality among children of *Luo* mothers could be attributed to the high incidence of HIV/AIDS in this group (Kenya Ministry of Health, 2001) due to the prevalence of levirate marriage and the belief that HIV/AIDS is caused by witchcraft and/or breaking of certain traditional taboos (Ocholla 1991). Also, among the *Mijikenda*, the first line of treatment for pregnancy related illness involves consulting traditional medicine men and witchdoctors, because the illnesses are attributed to spiritual causes (Boerma and Mati 1989). Potential pregnancy complications may therefore go undetected until it is too late to save the life of the child and the mother. Nonetheless, our understanding of ethnic mortality differentials would benefit from further research especially examining ethno-cultural differences in childcare and health related behaviour.

Mortality differentials by religion may be related to differences in attitudes and beliefs on nature and causation of disease and death and childcare practices between religious groups (Kuate-Defo, 1996; Gregson, Zhuwau, Anderson & Chandiwana, 1999; Ogunjuyigbe, 2004). Another possible explanation relates to the low status of women among Muslims (Caldwell and Caldwell, 1993; Jejeebhoy and Sathar, 2001). Low women status is reflected in their lack of decision-making, mobility, freedom from abusive relations with husbands and access to and control over economic resources. Therefore, in cultures where women have less autonomy, the inability to make decisions regarding childcare and treatment in particular, will have negative consequences on the survival of their children.

The results also show that children from polygynous and single families are more likely to die compared to those from monogamous families. The major hypothesis in the polygyny-mortality relationship is the competition for household resources due to a large number of children and mothers (Strassman, 1997; Oni, 1996). It has also been suggested that women in polygynous unions are traditional in their childbearing behaviour and are slower to adopt modern healthcare practices relating to prenatal care and child delivery (see United Nations, 1985; Kuate-Defo, 1996). The higher risk of death for children in single-parent families is attributable to poverty and economic hardships, especially among widowed and divorced or separated mothers, and young age at birth particularly among never married mothers (see Basu, 2000; Alam, 2000).

The effect of shared unmeasured and unmeasurable factors on the risk of child death in Kenya is not ignorable. The results for infant mortality show that a substantial amount of the unmeasured variation is explained by the selected factors. However, controlling for all selected factors did not significantly change the frailty effect for child mortality. This analysis did not include breastfeeding and healthcare factors such as immunization, prenatal and delivery care and place of child delivery because the information was collected for only children born in the three years preceding the survey. The unobserved heterogeneity estimate also includes the effect of healthcare factors. The exclusion of these important determinants of child survival therefore inflates the magnitude of the frailty effect. However, even if we are able to control for all measurable determinants of mortality, unobserved heterogeneity is likely to remain due to unmeasurable factors such as genetic frailty.

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