Child Survival and Policy Options in Kenya: Evidence from Demographic and Health Surveys

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Abstract: This paper investigates child survival in Kenya. We use survival analysis to explain childhood mortality and further simulate the impact of key policy variables on millennium development goals targets for mortality. The results show that favorable child and maternal characteristics, and household assets are associated with higher probability of survival at time t. The results further show that health care services are crucial for child survival. Policy simulations suggest that maternal education and use of modern contraception methods are key policy issues for child survival. The simulations further suggest that it is unlikely that the millennium development goals targets will be achieved.

Keywords: Child survival, mortality, asset index, Millennium Development Goals, Kenya.

1. INTRODUCTION AND MOTIVATION

In Kenya, child mortality rates remain high in spite of the government's commitment to create an enabling environment for the provision of quality health care and reduction of mortality levels. There is clear contrast in recent trends in mortality rates and the trends in the 1960s and the early 1980s. In the immediate post independence period (1960-1980), Kenya enjoyed impressive and sustained declines in under five mortality (U5M) rates of about 2-3 percent per annum. Thereafter, the rate declined to less than 2% between 1980 and 1990. From 1990, the declining infant and child mortality rates saw a reversal and the rates have since been raising (see Figure **1**). The impressive decline prior to the 1980s came at a period of relatively stable macroeconomic environment that spurred growth in post independent Kenya. In the early 1980s, macroeconomic instability started to reverse the growth rate of the economy and to pose a real threat to many socio-economic aspects of the economy. These were accompanied by deteriorating standards of living and increasing inequality.

The Economic Recovery Strategy and Millennium Development Goals (MDG) have been at the forefront of targeting child survival, through mortality reductions in Kenya. In addition, the current health sector strategic plan aims at reducing health inequalities and reversing the downward trend in health related outcomes and impact indicators. By addressing the major causes of morbidity and mortality, the plan hopes to contribute towards actualization of some of the MDGs and the reduction of existing disparities in health indices between: regions; population groups; and public and private sectors (Ministry of Health, 2005). However, given the current rates of infant and child mortality, the country faces a real challenge in the achievement of targets for child survival.

In this paper, child survival is viewed as a basic capability which is an important indicator of non-monetary well being. This follows Sen's argument that poverty should be viewed as a deprivation of ends (capabilities and functionings) that are intrinsically important (Sen, 1985)[1]. Following Sen's approach, this paper investigates the determinants of child survival in Kenya. The paper further simulates the impact of relevant policy variables for child survival and assesses the implications of these on the achievement of MDG targets in Kenya. The paper makes an important contribution to the existing literature in three ways. First, there are increasing empirical studies on poverty and child health determination based on Demographic and Health Survey (DHS) data. There are also a large number of studies that attempt to identify the determinants as well as principal causes of the health gap between the poor and the better off in both developed and developing countries (Wang, 2002). No such study has been done for Kenya using child survival as a welfare measure. This study addresses this knowledge gap. Second, analysis of mortality

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[1]Capability is a set of vectors of functionings (beings and doings) reflecting a person's freedom to lead one type of life or another (Sen, 1985). In terms of mortality, capabilities would embrace the ability to live through to mature age whereas the equivalent measure of functioning would be the mortality rates.

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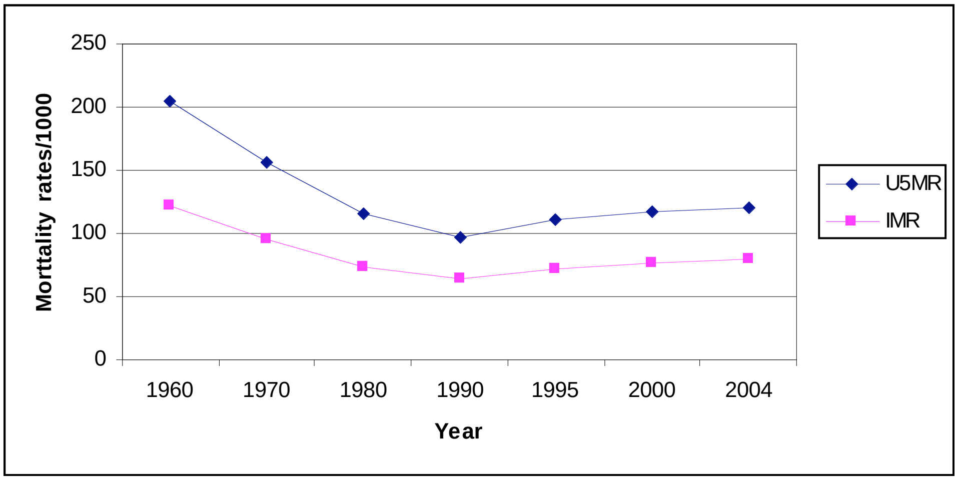

Figure 1: IMR and U5M rates per 1000 live births in Kenya (1960-2004).
Data source: UNICEF Statistics; http://www.childinfo.org/areas/childmortality [Accessed 2009 Nov 10].

necessitates the study of large populations or the cumulation of the mortality experience of smaller populations over long periods because death is a rare event (Mosley and Chen, 1984). In this paper, combining three DHS datasets offer the advantage of a large sample compared to individual year analysis. The study also examines the time series of childhood mortality in detail, using women's birth histories to construct mortality rates for many years prior to the survey date. Third, this study extends microeconomic analysis to estimate trends in mortality rates over the entire time period of the years of birth of children in the samples.

The rest of the paper is organized as follow. Section two presents a brief description of the country context and data types and sources. Section three presents the methodology. Section four presents the results and section five concludes.

2. COUNTRY CONTEXT AND DATA

2.1. Country Context

Kenya is a low-income country, located in East Africa. It is surrounded by Indian Ocean to the south-east, Tanzania to the south, Uganda to the west, South Sudan to the north-west, Ethiopia to the north and Somalia to the north-east. The country is divided into 8 main administrative regions or provinces: Central, Coast, Eastern, Nairobi, North Eastern, Nyanza, Rift Valley and Western. These regions have marked disparities in many socio-economic indicators (KNBS, 2007). Kenya has a population of about 41 million and an estimated gross national per capita income of about US$1,492 GNI per capita in PPP terms (constant 2005 international $). The Human Development Index for 2011 was estimated at 0.51, having risen from 0.42 in 1980 and ranking Kenya position 143 out of 185 countries in the world. Other related indices are the health, education and gender inequality indices estimated at 0.586, 0.582 and 0.627 respectively in 2011. In addition, Kenya has an intensity of deprivation of about 48, and a life expectancy at birth estimated at 57 years. Health indicators show that maternal mortality is quite high at 530 deaths per 100,000 live births, while the total fertility rate in Kenya was estimated at 4.49 children per woman in 2010 (UNDP, 2012). Child mortality rates have also remained unacceptably high, with infant mortality and under five mortality rates estimated at approximately 44 and 84 deaths per 1,000 live births respectively in 2012 (UNICEF, 2011). Half of Kenyan population is estimated to live under the poverty line. Poverty, deprivation and disease are highly correlated with child morbidity and mortality, with malaria, HIV/AIDS, pneumonia, diarrhea and malnutrition as major causes of death among poor children.

2.2. The Data

To achieve the objectives of the study, we used three rounds of Demographic and Health Surveys (DHS) data for the period 1993-2003. The DHS are nationally representative samples of women aged 15 to 49 and their children. The three surveys, while relatively comparable differ in a number of ways. The 1993 DHS collected information on 7,540 women aged 15-49, and 6,115 children aged less than 60 months from 7950 households in the months of February to

August 1993. The 1998 DHS collected information on 7,881 women aged 15-49, and 5,672 children aged less than 60 months from 8,380 households in the months of February to July 1998. The 2003 DHS covered 8,195 women aged 15-49 and 5,949 children aged less than 60 months from 8,561 households in the months of April to August, 2003. All surveys covered both rural and urban populations. The DHS utilized a two-stage sample design. The first stage involved selecting sample points (clusters) from a national master sample maintained by Central Bureau of Statistics (CBS) the fourth National Sample survey and Evaluation Programme (NASSEP) IV.

In this paper, we pooled together the three DHS survey datasets and used women's birth histories to create a long time series of data for cohorts of five year old children born between 1978 and 2003. This yielded a sample of 48,772 children, 36%, 34% and 29% from 1993, 1998 and 2003 respectively.

3. METHODOLOGY

3.1. Analytical Framework and Model Specification

The analytical framework for child survival adopted in this paper follows, with modification, the health production framework developed by Rosenzweig and Schultz (1983). In this framework, child health production is embedded in a household utility-maximizing behaviour. The basic idea is that a household allocates time and inputs to produce commodities some of which are sold on the market, some consumed at home, and some for which no market exists at all. The household utility function, U, depends on consumption of a vector of commodities, X, that have no direct effect on child health, on a health-related input that yields utility to the household and also affects child health, Y and on the health status of the child, H:

$$U = U(X, Y, H) \tag{1}$$

The child health production for the household can be defined as:

$$\mathrm{H} = \mathrm{h}(\mathrm{Y}, K, \varepsilon) \tag{2}$$

where K is a vector of purchased health inputs that affect household utility only through the effect on the health of the child. ε is the family specific health endowments such as genetic traits and environmental conditions. Such endowments are known to the household, but are outside its control.

The household maximizes utility given the child health production function and a budget constraint defined as

$$M = Xp_x + Yp_y + Kp_k \tag{3}$$

where M is income and p_x, p_y and p_k are the prices of commodities, health inputs and investment in child health respectively.

The household reduced-form demand function for goods, including health inputs, can be derived from maximization of equation (1) given (2) and (3). The same analogy can be used to derive the reduced-form of the demand/supply function for the child health outcome.

The child health production function is imbedded in the constrained utility maximisation behavior of the household defined above. Child health can be thought of as being generated by a biological production function in which a number of input allocations such as nutrient intake and general care result from household decisions. Households therefore choose to maximize chances of child survival given the resources and information constraints they face. In the context of mortality, these constraints are referred to as proximate determinants of child survival (Mosley and Chen, 1984).

The proximate determinants framework (Mosley and Chen, 1984) is based on several premises: First, in an optimal setting, 97% of infants may be expected to survive through the first five years of life; second, reduction in the probability of survival is due to social, economic, biological and environmental forces; third, socioeconomic determinants must operate through basic proximate determinants that in turn influence the risk of disease and the outcome of disease processes. Other premises relate to the relationship between morbidity and mortality (medical science methodologies), which is beyond the scope of this paper. Given these premises, the key to model specification is the identification of a set of proximate determinants or intermediate variables that directly influence the risk of childhood mortality. All social and economic determinants must operate through these variables to affect child survival (Mosley and Chen, 1984).

Following Mosley and Chen (1984) and Schultz (1984) and starting with the household production function, we can integrate the underlying production process with household choices to derive a reduced form[2] child health production function with the following relationships:

$$MR = \beta_0 + \beta_1 S_i + \beta_2 \mathrm{I}_i + \beta_3 \mathrm{C}_i + \beta_4 \mathrm{Z}_i + \mu_i \quad (4)$$

where MR is a 0/1 indicator of whether a child died before a given birthday. S is a vector of child's health endowments, the component of child health due to either genetics or environmental conditions. This component cannot be influenced by family behavior but is known to it. According to Schultz (1984), this component is referred to as health heterogeneity. I is a vector of a household's economic endowments and preferences. C is a vector of community-level characteristics that include regional, price and program variables. Z is a vector of macro level variables and μ_i is a stochastic disturbance term.

In this study, mortality rates are estimated for up to 15 years prior to the survey and so cover all births between 1978 and 2003. This has two advantages: one, mortality can be regarded as a measure of health outcomes for the period between the survey date and 15 years prior to the survey. Two, the measurement errors in mortality rates due to misreporting can be reduced to some extent when using the most recent maternal history data (Wang, 2002). Most studies calculate infant mortality rates (IMR) by taking all the children born in a given period, counting the number of deaths that occur after one year; then dividing the deaths by the number of children born. While straightforward, this approach has one important limitation: it cannot provide an estimate of the IMR for the period one-year immediately prior to the survey. Children born within a year before the survey will be censored in the sense that they will not have yet lived a year, and thus not run all the risks of death before reaching their first birthday. The IMRs based on these children will therefore be biased downwards. While this may not seem too important a limitation for IMRs, it is quite important for child or U5M rates. To solve this problem, under-five and child mortality rates for a given time period are usually calculated using synthetic cohorts of infants at risk. This method allows the researcher to calculate mortality rates for dates close to the survey date.

The DHS collect data on women's entire birth histories (all children born and about their survival). By using these birth histories, it is possible to construct mortality rates for many years prior to the survey date. However the expected negative correlation between mortality and mother's age is likely to introduce a bias to mortality rate calculations for periods far from the date of the survey[3]. To avoid any possible biases, we base the mortality analysis on five year cohorts of children born up to fifteen years prior to each survey date to mothers aged 15 to 34. This is calculated as the number of children from that cohort who died before age five divided by the total number of children in the cohort.

To correct for inherent censoring in mortality rates, we use one of the standard hazard or survival modeling techniques namely the Weibull parametric survival-time model. The censoring problem arises from the fact that if a child is dead or is of a given age, we have full information, but when a child is still alive and is less than 60 months, we do not have information whether the child will die or not. Hazard and survival (relative risk) models help to avoid any downward bias in estimation of mortality rates. They allow us to model the probability of a child dying at age x_{t+1} (say 60 months) conditional on being age x_t (say 59 months). This is very important because erroneous measures and estimation of mortality would lead to wrong policy implications[4].

Survival analysis is therefore a technique for analyzing time to event or failure data. It helps to model

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[2]Schultz (1984) has shown that the best approach would be to estimate both the demand equations for health inputs and the production function linking health inputs to child survival by simultaneous structural equation methods. This however requires that there are accurate data on prices, wages, programs and environmental conditions which can be used as exogenous instruments. In the absence of appropriate instruments, the reduced-form equation for child survival may be estimated without imposing a great deal of structure on the problem, as is commonly done is the literature.

[3]The survey interviewed women between the ages of 15 and 49 today, so the information it has on births and deaths (say 15 years ago) is for women who were zero to 34 years old at that time, and the estimated mortality rates for the earlier period would be biased upward because the sample of mothers is younger. At the same time, there are some mothers who were less than 15 but no information was collected on them. So an estimate of current mortality will be biased downward. Another possible bias arises from the fact that some women will have died in the years between the date for which a mortality rate is to be estimated and the survey date, as there is no information about them in the survey. If these women's infants were more likely to die than other infants then the mortality rates estimated for years prior to the survey will be biased downward (see Mosley and Chen, 1984; Ssewanyana and Younger, 2008). One problem of analyzing retrospective birth histories is the quality of information: misplacement of dates of birth is always possible, and so is misreporting of death as well as omissions of birth reporting of children who die very early in life. These problems are however more likely to bias neonatal and infant mortality but not U5M (Hobcraft, Mcdonald and Rustein, 1984). We investigate for possible biases in the data using education and mother's heights by women's birth cohort but uncover no evidence of any of these.

[4]To save on space, this analysis is based on U5M only. The advantage of using U5M is that duration models allow us to explore the determinants of probability of a child dying before the fifth birthday without losing nay information.

the risk of failure or the probability of experiencing failure (hazard) at time t_{+1} given that the subject is at risk at time t. The higher the hazard, the shorter the survival. In the case of mortality, the survival time of a child is a continuous non-negative random variable T with a cumulative distribution function F(t), and probability density function f(t). The survivor function is defined as $S(t) \equiv 1 - F(t)$, the probability of being alive at time t.

If we let the cumulative density function for the failure function to be $\Pr(T \le t) = F(t)$, then the survivor function can be estimated as:

$$S(t) \equiv \Pr(T > t) = 1 - F(t) \tag{5}$$

The Weibull model is parameterized as both a proportional hazard and accelerated failure-time model. It is suitable for modeling data with monotone hazard rates that either increase or decrease exponentially with time. The proportional hazard model for Weibull regression is specified as:

$$\theta(t : X) = \alpha t^{\alpha - 1} \exp(\beta ' X) = \alpha t^{\alpha - 1} \lambda \tag{6}$$

where $\lambda \equiv \exp(\beta ' X)$, α is the shape parameter to be estimated from the data and exp(.) is the exponential function. The hazard rate either rises monotonically with time (α> 1), falls monotonically with time (α<1), or is constant (α=1). The last case is the special case of the Weibull model known as the exponential model. For a given value of α, larger values of λ imply a larger hazard rate at each survival time. Like other probabilities, the survivor function lies between zero and one, and is a strictly decreasing function of t. The survivor function is equal to one at the start of the spell (t = 0) and is zero at infinity: 0 ≤ S(t) ≤ 1. The density function is non-negative but may be greater than 1 in value i.e. F(t) ≥0.

3.2. Definition and Measurement of Variables

Following Mosley and Chen (1984) and other relevant literature, a number of proximate determinants of childhood mortality can be identified. These include child, maternal, household and regional characteristics embedded in socioeconomic and environmental forces (Ssewanyana and Younger, 2008). It is however important to bear in mind that in view of the assumptions of Mosley and Chen (1984), Kenya is a sub-optimal case, with infant mortality rates well above 60 per thousand.

Child Characteristics

The study investigates the impact of individual characteristics including gender of the child, first-born children, birth order and children of multiple births, which are expected to have higher mortality probabilities, controlling for other factors. Though some studies have shown that male infants are more physiologically vulnerable than female infants, empirical studies have shown that this may be reversed where there are strong sex-of-child preferences (Muhuri and Preston 1991).

Maternal Characteristics

This paper investigates the impact of several maternal characteristics. Maternal education and age are expected to increase the likelihood of child survival through altering the household preference function and also through increasing her skills in health care practices related to conception, nutrition, hygiene, preventive care and disease treatment (Mosley and Chen, 1984). Other studies concur on the role of maternal education in reducing childhood mortality (Schultz 1984, Filmer and Pritchett 1997). The paper focuses on the impact of mother attaining primary and post primary education, relative to no education. Height of the mother is included to capture both the genetic effects and the effects resulting from family background characteristics not captured by maternal education.

Household Characteristics

Several household characteristics are included in the mortality model. Household resources/incomes are generally powerful determinants of child health through among other ways: housing, fuel/energy, hygiene, transportation and information (Mosley and Chen, 1984). In the absence of income data in the DHS, an asset index, (which takes into account household endowment of most of these income factors) is included as an indirect measure of the impact of resources/income. Previous studies have shown that the index is an important measure of wealth just like expenditures or incomes, whether instrumented or not in explaining health outcomes (Sahn and Stifel 2003, Ssewanyana and Younger, 2008). The asset index is constructed using factorial analysis (Sahn and Stifel 2000, 2003; Filmer and Pritchett 2000). Other household characteristics include access to water and sanitation. These variables can be seen as measures of the environmental quality of the residence of the child and are therefore expected to be important correlates of child mortality. Dirty environment is associated with some of the child hood diseases (such as diarrhoea and upper respiratory system diseases) which are the main causes of child mortality in developing countries.

Cluster, District and Regional Characteristics

Market prices affect household demand behavior and therefore production of child health. Price data is not always collected in household survey data but one set of proxies include availability of private and public services, where access is often a major part of price variation. Community characteristics are useful in estimating demand relationships because they generally can be assumed to be exogenous from the household's point of view (Schultz, 1984). In this paper, we generate a vector of community level (cluster and district) variables to proxy prices[5]. At the cluster level, we focus on the share of women who used modern contraceptive methods.

The district level (district year averages) shares include: the share of children who were fully immunized and the share of women who received professional pre-natal and birth care (doctor, midwife or nurse). These variables can be interpreted as proxying for availability of health care in a district for which we have no direct measure.

At the regional level, we include provincial dummies to capture the political economy and ecological setting (Mosley and Chen, 1984) in the absence of measures of these variables in the data.

National Characteristics

We also include a time trend to check for correlations between unexplained progress in child mortality over time that may be present once the microeconomic variables are controlled for. One would expect these variables to have a mortality reducing impact.

4. RESULTS

4.1. Descriptive Statistics

The characteristics for the pooled sample are presented in Table **1**[6]. A further tabulation of the statistics by survey year (not presented) suggests that demographic indicators, namely household size, number of children and number of women aged 15 to 49 years were much higher in 1993 compared to 1998 and 2003. For instance, the mean household size was 7 persons in 1993, but fell to 6 persons in 2003, probably reflecting a demographic transition over the 10 year period. Though the mean asset index changed significantly from 1993 to 1998/2003, the per capita index changed by only 0.01 points. The cluster share variables showed more variations across survey years than household, child and maternal characteristics. The statistics further show that boys were at a higher risk of mortality than girls throughout the decade. General vaccination of children declined over time, while the proportion of births assisted by a professional declined between 1993 and 1998, but thereafter increased in 2003. The proportion of assisted births remained quite low over the decade, with less than half of all women in the sample receiving any professional assistance.

4.2. Correlates of Child Survival[7]

Child survival analysis is based on four variants of the basic mortality model specified in equation (4) (Table **2**). The second column of the table presents the basic model (model 1), column three presents the basic model (model 2) plus the time trend variables, column four presents the variant omitting time trend but introducing a variable for the number of years between the relevant survey and when a child was born (model 3). Column five presents a variant introducing two district level health care variables (model 4). The introduction of the district health care averages reduces the number of observations from 38,733 to 27, 035 because the information on health care is only available for children born up to five years before the survey. The results for the basic model and the variants differ in terms of the goodness of fit. Though the new variables affect the overall fit of the model, all models fit the data better than the intercept only model.

The results presented are the exponentiated hazard ratios and the corresponding standard errors. The hazard ratios can be interpreted as follows. If the ratio is equal to 1, the estimated coefficient is equal to zero

[5]Cluster and district level shares are used instead of the individual responses to adjust for design effects in the survey and also to control for endogeneity of individual level data on service use. Endogeneity of these variables spring from the fact that they depend, on household characteristics among other factors and may also be jointly determined with other factors that affect mortality. For some variables, it is convenient to use cluster averages because of decentralization of service delivery (e.g. family planning clinics) but for other variables such as health facilities, delivery is less decentralized and so these variables are measured at the district level.

[6]The data used in this study is cross sectional rather than panel. For this reason, there was need to test for pool-ability of data- that is, whether coefficients were the same for the three time periods. This was tested using the Chow test. The test results {F(19, 38694) = 107.29; pr >F = 0.000} suggested that the coefficients in the three time periods are the same.

[7]As indicated earlier, this paper estimates reduced form rather than structural parameters. The estimates depend on the assumption of exogeneity. Due to lack of suitable instruments to estimate structural models, we have done the best we could with a cross section to select plausibly exogenous regressors. The estimated parameters should be interpreted as correlates rather than determinants.

Table 1: Descriptive Statistics

Variable	Mean	Std. Dev.
Household characteristics		
Household size	6.54	2.72
No. of children in a household	1.48	1.09
No of women 15 -49 in household	1.46	0.81
Log asset index	0.52	0.32
Public tap	0.10	0.29
Piped water in residence	0.15	0.36
Other water	0.05	0.21
Well water	0.21	0.41
Flush toilet	0.07	0.26
Other toilet	0.20	0.40
Child characteristics		
Gender of child dummy:1=male	0.50	0.50
Birth order	3.70	2.49
Child is first birth	0.22	0.42
Child is of multiple birth	0.03	0.17
Child is a first born twin	0.002	0.04
Mothers characteristics		
Mother has some primary education	0.20	0.4
Mother is primary graduate	0.39	0.49
Mother has some secondary education	0.09	0.29
Mother has secondary education or higher	0.12	0.32
Mother's age at child's birth	25.77	6.28
Mother's age/first-born interaction	4.37	8.34
Mother's height in cm	159.57	7.63
Cluster ave, use of modern contraception	0.30	0.18
Year/district average, Child received all vaccinations	0.54	0.26
Year/district average, professional birth assistance	0.44	0.21
Neonatal Mortality	30	235
Infant Mortality	69	250
Child Mortality	28	162
U5 Mortality	94	292
Sample size	48779	

and thus the explanatory variable has no impact on the likelihood of childhood mortality. If the hazard ratio is less than one, the coefficient is negative and reduces the likelihood of mortality by the difference between 1 and the coefficient. For example, if the hazard ratio is 0.5, an increase in the regressor in question by 1 will lower the probability of mortality by 50%, thus increasing the probability of survival time at time t. If the ratio is greater than 1, the probability of facing mortality is increased and thus the probability of survival time is deccelerated by a unit increase in the regressor. The shape parameter is less than 1 in all models, implying that the hazard of failure decreases with time (Statacorp, 2009).

Child Characteristics

All child characteristics included in the model are positively correlated with mortality. Boys have higher hazard rates, *ceterius paribus* than girls- (i.e., boys have higher conditional death rates and hence lower probability of survival time at time t). The estimates further show that at each survival time, the hazard rate

Table 2: Weibull Model Estimates for Under Five Mortality Rates

	Model 1	Model 2	Model 3	Model 4
Log asset index	0.6820***	0.6149***	0.6549***	0.7026**
	[0.094]	[0.088]	[0.092]	[0.119]
Unsafe drinking water	0.9648	0.9356	0.9596	0.8857
	[0.065]	[0.064]	[0.065]	[0.071]
Pit latrine	0.9036*	0.9143	0.9067*	0.9216
	[0.052]	[0.052]	[0.052]	[0.061]
Gender of child dummy:1=male	1.1366***	1.1326***	1.1342***	1.1237**
	[0.044]	[0.044]	[0.044]	[0.052]
Child is first birth	7.3404**	9.7174***	9.7954***	7.4843*
	[6.226]	[8.307]	[8.253]	[7.750]
Child is of multiple birth	3.0931***	3.0810***	3.1137***	2.8964***
	[0.288]	[0.291]	[0.289]	[0.341]
Mother is primary graduate	0.6425***	0.6495***	0.6424***	0.6242***
	[0.058]	[0.059]	[0.058]	[0.068]
Mother has secondary education or higher	0.6042***	0.6138***	0.6035***	0.5495***
	[0.072]	[0.073]	[0.072]	[0.071]
Mother's age at child's birth	0.8626***	0.8637***	0.8655***	0.8674***
	[0.026]	[0.026]	[0.026]	[0.031]
Mother's age at child's birth squared	1.0025***	1.0024***	1.0024***	1.0024***
	[0.001]	[0.001]	[0.001]	[0.001]
Mother's age/first-born interaction	0.8057***	0.7839***	0.7840***	0.8010**
	[0.061]	[0.060]	[0.059]	[0.074]
Mother's age/first-born interaction squared	1.0051***	1.0057***	1.0057***	1.0054***
	[0.002]	[0.002]	[0.002]	[0.002]
Mother's height in cm	0.9911***	0.9904***	0.9910***	0.9892***
	[0.003]	[0.003]	[0.003]	[0.004]
Use of modern contraception (cluster average)	0.3819***	0.3773***	0.3874***	0.3706***
	[0.068]	[0.067]	[0.069]	[0.076]
Nairobi	1.8172***	1.8098***	1.7998***	1.9485***
	[0.309]	[0.306]	[0.307]	[0.391]
Central	0.8903	0.8974	0.8897	1.0447
	[0.112]	[0.113]	[0.112]	[0.147]
Coast	1.4362***	1.4222***	1.4273***	1.2851**
	[0.138]	[0.139]	[0.137]	[0.143]
Eastern	1.1549*	1.1780*	1.1529	1.2199*
	[0.101]	[0.102]	[0.101]	[0.127]
Nyanza	2.9825***	3.0113***	2.9855***	2.8506***
	[0.247]	[0.249]	[0.250]	[0.269]
Western	1.9572***	1.9977***	1.9525***	1.8596***
	[0.166]	[0.166]	[0.166]	[0.186]

(Table 2). Continued.

	Model 1	Model 2	Model 3	Model 4
Time trend		0.4702*		
		[0.182]		
Time trend squared		1.0186*		
		[0.010]		
Time trend cubed		0.9999*		
		[0.000]		
Years between birth and survey date			0.9724***	
			[0.005]	
Year/district average, all vaccinations				0.7074***
				[0.068]
Year/district ave, professional birth assistance				0.6996**
				[0.121]
Constant	-0.5341	9.380.20*	-0.3209	0.1265
	[0.654]	[5.185]	[0.651]	[0.813]
Shape parameter	0.4648***	0.4715***	0.4720***	0.4774***
	[0.006]	[0.007]	[0.007]	[0.008]
Wald Chi2(--)	842.42***	923.80***	870.11***	636.18***
Observations	38733	38733	38733	27035

Exponentiated coefficients presented. Robust standard error eform in brackets. *Significant at 10%; ** significant at 5%; *** significant at 1%.

for boys is 13% higher than the hazard rate for girls. All results for dummy variables can be interpreted this way. First born children are more likely to suffer mortality than other children, while children of multiple births have a remarkably higher mortality probability than children of single births[8]. Compared to other variables in the model, first born children and children of multiple births have exceptionally huge impacts on the probability of mortality (Kembo and Van Ginneken 2009).

Mothers' Characteristics

Mother's education has a large significant impact of reducing the risk of childhood mortality. Specifically, children born of mothers with some level of education have higher probability of survival at time t, than children born of mothers with no education. The impact of mother's education increases with the level of education. This result supports findings in the literature (Schell *et al*., 2007; Kamal 2012). The hazard ratio for mother's age at child's birth suggests that an increase in mother's age lowers the probability of child mortality though the quadratic term suggests higher risks for children born of more elderly women. Predicted mortality rates at each year of mother's age at birth of a child suggests that each year of the mother's age at the child's birth on average lowers the probability of child mortality by about 0.1%. Since the highest mortality rates are observed for the age set 15-24 years, this result implies that delaying births, particularly teenage births would increase the likelihood of child survival in Kenya. To test for the expected impact of mother's age at first birth, we introduce an interaction term of mother's age with a dummy variable for first-born children. The impact of the variable shows a similar pattern to mother's age but the hazard ratios are much lower for the linear term and twice as much for the quadratic term. Children born of tall mothers face lower survival probabilities at time t, than children born of shorter mothers, though the impact is quite small (1%). This is probably due to the positive correlation between mother's height and the children's nutrition, holding genetics constant.

Household Characteristics

The coefficient of the asset index variable shows the expected negative correlation between level of well-

[8]Studies on fertility argue that multiple births may not be purely exogenous because women with high fertility are more likely to experience a twin birth. For this reason, such studies recommend the use of first born twins or ratio of twins to total births as experiments to instrument for fertility. There is no evidence that twins may be endogenous to mortality. Either way, we try to use twins at first birth and the results are robust with the use of any multiple birth except for urban areas where the number of observed first born twins is too small. We therefore present results using the multiple birth regressor.

being and childhood mortality, suggesting that assets increase the likelihood of child survival. The impact is large and significant, suggesting that an increase in the log of household assets by 1 unit would lower the probability of childhood mortality relative to the probability of the child surviving by between 24% and 36%. Since we use the log of asset index, the estimated hazard ratio represents a semi-elasticity of the probability of childhood mortality with respect to assets. Some studies have shown that poverty and inequality have a role to play in child mortality, suggesting the need for social protection to cushion poor children from death (Save the Children, 2010a; 2010b; Garde, 2010; Hypher 2011; UNICEF, 2011).

Use of unsafe drinking water (relative to safe water) and poor sanitary (relative to good sanitary) conditions accelerate the risk of mortality and lower the probability of survival at time t (Schell *et al*., 2007; Kamal 2012). Effect of water is mainly insignificant. Though the insignificant effect of unsafe drinking water may be surprising, it is consistent with studies on mortality using DHS data (see for instance Ssewanyana and Younger, 2008; Rutstein, 2000). There results could be due to unobserved attributes of water and sanitation. Probably microbiological examination of samples of water may be useful to test for the levels of environmental contamination in each of these sources (Strauss and Thomas, 1995).

Cluster Level Variables

The cluster share of women using a modern method of birth control at the time of the survey is included as a proxy for the availability of health care services. Controlling for other factors, this variable has a very large significant impact of lowering the probability of childhood mortality. An increase in the share of mothers using modern contraception by 1 would reduce the probability of childhood mortality by close to 60%, thus increasing the probability of child survival at time t. Contraception plays an important role through reduced fertility, birth spacing and also the prevalence of HIV and other sexually transmitted diseases (though condom use). This suggests the importance of health care in child survival and thus calls for reorienting health care interventions in order to intensify the fight against childhood mortality (Kembo and Van Ginneken 2009). The findings support findings by UNICEF (2011), that health is an important determinant of the levels and trends in mortality especially in sub Saharan Africa. Schell *et al*., (2007) and Kamal (2012) also find health, sanitation and infant feeding practices to have important implications for child mortality.

Regional Dummies

The results for the regional dummies suggest that relative to Rift Valley province, all provinces except Central are likely to face higher childhood mortality probabilities. The impacts are significant for all provinces. The magnitudes of the hazard ratios indicate that Nyanza province appears to be at highest risk of childhood mortality followed by Western and Nairobi provinces.

Trend Variables

The results discussed above are consistent across all the variants of the basic model. In model (2), we introduce the time trend variables. The hazard ratios suggest unexplained trend fluctuations in mortality probabilities up to the third level polynomial. The hazard ratio of the level is quite low, compared to the quadratic and cubic terms. Predicting the hazards of mortality for each trend value suggests that mortality increased by about 2.5% between 1978 and 2003. This implies that on average, mortality rose by about 0.1% per year due to unexplained trend variations.

As explained in the methodology section, one weakness of the data we have used is that some explanatory variables are available only at the time of the survey, while we have information on mortality for up to 15 years prior to the survey. We check on the appropriateness of using long lags for mortality, by introducing a variable for the number of years between the relevant survey and when a child was born (model 3)[9]. The impact of this variable could be interpreted as the trend in childhood mortality for years before the survey, controlling for other regressors. The coefficient for this variable is statistically significant and suggests that an increase in the years before the survey by one biases the probability of child mortality downwards by less than 3%. Since this model does not include a time trend, this variable probably also picks up the generally increasing trend in mortality rates in Kenya. A further test of the appropriateness of creating the long lags is done by interacting all the policy relevant explanatory variables in model (3) with the variables for years before the survey. The results (not presented) indicate that first, the coefficients and significance of policy

[9]If some women who died between a given year and the survey date, and were thus not surveyed, also had children more likely to die, (most frail children could have died before the survey) then their exclusion from the sample would cause a downward bias in the estimated mortality rate for years before the survey, and that bias should be greater with longer lags (Strauss and Thomas, 1995; Ssewanyana and Younger, 2008).

relevant variables generally remain the same; and second, only the interaction term with the log of the asset index variable is marginally significant at the 10% level. While the first result suggests that there is no problem with generating long lags for mortality, the second suggests that assets may have grown overtime and therefore we overestimate assets in the distant past by using current values. However, as shown later in the simulation section, assets grew by a rather insignificant rate over this period, and therefore any bias that may be present would be insignificant. A last test carried out was to reduce the estimation sample to only the survey period (5 years before the date of the survey). The results obtained were quite close to the results with long lags, suggesting that there are no serious biases arising from using the generated time series data.

District Characteristics

In Model (4), we introduce district average health indicators for children and their mothers. We investigate the impact of a child having received all vaccinations and whether a child's mother received any prenatal care and birthing assistance from a health professional. The results suggest that vaccination of children has the expected impact of reducing the probability of facing mortality. An increase in the proportion of fully immunized children by 1% would increases the probability of survival time at time‘t’ by 29%. Birthing assistance by a professional has a huge mortality risk reducing impact (Rutstein, 2000). Holding other factors constant, an increase in the proportion of mothers in a district receiving birthing assistance from a professional by 1% would reduce the probability of child mortality by 30%. These results imply the importance of improving access to health care services for child survival[10].

4.3. Policy Simulations for Millennium Development Goals

Kenya subscribes to the MDG targets of reducing by two thirds the U5M rates and a reduction in IMR from 79 to 25 per 1000 live births between 1990 and 2015 (UNDP,GOK and GOF, 2005). In this section, we simulate the impact of relevant policy variables on reducing childhood mortality rates and therefore test the likelihood of Kenya achieving the MDG targets. We use the respective variable means and the estimated coefficients of model 4 (Table **2**) to simulate the expected impact of a given change in an explanatory variable on the hazard ratio[11].

Improved Household Well-Being

The estimated semi-elasticity of the probability of childhood mortality with respect to assets (household well-being) implies that growth in assets may be expected to significantly reduce mortality. Still the question is whether the expected reduction would have a significant contribution towards achievement of the MDGs. To answer this question, we compute the annual rate of growth in the asset index over the decade covered by the three surveys. The annual rate of improvement is very small at only 0.5% per year. We project this increase from 2003 (time of last survey) to 2015 (MDGs target year). The results show very low mortality reductions at only 3 children per thousand live births (Table **3**). These simulations imply that holding other factors constant, the current rate of improvement of household well-being is too low to help the country achieve the MDGs targets for childhood mortality.

Improved Maternal Education

The results suggest that policies that improve maternal welfare will improve child welfare. The MDGs target to achieve universal primary education, and also to eliminate gender disparity in all levels of education by 2015. For maternal education, we simulate the impact of two policy options. First, if all mothers were to have complete primary education by 2015, childhood mortality would decline by 4/1000 live births. Kenya adopted universal primary education (UPE) in 2003. Thus the children who enrolled for primary education under UPE will complete primary education in 2011 and secondary education in 2015- the MDG target year. If all girls enrolled for primary education with the UPE, and assuming 100% completion rates, then Kenya would have to wait for close to two decades (for these girls to mature into motherhood) to enjoy this mortality reduction. For secondary and higher levels of education, we simulate the impact of raising completion rates to the primary school level. In the sample, 43% of

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[10]The use of district level averages can be criticized on the ground that mean distances to health facilities could decline drastically without affecting the distance that households in a particular area in a district must travel to access health care. It is however important to note that the variables we use here are proxies, and the estimated coefficients on proxies tend to be biased toward zero (or the hazard ratio biased toward one).

[11]Since the estimated model is nonlinear, we carry out simulations for each observation in the estimation sample and then find the average impact on the mortality risk. If we define the mortality hazard as $Y = \alpha + \beta X$, the new mortality hazard resulting from a change in X is given by $Y^1 = \alpha + \beta X^1$, where a Y^1 is the new probability of death resulting from a change in the policy variable from X to X^1.

Table 3: Simulated Reductions in Childhood Mortality Rates in Kenya

Policy change	Predicted reduction in mortality*	U5M rates (2003)	MDG target reduction
Increase household assets at present rate by 2015	3/1000 (0.065)		
All mothers complete primary education	4/1000 (0.058)		
Increase the proportion of mothers who complete secondary education from 23 to 43%	12/1000 (0.060)		
Give all districts with below mean (%) birth assistance by a professional the mean level	6/1000 (0.057)		
Give all clusters with below mean (%) use of modern contraception the mean level	7/1000 (0.038)		
Increase vaccination rates for all children to 100%	5/1000 (0.070)		
Total	37/1000	115/1000	77/1000

*Standard errors in parenthesis.

the women had graduated from primary school compared to only 23% who had some secondary education or higher. The results show that raising the proportion of the secondary women graduates to 43% would reduce childhood mortality by 12/1000 live births. Thus targeting women through education would make an enormous contribution towards the achievement of MDGs.

Improved Health Care

The proportion of children aged 12-23 months receiving full vaccination against vaccine preventable diseases fell from 65% in 1998 to 60% in 2003 (UNDP, GOK & GOF, 2005). Holding other factors constant, increased immunization coverage can help reduce mortality from immunizable diseases. The MDGs target 80% coverage by 2015. Our simulations show that if Kenya is to achieve 100% immunization coverage, she would reduce childhood mortality rates by only 6/1000 live births. Increased vaccination would therefore contribute towards the achievement, but not assure achievement of the MDGs targets.

One strategy towards achievement of the MDG target of reducing the neonatal and maternal mortality ratio is to raise significantly the proportion of births assisted by skilled health personnel. Yet this proportion is estimated to have declined from 51% in 1989 to 42% in 2003. However the estimated hazard rate ratios suggest that birth care by a professional would have a large mortality reducing impact. Estimates of district level attendance of births by a professional (nurse, midwife or doctor) suggest high levels of inequality with at least 1% of the districts having no professional care at all. Our simulation focuses on ensuring that birthing care is available in the districts with the lowest level of coverage. We therefore give each of the districts with less than the mean, the average sample coverage of 44%, raising the sample mean from 44% to 53%. The simulation results suggest that such a policy option would reduce childhood mortality by 6/1000 live births. Though this reduction may look small, it illustrates the potential impact if Kenya was to achieve 100% birth attendance by a professional.

The use of modern contraceptive methods has remained quite low in Kenya with a contraceptive prevalence rate of about 32% over the survey decade. There is still unmet demand (almost 40%) and persistent contraceptive stock-out. Yet the estimated hazard ratios show that contraception has a large significant impact of reducing childhood mortality, other factors held constant. The simulations focus on clusters with below average coverage of 30% in the estimation sample. The results suggest that if all these clusters were to achieve at least 30% coverage of mothers with modern contraception methods, childhood mortality would decline by 7/1000 live births. But even with this change, the average coverage would still be very low (37%). The province with the highest cluster level coverage over the survey decade was Central province with 46%. If family planning campaigns were intensified to push the lowest clusters to the Central province coverage, this would raise the mean coverage to 48% and reduce mortality by 16/1000 live births.

Is Kenya Likely to Achieve her MDG Goal of Reducing by Two Thirds U5M Rates by 2015?

In 1990, U5M rate in Kenya was estimated at 97/1000 live births. However, by 2003, this rate had risen to 115/1000 (UNDP, GOK & GOF, 2005). This means that evaluation of the MDG target is more realistic based on the 2003 than the 1990 mortality rate. This requires a mortality reduction of 77/1000 (115-(0.67*115)) between 2003 and 2015. The policy simulations in this paper suggest that though there is potential of making some progress, the MDG target cannot be achieved. Even if all the simulated impacts were to be achieved by 2015, there would still be a shortfall of 40/1000 live births (Table **3**).

5. CONCLUSION

This paper investigates the determinants of child survival in Kenya. We use three rounds of DHS data for the period 1993-2003 to construct a national time series for childhood mortality over a longer period of time (1978-2003). We use hazard functions to analyze the determinants of childhood mortality. We then use the estimated hazard rate ratios to simulate the impact of key policy variables on the likelihood of child survival and to assess the implications of such policies on the achievement of MDG targets in Kenya.

The estimated hazard ratios for the probability of childhood mortality show that boys, first borns and children of multiple births have lower probability of survival at time ‘t’ than the respective reference groups. Maternal education significantly lowers the risk of mortality, while age variables suggest the importance of reducing teenage births. The results further suggest high elasticity of the probability of childhood mortality relative to the probability of child survival with respect to assets. An increase in log of assets by 1% would lower mortality risks by between 24% and 36%. Controlling for other factors, cluster level use of modern contraception has a large significant impact of reducing the risk of mortality. We also find that there are unexplained macroeconomic variations that reduced the risk of mortality at a diminishing rate between 1978 and 2003. District level health care services are also found to be important factors for increasing probability of survival time at time ’t’.

The policy simulations results do not hold much promise for achievement of MDG targets, but show that these policy variables can make some contribution. Assets grew at a very low rate over the survey decade. Projecting this growth to the MDG target year suggests very modest reductions in mortality rates. The simulated impact of raising completion rates for post secondary education is larger than for primary education. The results imply that targeting women through secondary and post secondary education would make an enormous contribution towards mortality reduction in the long run. Simulations for improvement in health care service provision suggest that use of modern contraception has the largest potential of improving child survival. Other important policy issues include 100% immunization coverage for infants and improved coverage of birthing assistance by a professional. The policy simulations presented in this paper focus on realistic rather than the best possible policy scenarios. Most of the simulated policy scenarios are also long term due to for instance long gestation periods between enrollment in school and motherhood and low completion rates in schooling.

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