WHAT ACCOUNTS FOR THE UPTURN IN INFANT MORTALITY IN KENYA DURING THE 1989-2003 PERIOD?

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Abstract

Kenya witnessed an upsurge in early childhood mortality since the late 1980s through the 2003 period. The levels of infant mortality rates increased from 59 deaths per 1000 live births in 1989 to 78 deaths per 1000 live births respectively by 2003 (CBS, et al., 2004). These trends represent a percentage increase of about 32 percent in infant mortality and 29 percent in child mortality for the period of 1989-2003. Scanty research exists on the probable factors behind the upturn in infant and child mortality during the 1988-2003 period. One clearly investigated issue is that the upturn in infant mortality is not as a result of measurement error or deteriorating data quality (Hill et al., 2001; Wangila et al., forthcoming). This paper applies the Weibull regression models in accelerated failure time (AFT) framework using Stata 10 (StatCorp, 2009) to investigate some of the probable factors that may have fuelled the upsurge in infant mortality. The Mosley and Chen (1984) conceptual framework is used as a guide in the identification of the covariates.

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Introduction

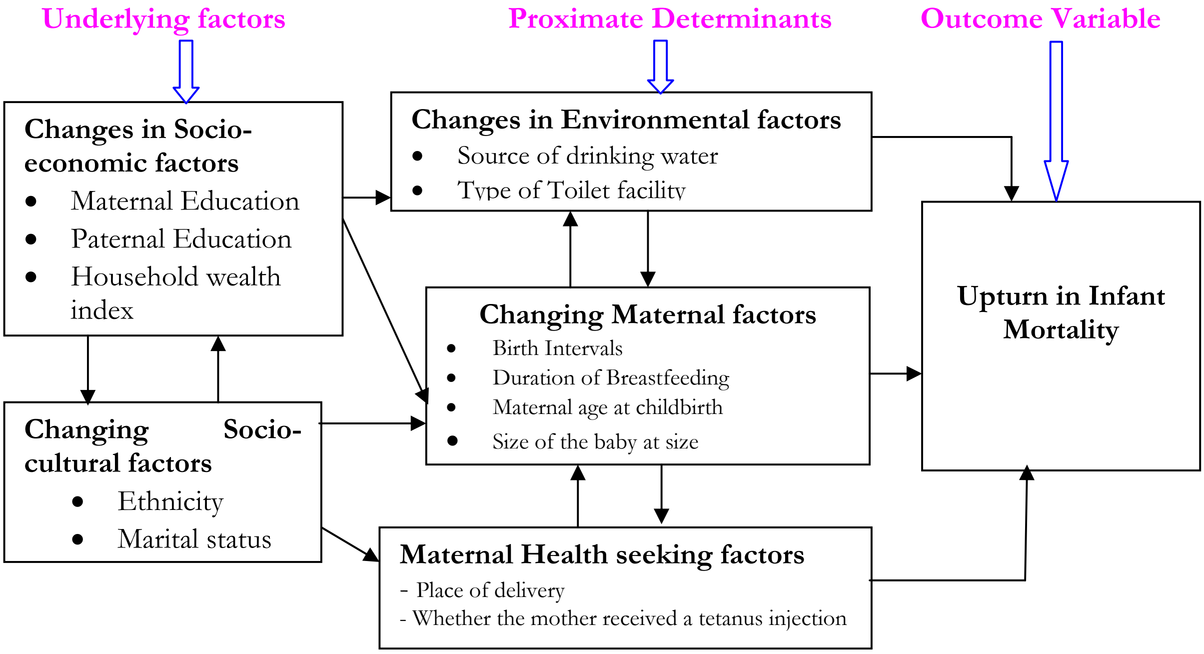
Despite recording an average annual decline in infant mortality of about 4 per cent in 1960-1980 (Hill et al., 2001), Kenya experienced an upsurge in under-five mortality since the late 1980s-2003 period. Infant and child mortality rose from 59 and 89 per 1000 live births in 1989 to 78 and 115 by 2003 respectively (CBS, *et al.* 2004). This was an increase of about 32 and 29 percent in infant and child mortality respectively. While past literature is replete on the factors responsible for mortality decline in Kenya prior to the late 1980s (Kibet 1982; Muganzi, 1984; KÓyugi 1992; Brass and Jolly 1993; Ikamari 1996; Khasakhala 2000), very little is known regarding the factors behind the recent upsurge in early childhood mortality in Kenya during the 1988-2003 period. A number of past studies however negate the observed upsurge in early childhood mortality in Kenya to poor or deteriorating data quality (Hill *et at.,* 2001; Ikamari 2004; Wangila et al., *forthcoming*).

This paper applies the Mosley and Chen framework to guide the specification of variables that are likely to have underlie the observed early infant mortality increase in Kenya. The framework asserts that early childhood mortality upturn can only occur if one or more of the proximate determinants change (Mosley and Chen 1984; Hill 2003; Garenne and Gakusi 2007). Since the factors behind the increase in mortality must have changed in value with the changing period under observation, this paper uses the Weibull parametric survival analysis techniques to study the role of changing child level factors, declining educational levels, deterioration in water and sanitation issues, and changes in maternal health care utilization on the upturn in early childhood mortality in Kenya. The paper uses a pooled KDHS dataset for 1993, 1998 and 2003 and applies the Weibull models that take the acceleration failure rate (AFT) framework to isolate the potential correlates behind the upturn in infant mortality.

Theoretical Framework

In this paper, we use the Mosley and Chen (1984) framework to guide our investigation into the factors behind the upturn in early childhood mortality increase in Kenya for the following reasons: First, it is one of few frameworks that attempts to address the linkages between child mortality due to public health interventions on the one hand and social, economic and intermediate variables on the other hand. Second, Mosley and Chen framework proposes a list of proximate determinants of mortality which are supposedly exhaustive, such that child mortality will change if — and only if — one or more of the determinants change (Hill 2003:2). This is relevant and critical for this particular study topic. Thirdly, apart from injury related factors, most other proximate determinants proposed by this model (maternal factors, environmental pollution, nutrient deficiency; and personal illness control) can directly or by proxy be measured from the available rounds of demographic and health survey data collected in Kenya since the 1989-2003 period when the country experienced an upsurge in early childhood mortality. Finally, the Mosley and Chen framework and its variants is the most widely used framework for studying mortality changes. Below is the conceptual framework we adopted in guiding this study.

Figure 1: The Operational Framework for Studying Infant Mortality in Kenya



Source: Authors' modification of the Mosley and Chen (1984) Conceptual Framework

In the next paragraph we review the methodological approaches used to examine the contribution of some of the aforementioned factors on the rising rates of early childhood mortality.

Methodology of Data Analysis

Although Cox regression is the most widely multivariate approach for analyzing time to event data, it is of paramount importance that prior to its application, the proportionality assumption holds for each and every selected covariate (Bradburn, *et al.,* 2003:432). When the proportionality assumption is not met, it implies that the linear component of the model varies with time in some manner (Collett 2003:142). Gray (1996) reports that as much as 90 percent reduction in the power of significance tests (i.e. the chances of false negatives, rejecting the existence of true covariate effects) may be witnessed when rates cross rather than when they are proportionate. A preliminary analysis done by the authors using the Schoenfeld residuals (appendix 1) and running of hazard plots (appendix II) revealed that the assumption of non-proportionality which is critical for the application of Cox Proportional Hazard model was flouted.

There are a number of ways for resolving hazards that are not proportional. Firstly, one can run stratified Cox regression models; Secondly, one can model Cox regression model with time dependent variables and thirdly, one can resort to the use of parametric models. Owing to the fact that KDHS data used in this study did not have time dependent variables, it was implausible to use Cox regression models with time dependent variables. Subsequently, this paper resorts to use of parametric models to investigate the factors responsible for the recent upsurge in infant mortality in Kenya. In particular, the Weibull model with an accelerated failure time (AFT) framework is used to investigate the role of selected covariates on the upturn in under-five mortality. The Stata version 10

(StataCorp, 2009) statistical program is applied due to its suitability of handling such models over other commonly used statistical programs.

The choice of Weibull models in this study is motivated by a number of reasons: Firstly, as a parametric model, it is less complex and lends itself to easy interpretation in comparison to Cox regression with time varying covariates or the stratified Cox regression models. Secondly, our choice is guided by the fact that the distribution of human mortality is theoretically known to follow a Weibull distribution (Cleves *et al.* 2004; Collett 2003; Omariba 2007) and thirdly, Weibull models have been shown to be appropriate for hazards that are either monotonically increasing or decreasing (Blossfeld and Rowher 2002; Dupont 2002). Overwhelming evidence demonstrated in this study show that the risk of dying has been increasing over the study period hence the appropriateness of the Weibull models.

In this study, we run Weibull models that assume that covariates change through an accelerated failure time (AFT) pattern using the *streg* command in Stata 10 (StataCorp, 2009). This modeling approach is appropriate in circumventing the problem of the violated proportional hazards assumption discussed earlier. In an AFT model, the dependent variable is event time. The AFT assumption is that all observations have the same shape hazard function, but the time axis varies such that some groups of children in our case pass through stages of the hazard curve faster than others.

In this study, for births 0-11 months with covariates (x_1, x_2, ... x_p), the Weibull AFT model can mathematically be written as

$S(t)=S_0(\varphi t)$ …………………Equation I

where $S_0(t)$ is the baseline survivor function and φ is an 'acceleration factor' that depends on the covariates according to the formula

$\varphi=\exp\{(b_1x_1+b_2x_2+\ldots+b_px_p)\}$.

The principle here is that the effect of a covariate is to stretch or shrink the survival curve along the time axis by a constant relative amount φ.

The most intuitive way of expressing AFT model coefficients is to exponentiate them as time ratios (TR). Normally, TR > 1 are associated with a prolonged survival time, or more accurately, an expansion of time to failure and vice versa. Suffice it to say, a time ratio above 1 for the covariate implies that this 'slows down', or prolongs the time to the event, while a time ratio below 1 indicates that an earlier event is more likely (Bradburn, *et al.,* 2003:432). If TR=1, it implies that the covariate has no effect on survival time.

Definition of variables

(i) Dependent variable

The dependent variable in this study is infant mortality rate. This is defined as the instantaneous risk of dying between ages 0 to 11 months after birth. This variable is measured as the number of deaths recorded in the age interval (0-11 months) divided by the person months lived in the same age interval. It is expected that infant mortality changed over the study period.

(ii) Mother's age at child birth

This is the exact age of the mother at the birth of the index child. This was computed as the maternal date of birth adjusted for missing dates minus the imputed dates of child birth. This variable is categorized in the following age categories: <20 years; 20-34; 35-49 years. It is hypothesized that the risk of death of a child varies by the age of the mother with young (<20 years) and old mothers (35+ years) associated with a heightened risk of experiencing early childhood mortality. We argue that the changing proportions of mother's age at child birth during the study period partly accounts for the upsurge in infant mortality.

(iii) Birth Interval

This variable refers to the length in months of the preceding birth before the index child. The categories used are <24 months; 25-36 months; 37+ months. Normally, it is expected that shorter birth intervals are associated with a heightened risk of infant mortality and vice versa. It is expected that birth intervals have been changing over the study period.

(iv) Duration of breastfeeding

This is the duration the child breastfeeds prior to being weaned. This is categorised as <10 months, 11-19 months and >20 months. Conventionally, shorter periods of breast feeding are associated with increased chances of child death and vice versa.

(v) Baby size

The variable refers to the physical size of the baby at birth. The categorization used is small and average/large. It is hypothesised that the child survival is a function of the size of the baby at birth with smaller that average baby size associated with heightened risk of experiencing death. While birth weight could have been an appropriate measure for size of the baby at birth and the probability of dying in childhood, our preliminary analysis revealed that about 55 percent of babies in the KDHS datasets used in this study had missing values of the actual weight at birth. Baby size with a higher response rate is used as a proxy measure for baby birth weight.

(vi) Educational level

This refers to the highest educational level attained by the mother or father. This study uses two variables under this: maternal education and paternal education. Categories used in both of these variables are 0 = none, 1= primary and 2= secondary and above. It is expected that the parents with no education will experience higher risks of infant mortality as compared to those with secondary schooling and above.

(vii) Household wealth Index

This is intended to capture the household resources available for childcare and is computed using the principal component analysis (PCA). The categories used are 1) Lower; 2) Middle; 3) Upper. It is expected that given the high likelihood of experiencing resource deprivation, households in the lower tertials will tend to have higher risks of infant mortality than the rest. It is expected that this variable has been changing since 1989-2003.

(viii) Ethnicity

This is aimed at capturing the socio-cultural and ethno-conflict issues that influence child care. Groups examined are the Kikuyu, Kalenjin, Luhya, Luo, Kisii, Kamba, and other (Miji Kenda, Somali, etc).

(ix) Type of Toilet facility

This refers to how the household disposes human excreta. The options used are flush toilet (own/shared), traditional pit latrine, VIP latrine and other (no facility, bush, etc). It is expected that households without any form of facility for human waste disposal will tend to adversely suffer heightened infant mortality from the consequences of poor sanitation as compared to the rest.

(x) Source of water
This variable is defined as the source of water for drinking in the sampled household. The categories used are piped water, well, and lake, pond and stream.

(xi)Tetanus toxoid
This variable measures whether or not the mother received a tetanus toxoid injection during pregnancy or at birth. It is measured as 1 for Yes and 0 for No. Studies have shown that receiving a tetanus jab is associated with a reduced risk of experiencing infant mortality from lockjaw disease especially during the first two weeks of birth.

(xii) Place of delivery
This refers to the place where the child was born. The categories used here are 1 for being born at home, 2 for being born in a government health facility and 3 for being born in a private health facility. It is hypothesized that being born outside a health facility is associated with a heightened risk of experiencing infant mortality.

KDHS Data structure and its implication for analysis

This paper uses a merged data on children born five years preceding each of the three rounds of KDHS conducted in 1993, 1998 and 2003. In total, 15, 125 singletons aged between 0-59 months were included in the study for analysis. The exclusion of multiple births in this study was motivated by the fact that such births tend to exhibit at least twice as much mortality as compared to that of singletons (Khasakhala 2000; Uthman, *et al.,* 2008; Kembo and Ginneken, 2009) and hence inclusion of such births could have biased our mortality estimates upwards. One notable issue was that in 1993 KDHS, the household wealth index variable was not computed and the household wealth index computed during the 1998 and 2003 KDHS was based on varied background variables. Consequently, this paper reconstructed a household wealth index variable of the merged KDHS data using the principle component analysis (PCA). Lastly, to account for sampling differences in the merged dataset, this paper applied the sampling weight prior to analysis.

Bivariate Analysis

Bivariate analysis (Table 1 below) revealed that generally, the infant mortality increased over the 1988-92 to 1999-2003 period. Findings revealed that infant mortality increased over the 1989-2003. The increase in infant mortality from 61.3/1000 live births to 79.6/1000 live births represents an upsurge of almost 30 percent in infant mortality for the entire period of 1988-2003. The results compare well with the 32 percent decline in infant mortality that was found in KDHS analysis (CBS, *et al.,* 2004). In general, the upturn in infant mortality during the 1993-98 (14.3 percent) was slightly greater than that observed during the 1988-1992 (13.5 percent).

Table 1: Changes in infant Mortality Rates by selected covariates, KDHS 1988-2003

	Changes in IMR, 1988-03			
	88-92 period	**93-98 period**	**99-03 period**	**% change 88-03**
IMR/1000 Live births	**61.3**	**69.6**	**79.6**	**29.8**
Mother's Age at child birth				
< 20years	74.9	93.5	87.2	16.4
20- 34	51.4	58.2	73.6	**43.2**
35+	77.6	82.8	90.6	16.8
Baby size at Birth				
Small	86.2	107.5	97.2	12.8
Av./ Large	53.7	58	73.6	**37.1**
Birth Interval				
<24 months	76.7	82.9	130.8	**70.5**
25-36	51.5	78.2	72.5	40.8
37+	47.1	50.5	67	42.3
Breastfeeding period				
<10 months	108.8	227.4	264.3	142.9
10-19 months	1.6	0.7	7.9	**393.8**
>20 months	92.9	6.5	1.5	-98.4
Maternal Education				
None	59	84.9	95.2	**61.4**
Primary	69.5	77.4	85.4	22.9
Sec+	40.1	41.6	54	34.7
Paternal Education				
None	81.5	91.5	104.9	28.7
Primary	63.4	83.5	87.8	**38.5**
Sec+	47.1	42	61.2	29.9
Ethnicity				
Kalenjin	38.4	48.6	50.3	31.0
Kamba	43.1	103.4	75.9	76.1
Kikuyu	27.5	32.9	62.6	**127.6**
Kisii	64.1	26.5	37	-42.3
Luhya	53.5	56.6	92.3	72.5
Luo	142.9	156.8	79.5	-44.4
Other	59.8	48.9	105.6	76.6
Household wealth				
Lower	42.1	60	75.6	**79.6**
Middle	56.5	74.2	80.1	41.8
Upper	79.4	76.4	62.3	-21.5
Place of delivery				
Home	68.8	78.8	83.4	21.2
Gov't Health facility	53.1	56.2	84	58.2
Private Health Facility	33.7	23.1	54.7	**62.3**
Received Tetanus Toxoid				
No	105.1	81.1	63.9	**-39.2**
Yes	54.4	63.8	53.6	-1.5
Total number of cases	**5707***	**4015***	**5403***	

*Source: Primary analysis of merged KDHS 1993, 1998 & 2003. * Some variables do not add up to these figures because of missing cases*

On the other hand, there was an upsurge in infant mortality rate on all the dummies for mother's age at child birth, baby size at birth, preceding birth interval, maternal/paternal education of the index child, household wealth, and place of delivery as indicated in Table I. This implies higher levels of infant mortality in the 1999-2003 period as compared to the 1988-1992 base period. An exception to this upsurge trend was noted on a few variables such as whether or not mothers had a tetanus jab during pregnancy or at child birth which indicated a decline in infant mortality. In addition, some of the dummies on ethnicity and duration of breastfeeding showed mixed trends over the study period.

Multivariate findings

Results revealed that none of the dummies for maternal age at child birth was significantly associated with the risk of infant mortality before and after child level factors were controlled for. On the other hand, compared to children whose preceding birth interval was at least 37 months, those with preceding birth interval of less than 24 months had 13 percent prolonged chances of surviving when child level factors were considered (p-value <0.05). Once child-level factors were adjusted for, the prolonged chances of surviving stood at 15 percent as compared to the reference category as shown in models II and III as shown below. As expected, the chances of survival remained high among infants whose preceding birth interval was 24-36 months as compared to the reference category before and after child level factors were adjusted for though this association was not statistically significant (p-value<0.05).

Table 2: Time ratios for some maternal factors adjusted for other factors associated with the changing infant mortality: KDHS, 1993-2003

Characteristic	Child level factors (Model I)		Maternal & SES factors (Model II)		Maternal, SES, HSF & Period (Full Model III)	
	TR	**Std Err.**	**TR**	**Std Err.**	**TR**	**Std Err.**
Maternal age						
20-34 years						
<20 years	0.984	0.125	0.993	0.145	1.052	0.145
35-49 years	0.944	0.054	0.975	0.062	0.985	0.061
Prec. Birth Interval						
37 months+						
<24 months	1.131*	0.050	1.015*	0.055	1.015*	0.056
24-36 months	1.221	0.046	1.048	0.052	1.030	0.053
Baby Size at birth						
Av./large						
Small	0.853	0.066	1.113*	0.099	1.116*	0.101
Breastfeeding period						
>20+ months						
<10 months	0.211*	0.040	0.227*	0.099	0.226*	0.099
10-19 months	6.869*	0.093	5.853*	0.394	5.772*	0.392
Ethnicity						
Kikuyu						
Kalenjin			0.976	0.079	0.987	0.081

Kamba		1.154	0.101	1.105	0.102
Kisii		1.034	0.072	0.962	0.071
Luhya		1.169*	0.090	1.153*	0.091
Luo		4.200*	0.436	4.204*	0.433
Other		1.004	0.071	0.920*	0.071
Maternal Education					
Sec+					
None		0.904	0.092	0.926*	0.092
Primary		0.941	0.055	0.946	0.056
Paternal Education					
Sec+					
None		1.146	0.118	1.092	0.117
Primary		1.081*	0.051	1.090	0.051
Source-Drinking Water					
Piped					
Well		2.971*	0.463	2.630	0.451
Lake, Pond, Stream		0.981	0.061	0.982*	0.062
Type of Toilet Facility					
Flush (own/shared)					
Trad. Pit Latrine		1.113	0.078	0.937	0.080
VIP		0.337*	0.518	0.828	0.112
Other		1.154	0.115	0.250*	0.587
Household Wealth Index					
Upper					
Lower		1.017	0.080	0.857	0.115
Middle		0.499*	0.350	1.006	0.080
Place of Delivery					
Government facility					
Home				1.089	0.063
Private Health Facility				1.015	0.059
Had Tetanus Injection					
Yes					
No				1.018	0.056
Study Period					
88-92					
93-98				0.947	0.105
1999-03				0.965	0.043
Model Parameters					
Ln_p	0.694	0.72		0.725	
P	2.002	2.054		2.064	
1/p	0.499	0.487		0.484	

*Notes * refers to p-value<0.05 at 95% Confidence Interval; SES =socio-economic status factors; HSF= Maternal Health seeking factors*
Source: primary analysis of pooled KDHS 1993- 2003

Results on baby size at birth show unique but interesting results. While children that were born with a small baby size were significantly associated with 14.7 percent reduced risk of surviving in infancy before maternal factors were adjusted for other covariates, it was associated with about 11 percent increased chances of surviving in infancy once child-level factors were adjusted for selected socio-economic factors and this association was statistically significant at 95 per cent confidence interval (p-value<0.05). The association between reduced risk of dying among babies with low baby size (12 percent) as compared to those with average or larger baby size in the full model is surprising.

The dummies for duration of breastfeeding of the child emerge as one of the strongest predictors of infant mortality during the entire period with all the dummies showing statistical significance (p<0.05) even after child-level factors were adjusted for socio-economic and maternal health seeking factors. Further, the observed association is in concurrence with past findings. For instance, as compared to children who were breastfeed for the longest period (>20 months), those who breastfed for less than 10 months had a 79 percent reduced chances of surviving in infancy when child level factors alone were considered and this association was statistically significant (p<0.05). Likewise, when child level factors were adjusted for socio-economic factors and health seeking factors, the probability of surviving in infancy was 77 percent lower as compared to children who breastfed for the longest period and this association was statistically significant (p-value<0.05).

However, as compared to children who breastfed for the longest period, those who breastfed for 10-19 months had 6.9 times prolonged chances of surviving in infancy when child level factors were considered and this association was statistically significant (p<0.05). However, when child-level factors were adjusted for socio-economic and maternal health seeking factors, the chances of surviving much longer as compared to our reference category stood at 5.9 and 5.8 times and this association was statistically significant. While one would have expected the longest duration of breastfeeding to be associated with the lowest risk of child death, a number of factors could explain the contrary results observed in this study when children who breastfeed for 10-19 months were compared to those who breastfed for the longest period (>20 months).

Firstly, this could be biological- the fact that hygienically nutritional ingredients of mother's milk including immunity against communicable diseases that it provides to the child peaks during the first six months of an infant and diminishes gradually thereafter (Gray, 1981, Lindstrom and Berhanu 1999). Thus the effect of breast milk on child survival diminishes to the extent that beyond a certain period (20 months or above), continued breastfeeding may in fact lead to reduced chances of childhood survival (Palloni and Tienda 1986). This explanation is plausible owing to the fact that during the study period, Kenya underwent through economic hardships (characterized by declining GDP, intermittent prolonged drought, el-Niño floods and extended famine) and thus longer durations of breastfeeding may in fact have increased childhood mortality due to resource deprivation which leads to delayed weaning practices and/or suspension of food supplementation (see also Lindstrom and Barhanu 1999).

Secondly, in generalized HIV/AIDS settings such as Kenya, prolonged breastfeeding could adversely affect survival in childhood. A randomized control trial done in Kenya for instance revealed that as compared to infants born from HIV-1 mothers who were using alternative feeding, those whose mother's were HIV-1 positive but breastfed tended to exhibit better nutritional status, significantly so during the first 6 months of life (Mbori-Ngacha, *et al.,* 2001). Further, the study revealed that children from both two arms did not experience any significant differences in the rates of morbidity and mortality which implies that even for HIV positive mothers, short term breastfeeding (<10 months) is not associated with heightened risk of death as compared to long duration of breastfeeding (>20 months).

Using the Kikuyu community as a reference, children born from most of the other ethnic communities were associated with a heightened risk of experiencing infant death. For instance, children belonging to Luhya mothers were associated with a 17 percent increased risk of dying as compared to children from Kikuyu community and this association was statistically significant ($p<0.05$). This increased risk of infant death persisted after maternal health seeking factors were included as shown in the model III with children belonging to Luhya women experiencing 15 percent more chances of dying as compared to those belonging to the Kikuyu community and this association was statistically significant ($p<0.05$).

Likewise, being born from a Luo mother was significantly associated with a 4.2 times increased risk of dying in infancy ($p<0.05$) as compared to being born by a Kikuyu mother and this persisted when the full model was considered. Additionally, belonging to other small ethnic groups (Rendile, Somali, Borana, etc) was significantly associated with an 8 percent reduced risk of dying in infancy as compared to belonging to the Kikuyu ethnic community.

The results show that children belonging to mothers with no formal schooling had a reduced risk (about 8 percent) of surviving as compared to belonging to mothers with secondary schooling when maternal factors are adjusted for socio-economic factors. Similar results for women with no education persist after child-level factors were adjusted for socio-economic and maternal health seeking factors (as shown in model III). Generally, apart from the full model where having no formal schooling was significantly associated a reduced risk of surviving, the rest of the dummies of maternal age in relation to the reference category were in the expected direction though not statistically significant (p value>0.05).

On the contrary, findings of paternal education and the risk of death in infancy are expected though the association is largely insignificant except for children belonging to fathers with primary level schooling as shown in Model II. As shown, infants whose fathers had only primary schooling had about 8 percent increased chances of dying as compared to those whose fathers had secondary education or above and this association was statistically significant (p-value <0.05).

Infants belonging to households that used water from the well as compared to those who used piped water had 197 percent prolonged chances of surviving and this association was statistically significant at 95 percent confidence interval (p-value <0.05). While this increased chances of survival persisted as shown in the full model, the association was no longer statistically significant. The increased infant survival associated with use of the well as the water source could be due to the fact that over the years in Kenya, more efforts seem to have been made to purify water either through water treatment chemicals even for water from other sources besides piped water as well as through sale of water purifying machines. With such programs in place, the source of water increasing seems to become less important. Unfortunately, the DHS surveys did not ask questions on whether water used for drinking and domestic use was purified or not.

On the contrary, results reveal that children belonging to households that draw water from the lake, pond or stream appear to experience reduced risk of survival in infancy as compared to those who drew water from piped water. In fact, when the full model was considered, drawing water from the lake, pond or stream was significantly associated with a 2 percent reduced risk of surviving in infancy. The marginal differences between households that use water from the lake, pond/ stream compared to those that use piped water could be a result of the positive effect of intentional use of water purification techniques among the former.

The association between type of toilet facility and the risk of dying in infancy show that using a traditional pit latrine was associated with 11 percent reduced risk of dying in infancy as compared to using a flush toilet that was either owned or shared. However, this association was not statistically significant ($p<0.05$). However, children belonging to households with VIP toilets had 66 percent reduced chances of surviving in infancy as compared to children belonging to households that utilize flush toilets and this association was statistically significant at 95 percent confidence interval. Equally, children belonging to households that had other forms of excreta disposal (including bush) had 75 percent reduced risk of surviving in infancy when compared to those of households with flush toilets when the full model was considered and this association was also statistically significant ($p<0.05$).

Infants belonging to a lower socio-economic household were not in any way statistically different in terms of survival as compared to those belonging to upper socio-economic households as shown in model 11 above. However, when the full model was considered, belonging to a lower household wealth index was associated with a 14 percent reduced chances of survival in infancy though this association was not statistically significant. On the contrary, children belonging to middle income households had 51 percent reduced chances of surviving in infancy as compared to those belonging to upper socio-economic status households and this association was statistically significant ($p<0.05$). However, when the full model was considered, belonging to middle or upper households appears to bear an equal force of mortality though this association was not statistically significant.

None of the dummies for place of delivery or a mothers prior jab of the tetanus injection was significantly associated with the risk of dying (p-value>0.05). However, compared to being born in a government run health facility, being born in a private health facility or at home was associated with a 1.5 and 9 percent increased chances of surviving in infancy. Likewise, children belonging to mothers who had not received any tetanus injection as well as themselves had almost 2 percent prolonged chances of surviving in infancy as compared to those whose mothers or themselves had received the injection during pregnancy at birth though this association lacked statistical significance ($p<0.05$).

Finally, the risk of surviving in infancy marginally reduced over the study period. For instance, being born during 1993-98 or 1999-2003 period was associated with a 5.3 percent and 4.5 percent reduced chances of surviving in infancy as compared to being born during the 1988-92 period although this association was not statistically significant (p-value<0.05).

One clear issue from this model is that generally, the risk of dying in infancy increased throughout the 1988-2003 period as seen from the values of the Weibull AFT ancillary parameter p. In particular, when child level factors were considered controlling for other factors, the model shows that the chances of infant mortality during the study period increased by 100 percent. When child level factors were adjusted for socio-economic factors, the increase in infant mortality was 105 percent and when the full model was considered, the increase was 106 percent. This translates to an approximate annual increase of 7 percent for the period under observation. Thus, the hypothesis that the risk of dying in infancy was constant over the study time is soundly rejected.

Discussion and Conclusion

The aim of this paper was to present some of the factors responsible for the observed upsurge in infant mortality observed in Kenya since the late 1980s through the 2003 period. Using a pooled KDHS dataset for 1993, 1998 and 2003 rounds, the paper examined the role of some select child level factors, maternal/paternal education, changing levels of water and sanitation issues, household socio-economic status and changes in maternal health and childcare utilization in the observed upsurge in infant mortality. In doing so, statistical techniques in particular, the Weibull models in the accelerated failure time framework was used.

Results presented revealed that a number of covariates were significantly associated with the upturn in infant mortality over the study period. The heightened risk of infant mortality among children with a preceding birth interval that is less than 24 months echoes findings from other past studies (Chidambaram *et al.,* 1985:21; Boerma and Bicego 1992; Kabir and Amin 1993). The mechanisms through which short birth intervals precipitate an increase in infant mortality are many: firstly, short birth intervals may increase the mortality risks for all the children in the family because of larger sibling sizes leading to competition for parental attention and resources; secondly, short intervals between successive pregnancies give women insufficient time to restore their nutritional reserves hence suffer from maternal depletion syndrome with adverse effect on foetal growth (Kabir and Amin 1993; Chidambaram *et al.,* 1985).

The heightened risk of infant mortality associated with small baby size before child-level factors were adjusted for other factors was expected. Small baby size is a proxy measure for low birth weight which is associated with a heightened risk of infant mortality. Studies have shown that low birth weight (LBW) is associated with premature births and such births have increased chances of experiencing intrauterine growth retardation (Miller 1993:98; Hobcraft *et al.,* 1985; Da Vanzo *et. al.,* 1983). However, the prolonged child survival among babies born with small body sizes is unique and may be a pointer that the results are affected by a statistical depression effect. This could imply that children of mothers with positive values of the other factors fare better even if born with small size. Some variables were not associated with the risk of infant mortality. These included maternal age at child birth, whether a mother had tetanus injection before or during delivery and birth cohorts. However, in general, the overall model shows that the level of infant mortality rate increased by about 7 percent per annum during the period under observation.

Given the findings, a number of recommendations were made. Firstly, there is need for the government and other stakeholders in health to boost parental education and address poverty among the general population owing to the fact that the household wealth status is an important predictor of infant mortality. There is also need for policy makers to promote family planning to increase birth intervals. Programs should also aim at strengthening PMTCT programs owing to the fact that duration of breastfeeding is an important predictor of infant mortality.

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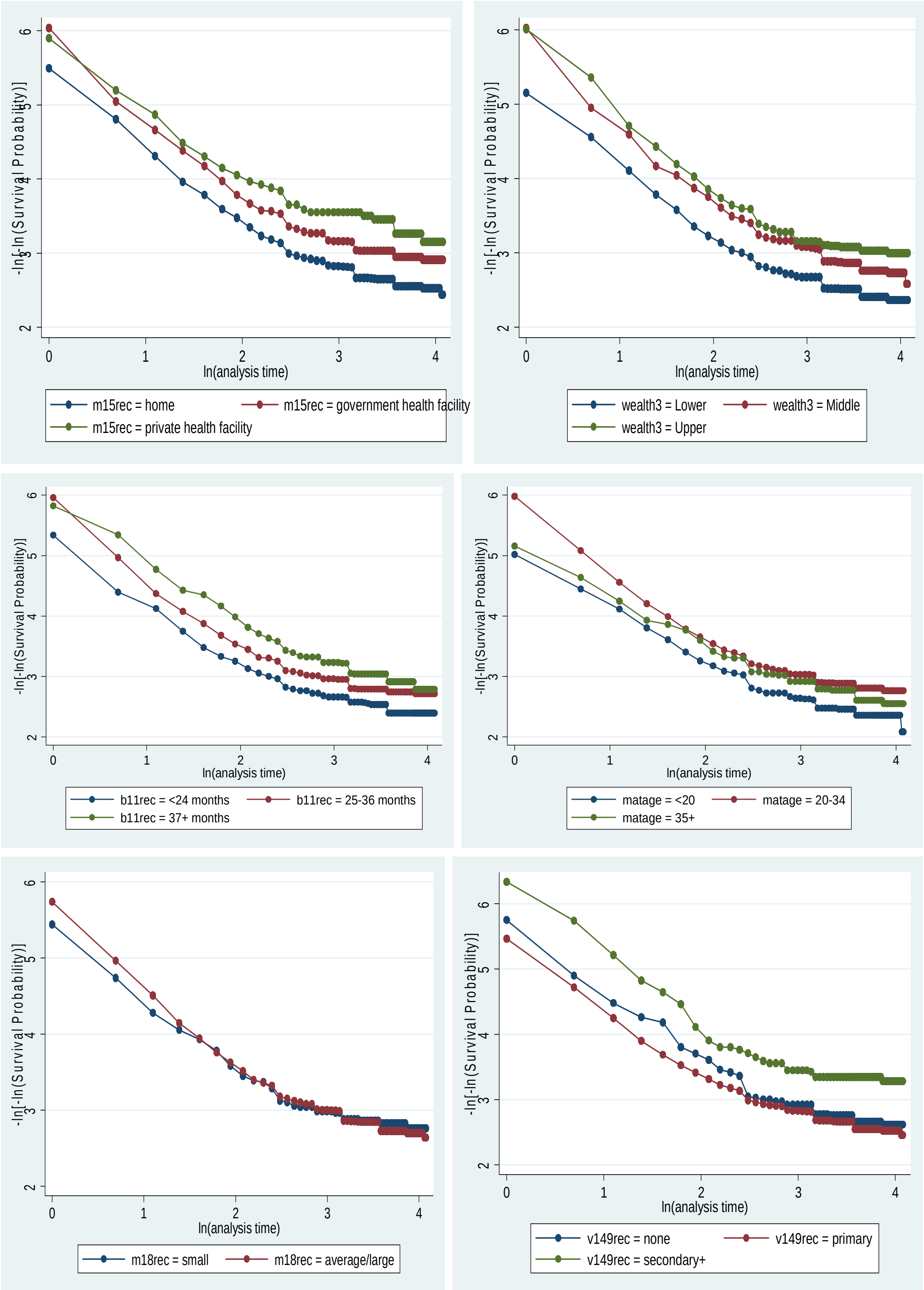
Appendix I: Testing the Proportionality Assumption: The Schoenfeld Residuals for selected covariates of early childhood mortality 1989-2003 KDHS

	Infant mortality			
	rho	chi2	df	Prob>chi2
Maternal age at child birth	-0.09647	0.52	1	0.4689
Preceding Birth Interval	0.11510	0.71	1	0.4010
Baby size at Birth	0.06044	0.24	1	0.6216
Birth weight	0.20897	2.77	1	**0.0377****
Breastfeeding period	0.20091	5.04	1	**0.0247****
Ethnicity	0.17781	1.63	1	0.2010
Maternal Education	-0.05661	0.19	1	0.6592
Paternal Education	-0.00339	0.00	1	0.9797
Water Source	-0.07908	0.42	1	0.5193
Toilet Facility type	-0.21566	2.41	1	0.1206
Household wealth Index	0.04891	0.13	1	0.7175
Place of delivery	0.04084	0.11	1	0.7449
Tetanus injection	-0.12935	1.06	1	0.3034
Birth cohort	0.03851	0.07	1	0.7936
Global test	**χ^2 = 12.26 ; df = 15 ; P-value =0.6593**			

*Notes: **Dummies that violated the proportionality assumption*
Source: Primary analysis of merged KDHS data

Appendix II: Testing the proportionality assumption: an illustration of graphical method for select infant mortality covariates, merged KDHS 1988-2003



Notes

m18rec = baby size at birth **149rec**= mother's educational attainment; **matage**= maternal age at child birth;
m15rec=Place of delivery; **wealth3**=household wealth index; **b11rec**=preceding birth interval