ENVIRONMENTAL DETERMINANTS OF CHILD MORTALITY IN KENYA

By

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Declaration

This research paper is my original work and has not been presented for a degree in any other university

Signed..

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This research paper has been submitted for examination with our approval as university supervisors:

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Dedication

To Ann Kaseni Muia,

the gracious lady who I never laid eyes on yet always miss her so much,

To her virtuous husband from whom I have learnt so many good things about life,

To all their offsprings, for all these times we have flocked together,

And to

Mary Nthenya, for Always

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Definition of terms

Neonatal mortality: the probability of dying within the first month of life

Postneonatal mortality: the difference between infant and neonatal mortality

Infant mortality: the probability of dying before the first birthday

Child mortality: the probability of dying between the first and fifth birthdays

Under-five mortality: the probability of dying before the fifth birthday

Abstract

This study focused on the determinants of infant and child mortality in Kenya. The study specifically examined how infant and child mortality is related to the household's environmental and socio-economic characteristics, such as mother's education, source of drinking water, sanitation facility, type of cooking fuels and access to electricity. A hazard rate framework was used to analyze the determinants of child mortality. Duration models are easily applicable to the problem of child mortality as this class of models straightforwardly accounts for problems like right-censoring.

Household's environmental and socio-economic characteristics were found to have significant impact on child mortality. Policies aimed at achieving the goal of reduced child mortality should be directed on improving the household's environmental and/or socio-economic status if this goal is to be realized.

CHAPTER 1: INTRODUCTION

1.2 Background

Child mortality, commonly on the agenda of public health and international development agencies, has received renewed attention as a part of the United Nation's Millennium Development Goals. Approximately 10 million infants and children under five years of age die each year, with large variations in under-five mortality rates, across regions and countries (Espo, 2002).

Childhood mortality rates have declined all over the world in the last fifty-five years. Between the mid 1940's and early 1970's, child death rates even in the developing countries reduced significantly (see for example, Baker, 1999). A great deal of these gains was achieved through interventions targeted at communicable diseases (diarrhea, respiratory infections, malaria, measles and other immunisable childhood infections).

However these health gains were short lived. In the mid 1970's the worldwide progress was not maintained and infant mortality rates rose especially in Africa because disease-oriented vertical programmes were not effective alone. Maternal, environmental, behavioral and socio-economic factors were recognized as additional important determinants of infant survival. According to UNICEF (1999), the decline in child mortality in Africa has been slower since 1980 than in the 1960s and 1970s. Of the thirty countries with the world's highest child mortality rates, twenty-seven are in sub-Saharan Africa. The region's under-five mortality in 1998 was 173 per 1000 live borns (UNICEF, 2000) compared to the minimum goal of 70/1000 internationally adopted in the 1990 World Summit for Children.

Although enormous literature exists on child mortality, evidence on why infant and child mortality rates remain high in many sub-Saharan African countries despite action plans and interventions made is still scanty. As the world enters into the 21st century, debate on childhood mortality remains a big issue for developing countries. Their commitment is reflected in their desire to reduce the level of child mortality by two- thirds of their 1990 levels by the year 2015, as expressed in the Millennium Development Goals. To achieve this goal, it is imperative to attempt and determine what factors contribute to the high levels of child mortality in developing countries, and Kenya, in particular.

1.2 Childhood Mortality in Kenya

Although accurate information on cause of death is lacking, the leading cause of under-five mortality in Kenya is pneumonia, malaria, measles and diarrheal disease, which are estimated to have been responsible for some 60 percent of disease burden in the region (Murray and Lopez, 1996). Kenya experienced dramatically fall in child mortality in the late 1940's and early 196o's. Until around 1980, the under -five mortality rate fell at an annual rate of about 4 percent per annum. This rate of decline slowed in the early 1980s to about 2 per cent per annum. Data from the 1998 Kenya Demographic and Health Survey (NCPD, 1989) show that, far from declining, the under-five mortality rate increased by 25 percent from the late 1980s to the mid 1990s. The recent Kenya Demographic and Health Survey (CBS, 2004) shows that under- five mortality rate is 115 deaths per 1,000 live births (see Table 1).

Table 1: Levels and Trends of Childhood Mortality in Kenya

Years preceding the survey	Neonatal mortality	Postneonatal mortality	Infant mortality	Child mortality	Under-five mortality
0-4	33	44	77	41	115
5-9	32	41	73	40	110
10-14	31	42	73	35	105

Source: CBS 2004. (All rates are expressed per 1,000 live births, except for child mortality, which is expressed per 1,000 children surviving to 12 months of age)

The table above shows the infant and under-five mortality rates for each of the three five-year periods preceding the 1998 KDHS and the 2003 KDHS. The use of rates for five-year periods conceals any year-to-year fluctuations in early childhood mortality. For the most recent five-year period preceding the survey, infant mortality is 77 deaths per 1,000 live births, and under-five mortality is 115 deaths per 1,000 live births. This means that one in every nine children born in Kenya dies before attaining his or her fifth birthday. This pattern shows that 29% of deaths under-age five occur during the neonatal period while 38% occur during the postneonatal period.

In general, both infant and under-five mortality rates are increasing, with the increases being more pronounced during the period between the mid-1980's and mid 1990's.

According to the 1999 population census (CBS, 2001), about 65.5% of the Kenyan population lives in the rural areas. Available evidence also shows that households living in the rural areas are much poorer than households living in the urban areas (Mwabu et. al, 2000; Kimalu et al., 2002; Geda et al., 2001) Children living in the rural areas of Kenya experience a higher risk of dying before age five than urban children (see for example; CBS, 2004; NCPD, 1998; NCPD, 1993; NCPD, 1989). The difference between rural and urban child mortality rates can completely be attributed to better living conditions in the urban areas. Women living in urban areas are more likely to be literate, to use clean cooking fuels and to have access to good sanitation facilities than women living in rural areas. This is not withstanding the relatively high levels of poverty and illiteracy also experienced by the urban poor.

1.3 Causes of Infant Mortality

Causes of infant mortality are multi-factorial, especially in developing countries, where there are great variations between social, economic and demographical groups of people even inside one country. Thus, in determining infant mortality one must take into account this diversity.

A three-tier model of causation of child mortality in developing countries was first put forward by Millard et al. (1989), as cited in Espo (2002) which mentioned three layers of causation as proximate, intermediate and ultimate. The proximate causes included the immediate biomedical causes of death. In populations with high mortality rates in early life, child death typically results from interactions of malnutrition, diarrhea and lower respiratory infections. Many public health programmes have addressed the proximate causes in an attempt to improve child health, for instance, through immunization campaigns. The intermediate layer includes those behavioural/culture-specific patterns that increase exposure to proximate causes (for example breast feeding habits, health-seeking behaviour etc). The ultimate layer includes economic, socio-cultural and political by a framework proposed by UNICEF and expounded by Kent (1991) to include intermediate, underlying and basic causes of infant mortality. According to Kent, immediate factors correspond to individual level (biomedical) aspects of both mother's and infant's conditions; specifically their disease and nutritional status. The underlying factors relate to the household level (for example, income, access to food and health services and marital status). Finally the basic or macrosocial factors relate to the socio-economic development of the society or region within which the household lives.

1.4 Poverty, Health and Environment

According to World Bank (2000), environmental health risks fall into two broad categories. The first are the traditional hazards related to poverty and lack of development, such as lack of safe water, inadequate sanitation and waste disposal, indoor air pollution, and vector-borne diseases. The second category is the modern hazards such as rural air pollution and exposure to agroindustrial chemicals and wastes that are caused by development that lacks environmental safeguards.

Environmental risk factors account for about one-fifth of the total burden of disease in low income countries according to recent estimates (World Bank, 2001). WHO (2002) reports that among the 10 identified leading mortality risks in high-mortality developing countries, unsafe water, sanitation and hygiene ranked second, while indoor smoke from solid fuels ranked fourth. About 3% of these deaths (1.7 million) are attributable to environmental risk factors and child deaths account for about 90% of the total.

1.5 Statement of Problem

The environment, which sustains human life, is also a profound source of ill health for many of the world's people. In the least developed countries, one in five children do not live to see their fifth birthday -- mostly because of avoidable environmental threats to health. This translates into approximately 11 million avoidable childhood deaths each year (WRI, 1999; WDI, 2004). Hundreds of millions of others, both children and adults, suffer ill health and disability that undermine their quality of life and hopes for the future. These environmental health threats -- arguably the most serious environmental health threats facing the world's population today -- stem mostly from traditional problems long since solved in the wealthier countries, such as a lack of clean water, sanitation, adequate housing, and protection from mosquitoes and other insect and animal disease vectors.

Poverty also influences health because it largely determines an individual's environmental risks, as well as access to resources to deal with those risks. Throughout the developing world, the greatest environmental health threats tend to be those closest to home. Many in these countries live in situations that imperil their health through steady exposure to biological pathogens in the immediate environment. More than 1 billion people in developing countries live without adequate shelter or in unacceptable housing. A further 1.4 billion lack access to safe water, while another 2.9 billion people have no access to adequate sanitation (WDI, 2004) -- all of which are essential for good hygiene. Unable to afford clean fuels, the poor largely rely on biomass fuels for cooking and heating. Inside the smoky dwellings of developing countries, air pollution is often higher than it is outdoors in the world's most congested cities.

As already mentioned, infant mortality rates in Kenya are still very high compared to other countries and have increased by 30 percent between 1989 and 2003. Reducing child mortality is the fourth Millennium Development Goal, whose target is to reduce the under-five mortality rate by two-thirds between 1990 and 2015. Despite numerous interventions and action plans, very little evidence exists on why the infant and child mortality rates are increasing in Kenya despite. If Kenya is committed to achieving the MDG on child mortality, it is prudent to understand clearly the factors that are contributing to the high levels of mortality. This study therefore explores the household's environmental and socio-economic characteristics and their effect on child and infant mortality in Kenya.

1.5 Objectives of the study

The general aim of the study is to explore the relationship between household's environmental and socio-economic characteristics on child mortality. The specific objectives are:

- To assess the relationship between the environment and child mortality in Kenya
- To identify the environmental determinants of child mortality, controlling for other covariates

1.6 Hypotheses of the study

In order to meet the above objectives, the following hypotheses are tested:

- Household's access to safe water has no effect on child mortality
- Children born in households without sanitation are more likely to die than those in households with sanitation
- The household's main source of cooking fuel has no effect on child mortality

1.7 Justification of the study

There are several studies which have been conducted on infant and child mortality in Kenya using census or survey data. All of these studies, including the four Demographic and Health Surveys (CBS, 2004; NCPD, 1998; NCPD, 1994; and NCPD, 1989) conducted so far, use indirect methods like the Trussell's technique to estimate the child mortality. Some of these studies have also employed multivariate linear and logistic regression to identify the determinants of infant child mortality. However, Ordinary Least Squares (OLS) or binary dependent variable regression models can not handle very well the aspect of child mortality because of the occurrence of the transition event being the dependent variable. OLS, for example is inadequate for survival data because of censoring (and truncation), time varying covariates and structural modeling (Jenkins, 2003). Binary dependent regression models can to some extend take care of both the censoring and structural modeling problem (not the time varying covariates) but there is a risk of loosing a lot of information in particular about when someone faced the hazard since the dependent variable is mis-measured (Jenkins, 2003).

This study is expected to contribute to methodological innovation in infant and child mortality studies in Kenya by introducing survival analysis into child mortality modeling. Duration models are the most suited for such analysis because they account for problems like right-censoring, structural modeling and structural modeling which traditional econometric techniques can not handle adequately.

The results of this study are expected to shed light on the linkage between the household's environmental status and child mortality, and consequently inform policy on the importance of improving households' environmental and socio-economic characteristics in a bid to reduce child mortality. This is line with the current government's effort of mainstreaming the environment into sustainable development planning and commitment to the achievement of the Millennium Development Goals.

CHAPTER 2: LITERATURE REVIEW

2.1 Theoretical literature review

There is a relatively large literature that focuses on the determinants of child mortality (see for a survey Wolpin, 1997). Theoretical frameworks are often presented as health production functions, which capture the structural relation between health outcomes and the household's behavioral variables, like nutrition, breastfeeding, child spacing, etc. (see Schultz, 1984). In the framework of a health production function, child mortality risks depend on both observed health inputs and unobserved biological endowment or frailty. Not properly taking account of these unobserved characteristics or the relation between children within a family may lead to inconsistent and inefficient estimators (for example, see Ridder and Tunali, 1999).

There are a number of different analytical frameworks through which to view the effects of different determinants on childhood mortality. Demographic research by Mosley and Chen (1984) and by Schultz (1984) made the distinction between variables considered to be exogenous or socioeconomic (i.e. cultural, social, economic, community, and regional factors) and endogenous or biomedical factors (i.e. breastfeeding patterns, hygiene, sanitary measures, and nutrition). The effects of the exogenous variables are considered indirect because they operate through the endogenous biomedical factors. Likewise, the bio-medical factors are called intermediate variables or proximate determinants because they constitute the middle step between the exogenous variables and child mortality (Jain, 1988; Mosley and Chen, 1984; Schultz, 1984; UN, 1985).

Mosley and Chen (1984) were among the first to study the intermediate biomedical factors affecting child mortality, labeled 'proximate determinants' They distinguished fourteen proximate determinants and categorized them into four groups: maternal [fertility] factors, environmental sanitation factors, availability of nutrients to the foetus and infant, injuries, and personal illness control factors.

2.2 Empirical literature review

This sub-section first reviews empirical studies in Kenya and thereafter reviews some studies outside Kenya. Several studies have been carried out in Kenya on infant and child mortality using census and survey data.

Jada (1992) combines the Trussell's technique for estimating child mortality based on the Coale Demeny model life table with multivariate linear regression. Child and infant mortality is found to be inversely proportional to the improvement in socio-economic and environmental factors. Environmental indictors such as source of drinking water, availability of toilet facilities were found to negatively improve the infant and child mortality rates.

Using the National Household Welfare Monitoring and Evaluation Survey (NHWMES), Wanjohi (1996) finds that environmental factors namely the type of bathroom, type of toilet facility and water source have significant effect on the ratio of observed to expected deaths. The Trussell-Preston methods and multivariate regression analysis are used to calculate mortality indices for each woman.

Omariba (1993) utilizes the Coale and Trussel indirect technique of estimating mortality, cross tabulation as well as multiple regression analysis using census data to estimate mortality in Kajiado district in Kenya. The ratio of observed to expected deaths iss the dependent variable in both the cross-tabulation and multiple regression analyses. Rural areas are found to have lower mortality levels than urban areas. In addition, health, environmental and socio-economic factors have close relationship with mortality.

Okumbe (1996) uses the Kenya Demographic and Health Survey (KDHS) 1993 to determine the relative frequency of women at risk of having neo-natal deaths. Logistic regression analysis iss used to measure the effect of the socio-economic and demographic covariates on neonatal mortality. Environmental (type of toilet facility, source of drinking water), demographic and socio-economic factors are found to be significantly related to the neonatal deaths.

Ouma (1991) employs the Trussell's technique for estimating child mortality. At the individual level, the Preston and Trussell's technique of estimating infant and child mortality is used to determine the mortality index of an individual woman. Stepwise linear regression analysis reveals that availability of safe drinking water and toilet facilities are significantly associated with the level of infant and child mortality.

Kamau (1998) using the Kenya Demographic and Health Survey (KDHS) 1993 data shows that, based on results from cross-tabulation and regression analysis, that significant relationship exists between the incidence of mortality and current marital status, level of education, age at first birth, type of floor material, religion, type of toilet facility and place of delivery.

De-Gita (1996) also employs the Trussell's technique to estimate the levels of infant and child mortality by various environmental socio-economic factors using the Kenya Demographic and Health Survey (KDHS) 1993 data. His study finds that households with flush toilets experience lower mortality than those using bush, pit or other toilet facilities. Source of drinking water is also found to have significant impact on mortality.

Due to the inadequacies of the registration of deaths in Malawi, Baker (1999) uses indirect methods to estimate levels and trends of mortality. She employs a most widely used technique that is based upon retrospective reports of children ever born and children surviving. This technique involves taking the proportion of the children dead to those ever born to women categorized by age group. The proportions are converted into probabilities by multiplying the proportion of children dead among children ever born to women of a certain age group by an adjustment factor that is based on comparisons of cumulative parities of women of different age groups. She then estimates a controlled regression model for medical and health environment and variables. The results indicate that owning a pit latrine does not have a significant effect on child mortality. This is contrary to her original hypothesis and she concludes that this variable is not a good measure of sanitation environment and has many limitations. Just because a household has sanitation facilities does not mean that it will be used hygienically or by all members of the household.

In a related study in Malawi, Espo (2002) employs logistic regression to assess associations between morbidity and various linear or dichotomous environmental predictor variables. The Kruskall Wallis non-parametric independent sample test and cross-tabulation with chi-square tests for statistical significance are used. The results indicate that source of drinking water and sanitation facilities were strong predictors of infant mortality.

Hala (2002) assesses water and sanitation's impacts on child mortality in Egypt. He estimates a duration model for the entire sample together with a three-part model. Neonatal mortality is first modeled by using a discrete dependent variable model and the mortality risk in the infant (up to his first birthday) and childhood (from the first birthday to fewer than 5 years) is modeled using non-parametric, semi-parametric and parametric duration models. In this particular application, this three-part model predicts mortality better than a duration model for the under five child mortality in general since it uncovers some interesting differences between the impacts of household environmental and socio-demographic determinants on the neonatal, infant and subsequent mortality risk. Results show that access to municipal water decreases the risk and sanitation is found to have a more pronounced impact on mortality than water.

Woldemicael (1988) examines the effect of some environmental and socioeconomic factors that determine childhood diarrhea in Eritrea. He uses data from the 1995 Eritrea Demographic and Health Survey (EDHS). The method employed is logistic regression. The results show that type of floor material, household economic status and place of residence are significant predictors of diarrhea. The study also discovers an important relationship between diarrhoeal morbidity and age of child and number of children living in the house with particularly high prevalence of diarrhea at the age of weaning and in households with large number of living children. However, the effects of toilet facility and maternal education are not found to be statistically significant when other factors are held constant.

A comparative study of rural areas of Ghana, Egypt, Brazil and Thailand by Timaeus and Lush (1995) clearly indicates that children's health is affected by environmental conditions and economic status of the household. According to these authors, children from better-off households have lower diarrhoeal morbidity and mortality in Egypt, Thailand, and Brazil. Such differentials in diarrhea diseases by household economic status are probably due to differences in child care practices, for instance preparation of weaning foods and personal hygiene.

Klaauw and Wang (2003) develop a flexible parametric framework for analyzing infant and child mortality. This framework is based on widely used hazard rate models, which they extend with two features. First, the model allows individual characteristics and household's socio-economic and environmental characteristics to have different impacts on infant and child mortality at different ages. Second, they allow for frailty at multiple levels, which can be correlated with each other. The first feature seems to be particularly relevant in describing infant and child mortality, child specific and household's socio-economic and environmental characteristics have significantly different impacts on mortality rates at different ages of the child. They also use the estimated model to perform a number of policy experiments. The policy experiments show that infant and child mortality rates can be reduced substantially by improving the household's socio-economic and environmental characteristics. Their model predicts that a significant number of under 5 years deaths can be averted by providing access to electricity, improving the education of women, providing sanitation facilities and reducing indoor air pollution. In particular, reducing indoor air pollution and increasing the educational level of women might have substantial impacts on child mortality.

Jacoby and Wang (2003) examine the linkages between child mortality and morbidity, and the quality of the household and community environment in rural China using a competing risks approach. The key findings are that (1) the use of unclean cooking fuels (wood and coal) significantly reduces the neonatal survival probability in rural areas; (2) access to safe water or sanitation reduces child mortality risks by about 34% in rural areas; (3) a higher maternal education level reduces child mortality and that female education has strong health externalities (i.e. controlling for other factors, a child living in a neighbourhood with more educated mothers has about 50% lower mortality risk); (4) access to safe water/sanitation, and immunization reduce diarrhea incidence in rural areas, while access to modern sanitation facilities (flush toilets) reduces diarrhea prevalence in rural areas; (5) significant linkages between Acute Respiratory Infections (ARI) incidence and use of unclean cooking fuels are found using the city level data constructed from the survey. The findings from the study indicate that effective policy interventions for improving health outcomes often lie both within and outside the health sector and that cross-sectoral approaches can potentially produce large health benefits.

In a related study Wang (2003), using the results from the 2000 Ethiopia DHS examines the environmental determinants of child mortality. She runs three hazard models, the Weibull, the Piece-wise Weibull and the Cox model to examine three age-specific mortality rates: neonatal (under one month), infant (under one year), and under-five mortality by location (rural/rural), female education attainment, religion affiliation, income quintile, and access to basic environmental services (water, sanitation and electricity). The estimation results show that children born in rural areas face much higher mortality risk compared with those born in urban areas. A strong statistical association is found between child mortality rates and poor environmental conditions.

2.3 Overview of Literature

There is a general consensus in literature that household's socio-economic and environmental characteristics do have significant effects on child and infant mortality. This is true for studies which employ both indirect and indirect techniques to estimate infant and child mortality.

As observed in most studies, household's income has significant effect on children survival prospects. Higher mortality rates are experienced in low income households as opposed to their affluent counterparts.

The mother's level of education is strongly linked to child survival. Higher levels of educational attainment are generally associated with lower mortality rates, since education exposes mothers to information about better nutrition, use of contraceptives to space births, and knowledge about childhood illnesses and treatment. Larger differences have been found to exist between the mortality of children of women who have attained secondary education and above and those with primary level of education or less.

There is U-shaped pattern relationship between mother's age at birth and childhood mortality, with children of the youngest and oldest women experiencing the highest risk of death. Childhood mortality rates are considerably higher among children born to women in their forties and lowest among whose mothers are age 20-29 years at the time of birth. A similar pattern occurs with the birth order of the child, but only for neonatal mortality. After the neonatal period, first-order births show lower mortality risks than births of order two to six.

On household's environmental characteristics, safe source of drinking water supply has negative significant effects on children mortality risk. The same holds true for those with sanitation, which in most cases is taken to be access to a flush toilet or a ventilated improved pit latrine.

Differentials by urban/ rural residence have commonly been observed, with urban areas having more advantages and therefore better child survival prospects.

As concerns the demographic variables, the patterns of mortality by maternal age and birth order are typically U-shaped; Children born to both relatively old and young women have higher mortality rates than others; the interpretation of the effect of maternal age at birth on infant mortality must be biological, i.e., it depends on reproductive maturity. Moreover, first and higher order births also have higher mortality rates since the birth order reflects the components of the child's biological endowments. As for the child's gender, it is widely believed that male mortality is higher due to biological disadvantages. Children born twins are faced with a higher mortality risk.

CHAPTER 3: METHODOLOGY

3.1 Theoretical Model

In this section, we present the model for estimating infant and child mortality. Our study employs survival analysis, whose main concepts are the hazard function and the survivor function. The aim is to estimate the probability of a child dying within the next day after surviving for *t* months as a result of environmental factors, among others. We focus on children that are born alive and model their mortality probabilities until reaching age 5. We use duration models to specify these mortality.

The survivor function denotes the probability that a child survives up to a particular age. The function is obtained from what is known in the survival analysis literature as the failure function F(t).

$$F(t) = \Pr(T < t) \qquad 3.1$$

where T is the length of a completed spell which implies that the Survivor function is given as:-

$$\Pr(T > t) = 1 - F(t) \equiv \overline{F}(t) \equiv S(t) \qquad 3.2$$

There is a one-to-one relationship between a specification for the hazard rate and the survivor function.

$$\theta(t) = \frac{f(t)}{1 - F(t)} \quad 3.3$$

which after some manipulation gives :

$$S(t) = \exp[-H(t)] \quad 3.4$$

where $H(t) = \int_0 \theta(u)du = -Ln[S(t)] \geq 0$ 3.5

as the integrated hazard function.

The important result is that, whatever functional form is chosen for (t), one can derive S(t) and F(t) from it (and also f(t) and H(t)), and vice versa. In the context of child mortality, the hazard rate is often referred to as mortality rate (Ridder and Tunali, 1999). The mortality rate at age *t* can be interpreted as the intensity at which a child dies at this age, given that the child survived until age *t*.

3.1.2 Specification of child mortality rates

Since the primary interest of this study is to investigate the effects of household environmental and socioeconomic characteristics on the probability of child mortality, a multivariate model of the child life duration is specified. Two popular methods of analyzing the effect of explanatory variables on the hazard rate are the proportional hazard model and the accelerated failure time. The former is based on semiparametric model. This is a flexible method of estimation since the baseline hazard is estimated nonparametricly and eliminates the risk of corrupting the estimated hazard parameters while the effect of the covariates takes a particular functional form.

To check robustness, we implement two models for the length of time t that a child survives. These are a parametric (Weibull model) and a semi- parametric model (the Cox proportional hazard model). The Cox proportional hazard framework is based on a hazard function for the distribution of living duration that is the transition rate. The probability of leaving life at any moment given that the child is still alive up to that moment is, $\lambda(t) = \lambda_0(t)e^{\beta' x}$ where, $\lambda_0(t)$ is the baseline hazard and $e^{\beta' x_i}$ is the relative risk associated with the regressors X.

In the proportional hazard specification the effect of the regressors is to multiply the hazard function itself by a scale factor. The vector of parameters β in this setting will be estimated without specifying the baseline hazard function i.e., $\lambda_0(t)$ is treated non-parametrically. Therefore a partial likelihood approach will be used to estimate the parameters (see, Cox, 1972). One of the problems here is the possible existence of unobserved heterogeneity[3] between children from different families since they potentially have a different duration distribution and the control for the effect of the related explanatory variables is incomplete. The result that holds generally about heterogeneity is that it leads to a downward biased estimate of duration dependence.

Therefore a further step is taken by incorporating unobserved heterogeneity into the model. Thus the hazard function will be of the following form:

[3] Most empirical studies assume that health inputs have constant impacts on child mortality over the age of the child. We will relax these assumptions by accounting for unobserved heterogeneity.

$$\lambda_i(t) = \lambda_0(t)\alpha_i e\beta'^{x_i} \quad 3.6$$

where α_i is the group *i* level frailty. The frailties are unobserved positive quantities with mean one and variance θ.

The literature contains an abundance of choices for parametric models; a popular one is the Weibull model. The hazard function of which is defined as $\lambda(t) = \lambda p(\lambda t)^{p-1}$ where $\lambda = e^{-\beta' x}$ and p is a scale parameter with $p < 1$ indicating that the hazard falls continuously over time, while $p > 1$ indicates the opposite (see Greene, 2000).

As previously mentioned, households and their environment differ in so many respects that no set of measured covariates can possibly capture all the variation among them. It is well known that the estimated hazard from a model that neglects heterogeneity falls more steeply or rises more slowly than the true hazards for homogenous groups. Gail et al. (1984) showed that the unobserved heterogeneity tends to attenuate the estimated coefficients toward zero. On the other hand, standard errors and test statistics are not biased. For this reason a correction for the unobserved heterogeneity based on the gamma distribution of heterogeneity with mean one and variance θ is used. Incorporating the heterogeneity into the Weibull distribution results in the following hazard function:

$$\lambda(t) = \lambda p(\lambda t)^{p-1}(s(t))\theta \quad 3.7$$

where $s(t) = \left[1 + \theta(\lambda)^{p}\right]^{-1/\theta}$ is the unconditional survival function, where the further θ deviates from zero, the greater the effect of the heterogeneity. The covariates X enter through the θ and in the survival time density is given by $h(t)S(t)$, where

$$S(t) = \exp^{\int_0^t h(u)du} \text{ is the survival probability.} \qquad 3.8$$

3.2 Empirical Model

The study estimates the following hazard rate based models:

3.2.1 Weibull Model

$$h(t) = \lambda^{\alpha}\alpha t^{\alpha-1} \qquad 3.9$$

Introducing the covariates, the model becomes:

$$h(t/X) = h_0(t)g(\beta_1 X_1 + \beta_2 X_2 ... \beta_n X_n) + \in \qquad 3.10$$

$$= e^{\beta_1 X_1 + \beta_2 X_2 ... \beta_n X_n}\alpha t^{\alpha-1} + \in \qquad 3.11$$

3.2.2 Cox Model

$$h\{(t),(X_1, X_2, ..., X_m)\} = h_0(t)\exp(\beta_1 * X_1 + ... + X_m * X_m) \qquad 3.12$$

where h(t,...) denotes the resultant hazard, given the values of the m covariates for the respective case (X_1, X_2,... ,X_m) and the respective survival time. The term $h_0(t)$ is called the baseline hazard and it is the hazard for the respective individual when all independent variable values are equal to zero. The model can be linearized by dividing by both sides of the equation 3.12 by $h_0(t)$ and then taking the natural logarithm of both sides.

$$\log[h\{(t),(X...)\}/h_0(t)] = \beta_1 X_1 + ... + X_m * X_m + \in \qquad 3.13$$

The estimated β's will give the marginal impact of X's (household's socio-economic and environmental characteristic on the hazard rate.

The hazard function *h(t/X)* will be estimated using Maximum Likelihood estimation. The likelihood function is given as:

$$L = \frac{f_1(t) f_2(t).....f_n(t)}{t, X, \beta, \alpha} \qquad 3.12$$

where $f_i(t)$ $i = 1.....n$ is the probability distribution

$$f(t) = h(t)S(t) \text{ if dead} = \begin{cases}1\\0\end{cases} \therefore f(t) = S(t) \qquad 3.13$$

$$L = \prod_{i=1}^{n} [h(t)S(t)][S(t)]$$

$$= \prod_{i=1}^{n} [h(t)S(t)] \qquad 3.14$$

The log-likelihood function is expressed as:

$$\log L = \sum_{i=1}^{n} \log h_i(t) + \sum_{i=1}^{n} \log S_i(t) \qquad 3.15$$

The log of *h(t)S(t)* is the individual contribution of the likelihood function that we intend to maximize.

3.3 Data

In this section we summarize the data used in the empirical analysis. The data was obtained from the Kenya Demographic and Health Survey (KDHS) 2003. The KDHS provides information on fertility, mortality, health issues, socio-economic and environmental conditions. It covers a nationally representative sample in 8 provinces. The data set contains information on 9,000 households.

As is often the case with data on child mortality, information on child mortality comes from surveys among women. A special survey questionnaire for women called the women's questionnaire is administered to capture data on women's birth history. For each live born child the month of birth is recorded and whether or not the child is still alive at the time of the interview. If a child died during the observation period, the age at which the child died is asked. The age of death is observed within intervals, in case a child died within a month after birth, the age of death is recorded in days, if the child died between 1 month and 2 years, it is recorded in months, and otherwise it is recorded in years. Because we are only interested in child mortality until age 5, we will artificially right-censor at this age. Right-censoring can also occur if a child is alive at the moment of the interview and younger than 5 years old.

The KDHS also collects information on asset ownership, such as car, radio, television, refrigerator etc. Asset ownership is a proxy for wealth and economic status (e.g. Filmer and Pritchett, 2001). In low-income countries; where household income is often difficult to measure (particularly in rural areas), consumption expenditures are often used in determining poverty (e.g. Deaton, 1997). Although asset ownership is less sensitive to short-term fluctuations than consumption expenditures, asset ownership and consumption expenditures are strongly correlated. Additionally, the KDHS provides information on livestock and land ownership, which are indicators of both economic and social status of a household. Land ownership is also an indicator of income from agriculture.

3.3.1 Limitations of the Data

The KDHS data are recorded retrospectively and can therefore suffer from misreporting, for example a child who died at a very young age might not be reported. Several DHS studies show evidence of downward bias in reporting child deaths (Jacoby and Wang, 2003), that is, the longer the recall period, the more likely the possibility of the respondents to misreport the case. The quality of mortality estimates calculated from retrospective birth histories depends upon the completeness with which births and deaths are reported and recorded. Potentially the most serious data quality problem is the selective omission from the birth histories of births who did not survive, which can lead to underestimation of mortality rates. Other potential problems include displacement of birth dates, which may cause a distortion of mortality trends, and misreporting of the age at death, which may distort the age pattern of mortality. When selective omission of childhood death occurs, it is usually most severe for deaths in early infancy. If early neonatal deaths are selectively underreported, the result is an unusually low ratio of deaths occurring within seven days to all neonatal deaths, and an unusually low ratio of neonatal to infant deaths. Underreporting of early infant deaths is most commonly observed for births that occurred long before the survey. An examination of the ratios shows no significant number of deaths was omitted in the 2003 KDHS.

3.3.2 Data processing and validation

KDHS 2003 survey data was downloaded with the express permission of Macro International from their website (www.measuredhs.com). The relevant variables for the study were filtered using StatTransfer Version 6 software from SPSS spreadsheet into STATA Version 8 software which was employed to perform the analysis.

3.4 Definition of variables

The variables used in the estimations are defined in this section. The hazard rate is the dependent variable. The hazard rate, or in our case the child mortality rate, is defined as the probability per time unit that a case that has survived to the beginning of the respective interval will fail in that interval. Specifically, it is computed as the number of failures per time units in the respective interval, divided by the average number of surviving cases at the mid-point of the interval.

The explanatory variables are classified into three groups: environmental, socioeconomic and demographic. The choice of these variables was guided by the determinants of child mortality literature. The main focus of this study though is however, on the environmental variables.

Table 2: Variable Measurement and Definitions

Variable	Apriori Impact on Child Mortality Rate
Socio-economic	
Female headed household	Negative
Household size	Negative
Mother's age	Positive
Mother with no education	Positive
Mother with primary education	Negative
Mother with secondary education	Negative
Household has radio	Negative
Household has TV	Negative
Main dwelling unit made of thatch/grass	Negative
Main dwelling unit made of *mabati* (iron sheets)	Negative
Main dwelling unit made of tiles	Negative
Demographic	
The child is male	Positive
The child is a twin	Positive
Preceding birth interval is 2 yrs	Uncertain
Birth order between 2 and 3 yrs	Uncertain
Birth order between 4 and 6 yrs	Uncertain
Birth order 7 yrs and above	Uncertain
Environmental	
Household with safe water	Negative
Household with flush toilet	Negative
Household with pit latrine	Negative
Household without toilet facility	Positive
Household using low-polluting fuel	Negative
Household using medium-polluting fuel	Positive
Household using high-polluting fuel	Positive

3.4.1 Measurement of Variables

Household income is proxied by assets. An asset index is constructed based on household's access to assets as well as roofing material of the main dwelling unit.

Four dummies are constructed for mother's education. These are mother's with no education, with primary education and those with secondary and higher (tertiary) education.

In this study, households with access to private or public tap water as well as those with private well water are considered to have safe water. Similarly, households that have either a flush or a pit latrine are regarded to have sanitation as opposed to those which are lacking either facility.

Household's main source of cooking fuel is categorized into three with liquefied petroleum gas (LPG), electricity and biogas being considered as low- polluting, kerosene and charcoal as medium-polluting and firewood and coal as high-polluting fuels.

CHAPTER 4: RESULTS

4.1 Descriptive Statistics

This section contains a discussion of the characteristics of the study variables. Table 3 below presents the descriptive statistics.

Table 3: Descriptive Statistics

Variable	Observations	Mean	Std. Dev	Min	Max
The child is a twin	100	0.028	0.166		
The child is male	1779	0.504	0.500		
Household with piped water or private well	1261	0.357	0.479		
Household with piped water or private well	2865	0.811	0.391		
Household with electricity	294	0.083	0.276		
Mother's age	3531	27.287	6.536	15	49
Main source of fuel low-polluting	185	0.311	0.174		
Main source of fuel medium-polluting	1457	0.245	0.430		
Main source of fuel high-polluting	4128	0.693	0.461		
Female headed household	932	0.264	0.441		
Household size	3531	6.247	2.824	1	30
Preceding birth interval is 1 yr	3531	44.279	21.547	9	192
Preceding birth interval is 2 yrs	707	0.200	0.400		
Birth order 1 yr	873	0.247	0.432		
Birth order between 2 and 3 yrs	1199	0.340	0.473		
Birth order between 4 and 6 yrs	949	0.269	0.443		
Birth order 7 yrs and above	326	0.092	0.289		
Mother with no education	411	0.116	0.321		
Mother with primary education	2266	0.642	0.480		
Mother with secondary and tertiary education	56	0.016	0.125		
Household has radio	2261	0.640	0.480		
Household has TV	367	0.104	0.305		
Main dwelling unit made of grass/thatch	1331	0.377	0.485		
Main dwelling unit made of *mabati* (iron sheets)	2107	0.600	0.491		
Main dwelling unit made of tiles	43	0.012	0.110		

Table 3 shows that the youngest woman was found to be 15 years while the oldest was 49 years old, resulting in a mean age of 27.29 years. The mean household size was 6.24. With regard to educational attainment, 64.2% of the women had primary education, while 1.6% and

11.6% had secondary education or no education respectively. With regard to household assets, 64.04% and 10.39%, of the households have radio and television respectively.

Households whose main dwelling unit is roofed of grass or thatch are 37.69%, while 59.67% and 1.22% have iron sheets (*mabati*) and tiles respectively as their main dwelling unit's roofing material. 26.39% of the households interviewed are female-headed. Out of the sample, 2.8% of the children ever born are twins while 50.38% of them are males.

Out of the women interviewed, 81.8% of them were from a household with a flush toilet or a pit latrine and are considered to have sanitation. In addition, 35.7% had access to either tap water or private well thus meeting the study's qualification of having safe water. Only a paltry 8.3 % of the households had access to electricity. Majority (69.31%) of the households use high-polluting fuels (firewood and coal) as the main source of cooking. 24.49% use either charcoal or kerosene which are considered medium polluting in this study while only 3.11% use low polluting fuels (LPG, electricity and biogas).

4.2. Empirical Results

4.2.1 Weibull Model Estimates for Child Mortality in Kenya

Table 4 indicates the Weibull Model coefficient estimates for child mortality in Kenya. Table 5 provides the respective hazard ratios for the variables which show the marginal impact of the variable on child mortality. The standard errors are adjusted to clustering on the clusters.

Table 4: Weibull Model coefficient estimates

_t	Coefficient	Robust Std. Err.	z	P>z
The child is male	0.210249	0.1103689	1.90	0.057
The child is a twin	1.251359*	0.2227829	5.62	0.000
Preceding birth interval is 2 yrs	0.692444*	0.1303476	5.31	0.000
Birth order between 2 and 3 yrs	-0.404619*	0.1393165	-2.90	0.004
Birth order between 4 and 6 yrs	-0.174995*	0.1689254	-1.04	0.300
Birth order 7 yrs and above	0.559237*	0.2473051	2.26	0.024
Female headed household	-0.100439	0.1294684	-0.78	0.438
Household size	-0.213146*	0.0427125	-4.99	0.000
Mother's age	0.010214	0.013173	0.78	0.438
Mother with no education	0.339856	0.2869543	1.18	0.236
Mother with secondary education	0.352541	0.1947287	1.81	0.070
Household with safe water	-0.896102*	0.3225468	-2.78	0.005
Household with pit latrine	0.9806366*	0.3640345	2.69	0.007
Household without toilet facility	0.8556486*	0.4131599	2.07	0.038
Household using medium-polluting fuel	1.554067*	0.2776315	5.60	0.000
Household using high-polluting fuel	1.371767*	0.2735628	5.01	0.000
Household has radio	-0.111722	0.136277	-0.82	0.412
Household has TV	-0.222397	0.2535072	-0.88	0.380
Main dwelling unit made of *mabati* (iron sheets)	-0.020203	0.1269576	-0.16	0.874
Main dwelling unit made of tiles	-1.997012*	0.5795006	-3.45	0.001
Constant	-2.529933*	0.5129686	-4.93	0.000
/ln_p	-1.097358	0.0513981	-21.35	0.000
p	0.3337516	0.0171542		
1/p	2.99624	0.1540011		

No. of subjects = 4415
No. of failures = 378
Time at risk = 117421.6667
Log likelihood = -1992.2105

Number of observations = 4415
Wald $chi^2(22)$ = 208.89
Prob > chi2 = 0.0000

* Significant at 5%

Table 5: Weibull Model hazard ratio estimates

_t	Hazard Ratio	Robust Std. Err.	z	P>z
The child is male	1.233986	0.1361936	1.90	0.057
The child is a twin	3.495089*	0.7786462	5.62	0.000
Preceding birth interval is 2 yrs	1.998595*	0.260512	5.31	0.000
Birth order between 2 and 3 yrs	0.6672311*	0.0929563	-2.90	0.004
Birth order between 4 and 6 yrs	0.839461	0.1418063	-1.04	0.300
Birth order 7 yrs and above	1.749337*	0.43262	2.26	0.024
Female headed household	0.9044401	0.1170964	-0.78	0.438
Household size	0.8080377*	0.0345133	-4.99	0.000
Mother's age	1.010266	0.0133082	0.78	0.438
Mother with no education	1.404745	0.4030976	1.18	0.236
Mother with secondary education	1.422679	0.2770363	1.81	0.070
Household with safe water	0.4081575*	0.1316499	-2.78	0.005
Household with pit latrine	2.666153*	0.9705717	2.69	0.007
Household without toilet facility	2.3529*	0.9721239	2.07	0.038
Household using medium-polluting fuel	0.2113864*	0.0586875	5.60	0.000
Household using high-polluting fuel	0.2536583*	0.0693915	5.01	0.000
Household has radio	0.8942933	0.1218716	-0.82	0.412
Household has TV	0.8005976	0.2029573	-0.88	0.380
Main dwelling unit made of *mabati* (iron sheets)	0.9799996	0.1244184	-0.16	0.874
Main dwelling unit made of tiles	7.367012*	4.269188	-3.45	0.001
/ln_p	-1.097358	0.0513981	-21.35	0.000
p	0.3337516	0.0171542		
1/p	2.99624	0.1540011		

* Significant at 5%

All the variables in the estimated Weibull model have the expected signs. There are four significant demographic variables namely, if the child is born twin, children born with birth interval of two years, children with birth order between two and three years, and birth order of seven years. A child born twin has a significantly lower survival probability than a single born mainly due to biological factors. Children with a preceding birth interval of two years have a significantly higher mortality hazard. Children whose birth order is between 2 and 3 are faced with lower mortality hazard while those of birth order 7 have higher mortality rate at each survival time.

As for the socio-economic variables, household size is negatively related to child mortality, meaning that higher child survival prospects are experienced in larger households in Kenya. Households with iron sheets and those with tiles as the roofing material for their main dwelling unit have lower child mortality rates as compared to those with grass or thatch. Lower mortality is experienced in households with both radio and television. These are by implication affluent households which are expected to have better child survival prospects.

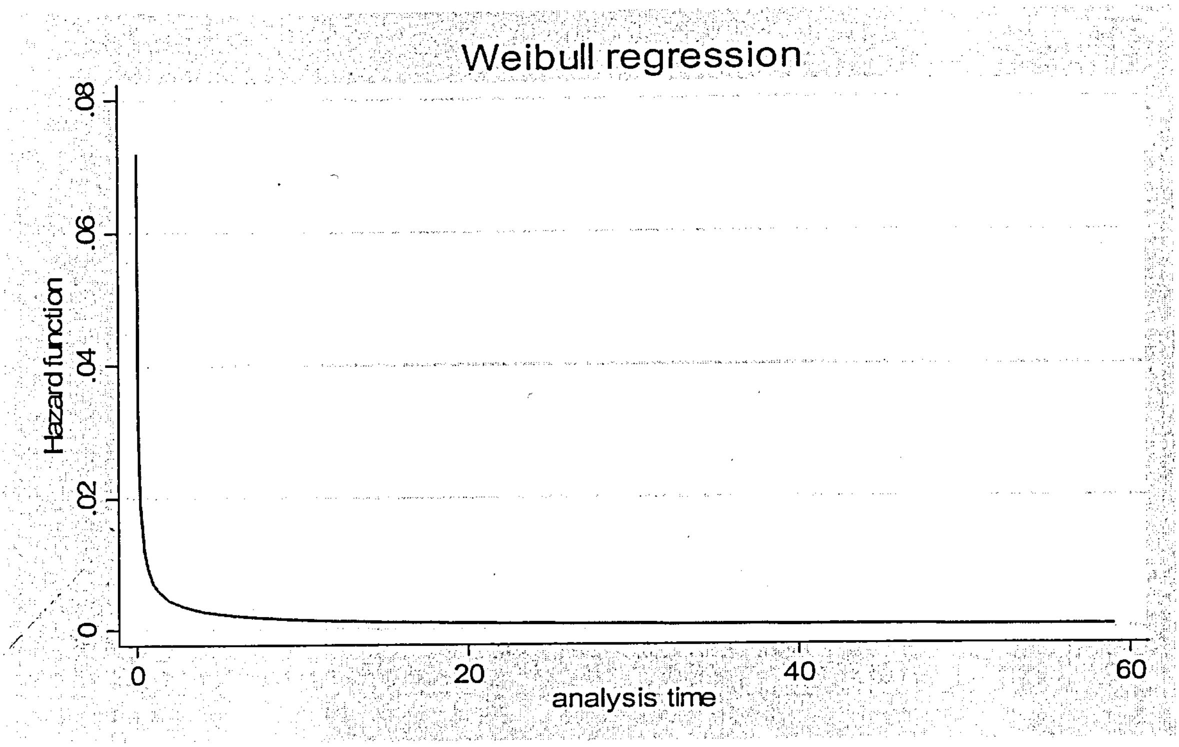
Households with access to tap and private and private well water have significantly lower mortality rates. At each survival time, the mortality rate for children born into the household with access to safe water have is 40% less than those in households without. Access to sanitation facilities is also significantly related to child mortality. Children born in household's with pit làtrines have higher mortality rate than those born in households with flush toilet.

With regard to source of cooking fuel, children born in households using both medium and high polluting fuels as their main source of cooking fuel have higher mortality rates as compared to those using low polluting fuels. Higher incidence of respiratory infections which are responsible for child deaths is expected in households which use dirty fuels as opposed to those using clean cooking fuels.

All these findings are consistent with Hala (2002), Woldemicael (1988), Klaauw and Wang (20030 and Jacoby and Wang (2003).

From the Weibull model estimates, the shape parameter α which is shown as ρ in STATA has a value of 0.3 which implies that the hazard rate is decreasing continuously over time or in other words there is negative time dependence. This means that children face a higher hazard (mortality rate) in the initial days of birth than in later periods. The same is shown by the plotted graph of the hazard function.

Graph 1: Weibull hazard function



4.2.2 Cox Model Estimates for Child Mortality in Kenya

Table 6: Cox Model coefficient estimates

_t _d	Coefficient	Robust Std. Err.	z	P>z
The child is male	0.2177706*	0.1089796	2.00	0.046
The child is a twin	1.247827*	0.217996	5.72	0.000
Preceding birth interval is 2 yrs	0.692979*	0.1280248	5.41	0.000
Birth order between 2 and 3 yrs	-0.3929023*	0.1380752	-2.85	0.004
Birth order between 4 and 6 yrs	-0.1855194	0.1660851	-1.12	0.264
Birth order 7 yrs and above	0.517859*	0.2407519	2.15	0.031
Female headed household	-0.0940534	0.1273141	-0.74	0.460
Household size	-0.2118313*	0.0421702	-5.02	0.000
Mother's age	0.0130753	0.0129068	1.01	0.311
Mother with no education	0.3432485	0.2829217	1.21	0.225
Mother with secondary education	0.3526633	0.192965	1.83	0.068
Household with safe water	-0.8910278*	0.3197842	-2.79	0.005
Household with pit latrine	0.9958622*	0.3556574	2.80	0.005
Household without toilet facility	0.8762013*	0.4032896	2.17	0.030
Household using medium-polluting fuel	1.559201*	0.2685762	5.81	0.000
Household using high-polluting fuel	1.382799*	0.264548	5.23	0.000
Household has radio	-0.1175354	0.1352206	-0.87	0.385
Household has TV	-0.2203792	0.2509631	-0.88	0.380
Main dwelling unit made of *mabati* (iron sheets)	-0.005832	0.1275821	-0.05	0.964
Main dwelling unit made of tiles	-1.953231*	0.5640541	-3.46	0.001
No. of subjects = 4415 No. of failures = 378 Time at risk = 117421.6667 Log likelihood = -3007.6596	Number of obs = 4415 Wald chi2(22) = 212.43 Prob >chi2 = 0.0000			

* Significant at 5%

Table 7: Cox Model hazard ratio estimates

_t _d	Hazard Ratio	Robust Std. Err.	z	P>z
The child is male	1.243302*	0.1354945	2.00	0.046
The child is a twin	3.482766*	0.7592291	5.72	0.000
Preceding birth interval is 2 yrs	1.999664*	0.2560066	5.41	0.000
Birth order between 2 and 3 yrs	0.6750947*	0.0932138	-2.85	0.004
Birth order between 4 and 6 yrs	0.8306727	0.1379624	-1.12	0.264
Birth order 7 yrs and above	1.67843*	0.4040853	2.15	0.031
Female headed household	0.9102342	0.1158857	-0.74	0.460
Household size	0.8091012*	0.03412	-5.02	0.000
Mother's age	1.013161	0.0130766	1.01	0.311
Mother with no education	1.409519	0.3987836	1.21	0.225
Mother with secondary education	1.422852	0.2745606	1.83	0.068
Household with safe water	0.4102339*	0.1311863	-2.79	0.005
Household with pit latrine	2.707057*	0.962785	2.80	0.005
Household without toilet facility	2.401759*	0.9686044	2.17	0.030
Household using medium-polluting fuel	0.210304*	0.0564827	5.81	0.000
Household using high-polluting fuel	0.2508753*	0.0663686	5.23	0.000
Household has radio	0.8891091	0.1202258	-0.87	0.385
Household has TV	0.8022145	0.2013262	-0.88	0.380
Main dwelling unit made of *mabati* (iron sheets)	0.994185	0.1268402	-0.05	0.964
Main dwelling unit made of tiles	7.051437*	3.977392	-3.46	0.001

*Significant at 5%

All the variables in the estimated Cox model exhibit the expected signs. As in the Weibull model, there are four significant demographic variables namely, if the child is born twin, children born with birth interval of two years, children with birth order between two and three years, and birth order of seven years. Children born twins have a significantly higher mortality probability mainly due to biological factors. Children with a preceding birth interval of two years have a significantly higher mortality hazard while children whose birth order is between 2 and 3 are faced with lower mortality hazard. Higher mortality is experienced in children whose birth order is 7.

As for the socio-economic variables, household size is negatively related to child mortality, meaning that lower child mortality risks are experienced in larger households. Households with iron sheets and those with tiles as the roofing material for their main dwelling unit have lower child mortality rates as compared to those with grass or thatch. Lower mortality is experienced in households with both radio and television. The housing characteristics and the household assets are proxies for the household's socio-economic status which in this case implication affluent households which are expected to have better child survival prospects.

Lower mortality rates are incident upon households that have access to private tap and well water which in this study are considered to have safe drinking water. At each survival time, the mortality rate for children born into the household with access to safe water have is 41% less than those in households without. Access to sanitation facilities is also significantly related to child mortality. Children born in household's without any sanitation facility have significantly very higher mortality rates than those born in households with pit latrines who also have significantly higher mortality rates than those born in households with flush toilet.

With regard to source of cooking fuel, children born in households using both medium (kerosene and charcoal) and high polluting fuels(mostly firewood) as their main source of cooking fuel have higher mortality rates as compared to those using low polluting fuels (LPG and electricity). There is higher incidence of respiratory infections, which are believed to be responsible for child deaths, in households which use dirty fuels as opposed to those using clean cooking fuels.

CHAPTER 5: CONCLUSIONS AND POLICY RECOMMENDATIONS

5.1 Summary and Conclusions

The paper has empirically examined the environmental determinants of child mortality in Kenya. Estimation results from both the Weibull and Cox models have shown that both household's socio- economic and environmental characteristics do have significant impact on child mortality.

Of the demographic variables, four variables namely, if the child is born twin, children born with birth interval of two years, children with birth order between two and three years, and birth order of seven years are found significant in both models. Children born twins, those with a preceding birth interval of two years have a significantly higher mortality probability. While children whose birth order is between 2 and 3 are faced with lower mortality hazard, higher mortality is experienced in those whose birth order is 7. All these are mainly due to biological factors.

As for the socio-economic variables, better survival prospects are found to exist for children born in wealthier families. These households are expected to have better housing conditions, better nutrition, better education and hence more empowerment and are able to afford better medical attention and care thus significantly enhancing the survival probability of all their members including the children. Lower mortality rates have been found for households with better roofing material for their main dwelling unit (iron sheets and tiles) and in households rich in household assets (radio and television).

As expected, environmental characteristics of the household are found to be significantly related to child mortality. Lower mortality rates are experienced in households that have access to safe drinking water, those with access to sanitation facilities and those using low polluting fuels as their main source of cooking.

5.2 Policy Recommendations

From the study, socio-economic and environmental variables are important determinants of child mortality. Kenya has committed herself to the Millenium Development Goals, the fourth of which is the reduction of child mortality. To achieve this goal, policy should be directed at the underlying determinants of child mortality. The Kenyan government is aware of the importance of the environment in poverty reduction and has launched an initiative aimed at mainstreaming the environment into development planning. The findings of this study are intended to inform policy in this direction.

The government should be relentless in family planning interventions. Through such campaigns, demographic issues like birth spacing should be given the importance they deserve. Related to this should be the strengthening of the government's Integrated Mother and Childhood Illnesses (IMCI) programme to put more emphasis on children born twins as these face higher mortality risks.

Pro-poor development strategies, as recognized in various government sessional papers, should be pursued vehemently so as to enhance the economic status of the poor households who are faced with higher risks of child mortality. The poor are not only more concentrated in the rural areas of Kenya but also the emergent urban poor.

Greater efforts need to be put in place to ensure provision of basic services like water for all. Availability of safe sources of drinking water will significantly reduce child mortality and therefore investments in this sector will be rewarding.

Access to sanitation facilities like constructing toilets entail a private cost but do have significant social benefits. The government should work closely with both the private sector and civil society to ensure that households have universal access to sanitation facilities as this will to a great extend reduce the number of infant deaths. In addition, the proposed housing policy should make it mandatory for each housing unit to have a sanitation facility such that all households have access to access to sanitation facilities.

The government policy should be focused towards promoting the use of low polluting fuels and in particular discouraging the use of firewood which also causes deforestation and other environmental problems. Through the use of economic instruments, incentives should be created for promotion of cleaner fuel sources such as solar and biogas. This will also create employment opportunities which will translate into increased earnings and reduced poverty.

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